www.e-rara.ch

The compleat surveyor containing the whole art of surveying of land by the plaine table, theodolite, circumferentor, peractor and other Instruments...

Leybourn, William

London, M. DC. LVII. [1657]

ETH-Bibliothek Zürich

Shelf Mark: Rar 3068

Persistent Link: https://doi.org/10.3931/e-rara-16626

www.e-rara.ch
Die Plattform e-rara.ch macht die in Schweizer Bibliotheken vorhandenen Drucke online verfügbar. Das Spektrum reicht von Büchern über Karten bis zu illustrierten Materialien – von den Anfängen des Buchdrucks bis ins 20. Jahrhundert.

e-rara.ch provides online access to rare books available in Swiss libraries. The holdings extend from books and maps to illustrated material – from the beginnings of printing to the 20th century.

e-rara.ch met en ligne des reproductions numériques d'imprimés conservés dans les bibliothèques de Suisse. L'éventail va des livres aux documents iconographiques en passant par les cartes – des débuts de l'imprimerie jusqu'au 20e siècle.

e-rara.ch mette a disposizione in rete le edizioni antiche conservate nelle biblioteche svizzere. La collezione comprende libri, carte geografiche e materiale illustrato che risalgono agli inizi della tipografia fino ad arrivare al XX secolo.

Nutzungsbedingungen Dieses Digitalisat kann kostenfrei heruntergeladen werden. Die Lizenzierungsart und die Nutzungsbedingungen sind individuell zu jedem Dokument in den Titelinformationen angegeben. Für weitere Informationen siehe auch [Link]

Terms of Use This digital copy can be downloaded free of charge. The type of licensing and the terms of use are indicated in the title information for each document individually. For further information please refer to the terms of use on [Link]

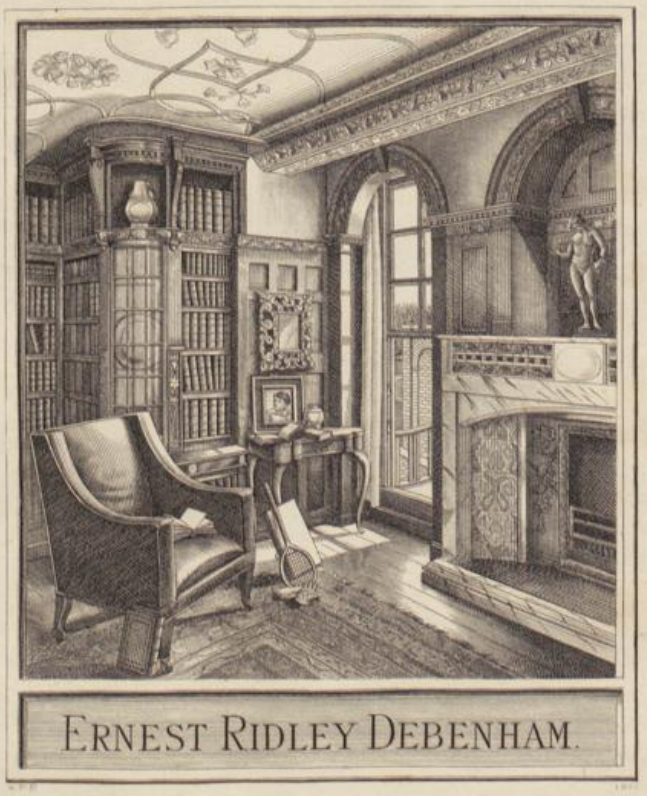
Conditions d'utilisation Ce document numérique peut être téléchargé gratuitement. Son statut juridique et ses conditions d'utilisation sont précisés dans sa notice détaillée. Pour de plus amples informations, voir [Link]

Condizioni di utilizzo Questo documento può essere scaricato gratuitamente. Il tipo di licenza e le condizioni di utilizzo sono indicate nella notizia bibliografica del singolo documento. Per ulteriori informazioni vedi anche [Link]

Visual Library

RAR 3068

STC 1908



ERNEST RIDLEY DEBENHAM.

E 3=9

THE COMPLEAT SURVEYOR,

Containing the whole ART *of*

Surveying of Land.

BY THE

Plaine Table, Theodolite, Circumferentor, Peractor,

and other Instruments.

After a more easie, exact and compendious manner, then hath been hitherto published by any: the *Plain Table* being so contrived, that it alone will conveniently perform whatsoever may be done by any of the fore-mentioned *Instruments*, or any other yet invented, with the same ease and exactness; and in many cases much better.

Together with the taking of all manner of Heights and Distances, either accessible or in-accessible, the Plotting and Protracting of all manner of Grounds, either small Inclosures, Champion Plains, Wood-lands, or any other Mountainous and un-even grounds. Also, how to take the Plot of a whole Manor, to cast up the content, and to make a perfect Chart or Map thereof. All which particulars are performed three several ways, and and by three several *Instruments*.

Hereunto is added a new way of *Surveying* of *Land*, by which a man may be satisfied whether his Plot will close before he begins to protract the same, with the manner how to order such Water Colours as are necessary for the beautifying of *Maps* and *Plots*; Also how to know whether *Water* may be conveyed from a Spring-head to any appointed place or not, and how to effect the same: With whatsoever else is necessary to the *Arts* of *Surveying*.

The Second Edition, *with many* Additions.

By WILLIAM LEYBOURN.

LONDON,
Printed by *R.* and *W. Leybourn*, for *G. Sambridge*, at the signe of the Bible upon *Ludg*-gate-hill, *M. DC. LVII.*

7 1

PRÆSTO
ET
PERSTO
The Right Honble Thomas
Earl of Hadinton

To His Much

HONOUR'D FRIEND

EDMVND VVINGATE,

of *Grayes Inne* Esq.

SIR,

THis *Treatise* being finish-ed, and ready to see the light, I could not bethink my selfe of a fitter Patron then your self to protect it; Your knowledge in, and affection to the *Sciences Mathematical*, as also the civil respect you usually vouchsafe such as affect those Studies, arm me with this confidence.

I foresee that this my presumption in exposing this Work to publike view, may meet with some *Detractors*, but Your approbation thereof, will both convince them of their *Errour*, and plentifully satis-

fie me for the pains I have taken therein. Howbeit, what reception soever it may obtain with the *Vulgar*, my intention (I doubt not) will give me support and encouragement, my aime therein being nothing else but the publike good, and this my Dedication an evidence to let You know how much I am,

SIR,

Your most humble and obliged Servant,

William Leybourn.

TO THE READER.

Courteous Reader,

ABout three yeares ſince there came into the World a little Pamphlet entituled *Planometria*, or the whole Art of Surveying of Land, under the name of *Oliver Wallinly*, of which I confeſs my ſelf to be the Authour, that name being only the true letters of my own name tranſpoſed. I was indeed very unwilling the World ſhould know me to be the Author thereof, it being ſo immaterial a Treatiſe, and too particular for a Subject of ſo large an extent, but that was occaſioned by over-much haſte, for (being urged thereunto) it was not above ſix weeks conceived before it was brought forth, and therefore muſt needs be little leſs then monſtrous: yet the good acceptance which that Pamphlet received, occaſioned me to proſecute that Subject more at large.

Now as the opinions of men in the World are various, ſo I know this Work will be variouſly cenſured, and therefore it might (perchance) be expected by ſome, that I ſhould make an apologie for my ſelf, as to crave pardon or excuſe for whatſoever any man ſhall be pleaſed to object againſt, but I mean to make no excuſe, for I know of nothing that needs it, neither did I ever know any Book the more favoured for the Authours beſpeaking it; beſides, the ſubject of the enſuing Treatiſe being *Geometry*, needeth no ſuch thing, for [*Demonſtration*] the grand ſupporter thereof, is able to with-ſtand all oppoſers, and ſilently with Lines and Figures to *non-plus* the moſt malevolent tongue or Pen that ſhall either ſpeak or write againſt it. But to the judicious Reader I ſhall ſay thus much; As I dare not think my doings free from all exception, ſo I do not know of any thing herein contained worthily deſerving blame: Some ſmall overſights which may poſſibly have crept in by chance, I muſt intreat the friendly Reader to over-ſee or wink at, as for the

understanding Reader, I am sure he will scorn to cavil at every slight mistake or literal fault in the Printing: as for material faults I know of none in the whole Work, although I have diligently examined the Printed sheets.

In the following Treatise I have endeavoured to proceed methodically, and to insert every particular Chapter, as it ought to be read and practised, and have omitted nothing that might any way tend to make a man in short time become an exquisite proficient in the Geometrical part of Surveying.

The first Part of this Book consisteth of Geometry only, and containeth such Problemes as are meet and necessary to be known and practised by any man that intendeth to exercise himself in this employment: by help of these Problemes the Plot of any piece of Land may be inlarged or diminished according to any assigned proportion, and separation and division thereof made, if need be, by Rule and Compass only, and also by Arithmetick.

In the second Book, you have a general description of all the most necessary Instruments used in Surveying, as of the *Theodolite*, *Circumferentor*, *Plain Table*, and the like, and more particularly of those which I make use of in the prosecuting of this Discourse. Also I have given such directions for the making of the *Plain Table*, and furnished the Index and other parts thereof with divers necessarie lines for several occasions, so that it being made according to the directions there given, it is the most absolute and universal Instrument for all occasions yet ever invented; for by it may be performed whatsoever may be done by the *Theodolite*, *Circumferentor*, or *Peractor*, with the same facility and exactness, and in many cases better, as in the particular uses thereof will plainly appear.

And in the fifth Chapter of the second Book, I have described the making of an Instrument which will perform all the uses of the *Theodolite*, *Semicircle*, *Circumferentor*, and *Peractor*, and for Portability exceeds any of them. In the eighth Chapter of this second Book, there is also described a new kinde of *Protractor*, which is far more convenient for use then that which is usually made, and as is described in the former part of the said Chapter.

The third Book is of *Trigonometry*, or the Doctrine of the dimension of Plain Triangles, by *Sines*, *Tangents*, and *Logarithmes*, by which the nature & reason of the taking of all manner of Heights and Distances may the better appear, and for that reason I have in this third Book added short Tables of *Sines* and *Logarithmes*, namely, a Table of *Sines* to every ten minutes of the Quadrant, and a Table of *Logarithmes* from 1 to 1000, by which more Questions may be resolved in the space of one hour, then by the usual wayes taught by others can be performed in six, if the like exactness be required. And for a further abreviation of these Calculations, I have also shewed how to resolve all such Cases in Plain Triangles as may at any time come in use in the practice of Surveying by the Lines of Artificial *Numbers*, *Sines*, and *Tangents*, whereby all

such

ſuch Caſes may be reſolved without Pen, Inke, or Paper.

In the fourth Book is ſhewn the uſe of all the fore-mentioned Inſtruments in the practice of ſurveying, and firſt in taking of all manner of Heights and Diſtances, either acceſſible or inacceſſible, in the practice whereof the young Practitioner will take much delight, and receive no ſmall ſatisfaction.

There is alſo taught how to take the Plot of any field or other incloſure ſeveral ways, both by the *Plain Table*, *Theodolite*, and *Circumferentor*, by which will appear what congruity and harmony there is between theſe ſeveral Inſtruments, for if you take the Plot of any field by any one of them, and then by another of them, and plot your work by the ſame Scale at both your obſervations, you ſhall (if you be careful) finde that theſe two Plots will agree together as exactly as if they had been both taken by one and the ſame Inſtrument. And for this reaſon I have made one Scheme or Figure ſerve for three ſeveral Chapters, which hath much abreviated the number of Diagrams, and will (I perſwade my ſelf) give better ſatisfaction to the Learner, then variety of Figures could have done.

In the manner of protracting, when you have obſerved your degrees cut by the Needle in the *Circumferentor*, or the Index of the *Peractor*, I have (becauſe the practice thereof is very uſual and no leſs difficult) in *Page* 239 inſerted a Figure ſo plain and perſpicuous, that the very ſight thereof will be enough (if there were no words uſed) to explain the uſe thereof.

After the Plot of any field is taken and protracted according to any of the former directions, I come to ſhew how the content thereof may be attained ſeveral ways, that is, to finde how many Acres, Roods and Perches are contained in any Field thus plotted. Alſo there is taught how to meaſure Mountanous and uneven grounds, and to finde the area or content thereof.

You are alſo taught in this fourth Book how to take the true Plot of a whole Manor, or of divers ſeverals, both by the *plain Table*, *Theodolite*, *Circumferentor* or *Peractor*, with the manner how to keep account in your Field-Book after the moſt ſure and exacteſt way. And here is alſo added a new way of Surveying of Land by the *Circumferentor* or *Peractor*, by which when you have gone round about the field & made obſervation of the ſeveral ſides and angles, you may with ſmall troub'e make examination thereof, and be ſatisfied whither your plot will cloſe or not, before you begin to protract. Alſo how to reduce your Plot, to any proportion, to draw a perfect draught thereof, and to deck and beautifie the ſame, with the manner how to order ſuch Colours as are neceſſary thereunto. And in the laſt place there is an example of Water-leveling, by which you may know whether water may be conveyed from a Spring-head to any determinate place or not.

Thus have I given you ſome general intimation of the principal heads conteined in the following Treatiſe, which you may ſee more aparent in the following *Analyſis*, but beſt of all in the Book it ſelf,

ſelf, unto which I chiefly refer you, wiſhing that you may take the ſame delight and pleaſure in the practice of thoſe things therein conteined, as I did in the compoſing of them, ſo ſhall I think my labour well beſtowed, and be the more animated to preſent thee with ſome other Mathematical Treatiſe, who am

A Friend to all that are Mathematically affected.

London, June 1653

William Leybourn.

A GENERAL SVRVEY OF the whole WORK.

The following---

I *Of* Geometry, *which consisteth of*
- 1 Definitions, *Page* 3
- 2 Theoremes, 10
- 3 Problemes *concerning*
  - 1 *Raising and letting fall of* Perpendiculars, 11
  - 2 *The making of equal* Angles, *and drawing of* parallel Lines, 13
  - 3 *The dividing of* right Lines *equally*, 14
  - 4 *The constituting of* right lined Figures, 16
  - 5 *The working of* proportions *by* lines, 17
  - 6 *The dividing of* right lines *proportionally*, 18
  - 7 *The dividing of* Triangles *according to proportion*, *both* Arithmetically *and* Geometrically,
    - *by a* line *drawn*
      - 1 *From any* angle, 19
      - 2 *From a* point *in any* side, 21
      - 3 Parallel *to any* side, 22
  - 8 *The power of* Lines *and* Superficies, 25
  - 9 *The reducing of* figures *from one form to another, as*
    - *Four*
    - *Five*
    - *Six*

    sided figures *into* Triangles, 28. *&c.*
  - 10 *The dividing of any plain* Superficies *into two or more parts*, *according to any* proportion, *by* lines *drawn either from any* angle, *or from a* point *in any side*, 31

II *Of* Instruments, *as*
- 1 *In general*, 41
- 2 *Of the* Theodolite, 43
- 3 *Of the* Circumferentor, 44
- 4 *Of the* Plain Table, 45
- 5 *Of a new* Instrument, 49
- 6 *Of the* Crosse, 50
- 7 *Of* Chains, *and chiefly, of*
  - *Mr.* Rathborns, 51
  - *Mr.* Gunters, 52
- 8 *Of the* Protractor, 55
- 9 *Of* Scales, *Plain and Diagonal*, 58
- 10 *Of a* Field-book, 60
- 11 *Of the* Parallelogram, 61

III *Of* Trigonometrie *and*
- 1 *Of the description and use of the* Tables *of*
  - Sines 65
  - *and*
  - Logarithmes, 71
- 2 *The application and use of these* Tables, *as also of the lines of* Numbers, Sines *and* Tangents, *in resolving of* Plain Triangles,
  - Right angled, 79
  - *and*
  - Oblique angled 87

1 *Of*

--- *Treatise is divided into* ---

IV *The use of Instruments, and,*

1 *Of the* Scale *in* { *taking there from* / *laying down* } { *lines & angles of any quantity*, 179

2 *Of the* Protractor *in* { *laying down* / *finding the quantity of* } { *any* Angle, 182

3 *Of the* { Plain Table, / Theodolite, / Circumferentor, } { *to finde an angle in the field therewith*, 183

4 *Of the* Label, *thereby to observe* { *an* Horizontal line, *or line of level*, / *an* angle *of* altitude, 186

5 *Of taking of* Distances { *accessible* / *or* / *inaccessible* } { *by the* Plain Table, 187 / Theodolite, 189 / Circumferentor, 190. *and* (*to protract the same*, 191

6 *Of the taking of* { *accessible*, / *inaccessible*, } { *altitudes by the* Label *and* Tangent line 192 (*and to protract the same* 193

7 *Of taking divers distances at once, by the* { Plain Table, 196 / *and* / Theodolite, 198 } { *and to protract the same*, 199

8 *To take the plot of a Field at one station taken in the middle thereof by the* { Plain Table, 201 / Theodolite, 203 / Circumferentor, 205 (*and to protract the same*, 206

9 *To take the plot of a Field at one station taken in any angle thereof, by the* { Plain Table, 208 / Theodolite, *ibid.* / Circumferentor, 210 (*and to protract the same*, 210

10 *To take the plot of a field at two stations taken in any parts thereof, by the* { Plain Table, 212 / Theodolite, 214 / Circumferentor, 216 (*and to protract the same*, 216

11 *To take the plot of a Field at two stations taken in any part thereof, only measuring the stationary distance, by the* { Plain Table, 218 / Theodolite, 220 / Circumferentor, 220 (*and to protract the same*, 222

12 *Of large Champion Plains or Woods, to take Plots thereof by the* { Plain Table, 223 / Theodolite, 226 (*and to protract the same*, 230

With a way to prove the truth thereof, 232

13 *To take the plot of any Field, Wood, Park, Chase, Forrest, or other large Champion Plain, by the* { Circumferentor, 234. *And to protract the same*. 237. *With divers cautions for the exact performance thereof.*

14 *Of the* Peractor, *contrived by Master* Rathborn, *how to make the* Plain Table *to do the Work thereof better then the* Peractor *it self*, 240

15 *To take the plot of any piece of Land by the* Peractor, 236, *and to protract the same*, 244
16 *To surveigh by the Chain only, and no other Instrument*, 247
17 *To take Plot of a Forrest, Chase, or Wood by the* Circumferentor, *of which you may know whether your plot will close or not before you begin to protract*, 250
18 *To protract the same*, 259
19 *Of finding the area or superficial content of any piece of Land, the plot therof being first taken, & chiefly of* { *The* Geometric Square, 262; *The* Long Square, 263; *The* Triangle, 263; *The* Trapezia, 264; *Any irregular plot of a Field*, 265; *The* Circle, 267
20 *The manner of casting up the content of any piece of Land in Acres, &c. by* { *Mr.* Rathborns *Chain*, 267; *Mr.* Gunters *Chain*, 270
21 *To reduce* Acres *into* Perches, *and the contrary*, 270
22 *The use of a* Scale, *of* Reduction *necessary, for finding the fraction parts of an Acre*, 272
23 *Divers compendious Rules for the ready casting up of any plain Superficies, with divers other* Compendiums *in* Surveying, *by the Line of* Numbers, 273
24 *Of Statute and Customary measure to reduce one to the other at pleasure*, 276
25 *Of the laying out of common fields into* Furlongs, 277
26 *How a Lordship lying in common fields is to be divided*, 279
27 *Of Hils and Mountains, how to finde the Lengths of the Horizontal Lines on which they stand several ways*, 282
28 *Of Mountanous and un-even grounds, how to protract or lay the same down in* plano *after the best manner, giving the area or content thereof*, 283
29 *How to take the Plot of a whole Manor by the* { Plain Table *three several wayes*, 285; Circumferentor *or* Peractor, 291
With the keeping an account in your Field-book, *after the best and most certain manner* 295, *and to protract any observations so taken*, 296
30 *Of inlarging or diminishing of Plots according to any possible proportion by* { *Two* Semicircles, *Mr.* Rathborns *Ruler*, *A* Line *into* 100 *parts*, *The* Parallelogram, 289
31 *To draw a perfect draught of a whole Manor, and to furnish it with all necessary varieties*, 300
32 *The names of such Colours as are necessary for the washing of Maps or Plots, with the manner how to temper & use the same*, 301
33 *Of conveying of Water*, 305

Note that all Chapters and parts of Chapters that are added in this Edition, are noted with this mark before the Chapter ☞

---four Books.

For as much as the whole Art of Surveying, *of* Land *is performed by* Instruments *of several kinds, and that the exact and careful making and dividing of all such* Instruments *is chiefly to be aimed at, I thought good to intimate to such as are desirous to practise this Art, and do not readily know where to be furnished with necessary* Instruments *for the performance thereof, that all, or any of Instruments used or mentioned in this Book, or any* Mathematical Instruments *whatsoever are most exactly made by Mr.* Anthony Thompson *in* Hosier Lane *neer* Smithfield, London.

THE COMPLEAT SURVEYOR.

The First Book.

THE ARGUMENT.

THis first *Book* consisteth of divers *Definitions* & *Problemes Geometricall*, extracted out of the Writings of divers ancient and modern *Geometricians*, as *Euclid*, *Ramus*, *Bagdedine*, *Clavius*, *&c.* and are here so methodically disposed, that any man may gradually proceed from *Probleme* to *Probleme* without interruption, or being referred to any other *Authour* for the Practicall performance of any of them. Onely the *Demonstration* is wholly omitted; partly, because those *Books* out of

which they were extracted, are very large in that particular, and also for the avoiding of many other *Propositions* and *Theoremes*, which (had the ensuing *Problemes* been *demonstrated*) must of necessity have been inserted. Also, the figures would have been so incumbred with multiplicity of lines, that the intended *Problemes* would have been thereby much darkened. And besides it was not my intent in this place to make an absolute or entire *Treatise* of *Geometry*, and therefore I have only made choice of such *Problemes* as I conceived most usefull for my present purpose, and come most in use in the practise of *Surveying*, and ought of necessity to be known by every man that intendeth to exercise himselfe in the Practice thereof, and those are chiefly such as concern the reducing of *Plots* from one forme to another, and to inlarge or diminish them according to any assigned *Proportion*, also divers of the *Problemes* in this *Book* will abundantly help the *Surveyor* in the division and seperation of *Land*, and in the laying out of any assigned quantity, whereby large parcels may be readily divided into divers severals; and those again sub-divide if need be. Also for the better satisfaction of the *Reader*, I have performed divers of the following *Problemes* as well *Arithmetically* as *Geometrically*.

GE-

GEOMETRICALL DEFINITIONS.

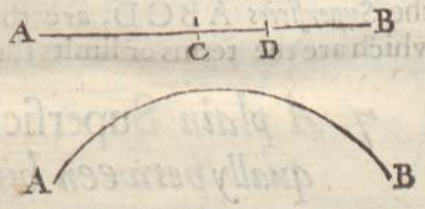
1 *A* Point *is that which cannot be divided.*

A *Point* or *Signe* is that which is void of all *Magnitude*, and is the leaſt thing that by minde and underſtanding can be imagined and conceived, than which there can be nothing leſſe, as the *Point* or *Prick* noted with the letter A, which is neither quantity nor part of quantity, but only the terms or ends of quantity, and herein a *Point* in Geometry differeth from *Unity* in *Number*.

A

2 *A line is a length without breadth or thickneſſe.*

A *Line* is created or made by the moving or drawing out of a *Point* from one place to another, ſo the *Line* A B, is made by moving of a *Point* from A to B, and according as this motion is, ſo is the *Line* thereby created, whether *ſtreight* or *crooked*. And of the three kindes of *Magnitudes* in *Geometry*, viz. *Length*, *Breadth*, and *Thickneſſe*, a *Line* is the firſt, conſiſting of *Length* only, and therefore the *Line* A B, is capable of diviſion in *Length* only, and may be divided equally in the *point* C, or unequally in D, and the like, but will admit of no other dimenſion.



3 *The ends or bounds of a* Line *are* Points.

This is to be underſtood of a finite *Line* only, as is the line A B, the ends or bounds whereof are the points A and B: But in a Circular *Line* it is otherwiſe,

A B

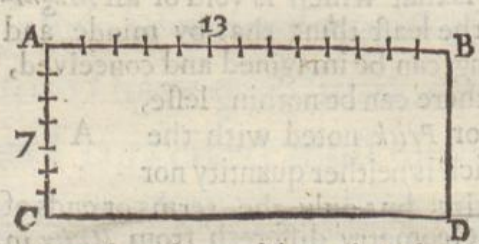
wiſe, for there, the *Point* in its motion returneth again to the place where it firſt began, and ſo maketh the *Line* infinite, and the ends or bounds thereof undeterminate.

4 *A* Right line *is that which lieth equally betweenhis points.*

A ——————— B

As the *Right line* A B lieth ſtreight and equall between the points A and B (which are the bounds thereof) without bowing, and is the ſhorteſt of all other lines that can be drawn between thoſe two points.

5 *A* Superficies *is that which hath only length and breadth.*



As the motion of a point produceth a Line, the firſt kinde of Magnitude, ſo the motion of a Line produceth a *Superficies*, which is the ſecond kinde of Magnitude, and is capable of two dimenſions, namely, length and breadth, and ſo the *Superficies* A B C D may be divided in length from A to B, and alſo in breadth from A to C.

6 *The extreams of a* Superficies *are Lines.*

As the extreames or ends of a Line are points, ſo the extreams or bounds of a *Superficies* are Lines, and ſo the extreams or ends of the *Superficies* A B C D, are the lines A B, B D, D C, and C A, which are the terms or limits thereof.

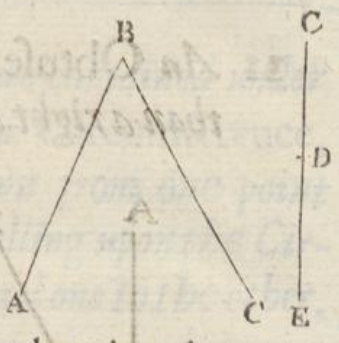
7 *A plain* Superficies *is that which lieth equally between his lines.*

So the *Superficies* A B C D, lieth direct and equally between his lines: and whatſoever is ſaid of a right line, the ſame is alſo to be underſtood of a plain Superficies.

8 *A plain* Angle *is the inclination or bowing of two lines the one to the other, the one touching the other, & not being directly joyned together.*

As the two lines A B and B C incline the one to the other, and touch one another in the point B, in which point, by reaſon of the incli-

inclination of the ſaid lines, is made the *Angle* A B C. But if the two lines which touch each other be without inclination, and be drawn directly one to the other, then they make no angle at all, as the lines C D and D E, touch each other in the point D, and yet they make no angle, but one continued right line.



¶ And here note, that an Angle commonly is ſigned by three Letters, the middlemoſt whereof ſheweth the angular point: As in this figure, when we ſay the angle A B C, you are to underſtand the very point at B: And note alſo, that the length of the ſides containing any angle, as the ſides A B and B C, do not make the angle A B C either greater or leſſer; but the angle ſtill retaineth the ſame quantity be the containing ſides thereof either longer or ſhorter.

9 *And if the lines which contain the angle be right lines, then is it called a right lined angle.*

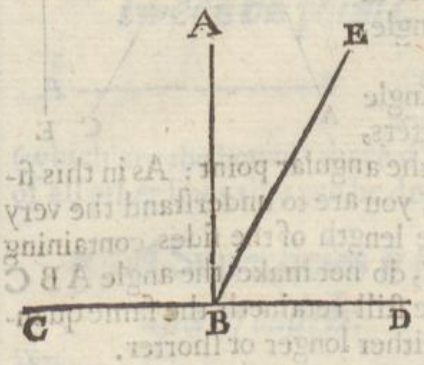
So the angle A B C is a right lined angle, becauſe the lines A B and B C, which contain the ſaid angle, are right lines. And of right lined Angles there are three ſorts, whoſe Definitions follow.

10 *When a right line ſtanding upon a right line maketh the angles on either ſide equall, then either of thoſe angles is a right angle: and the right line which ſtandeth erected, is called a perpendicular line to that whereon it ſtandeth.*

As upon the right line C D, ſuppoſe there do ſtand another right line A B, in ſuch ſort that it maketh the angles on either ſide thereof equall, namely, the angle A B D on the one ſide, equall to the Angle A B C on the other ſide: then are either of the two angles A B C, and A B D right angles, and the right line A B, which ſtandeth erected upon the right line C D, without inclining to either part thereof, is a perpendicular to the line C D.

11 *An*

11 *An* Obtuſe angle *is that which is greater than a right angel.*



So the angle C B E is an obtuſe angle, becauſe it is greater than the angle A B C, which is a right angle; for it doth not only contain that right angle, but the angle ABE alſo, and therefore is obtuſe.

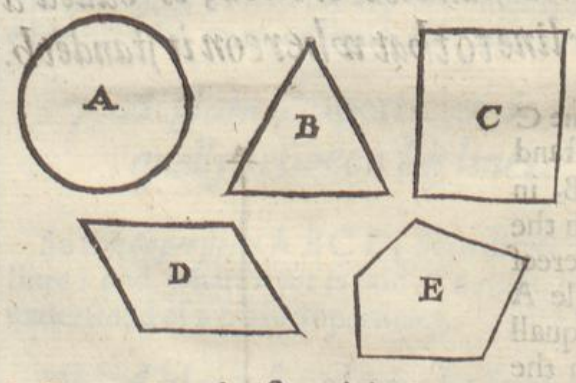
12 *An* Acute angle *is leſſe than a right angle.*

So the angle EBD is an acute angle, for it is leſſe than the right angle A B D (in which it is contained) by the other acute angle A B E.

13 *A* li nit *or* term *is the end of every thing.*

As a point is the limit or term of a Line, becauſe it is the end thereof, ſo a Line likewiſe is the limit and term of a Superficies; and a Superficies is the limit and term of a Body.

14 *A* Figure *is that which is contained under one limit or term or many.*

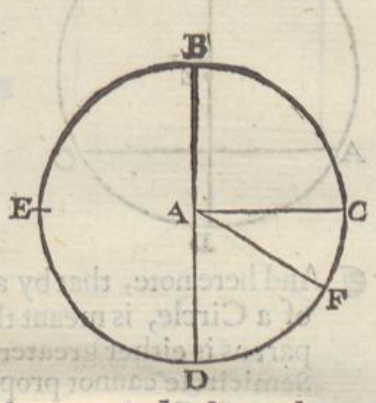


As the Figure A is contained under one limit or term, which is the round line. Alſo the Figure B is contained under three right lines, which are the limits or terms thereof. Likewiſe, the Figure C is contained under four right lines, the Figure E under five right lines, and ſo of all other figures.

¶ And here note, that in the following work we call any plain Superficies whoſe ſides are unequall, (as the figure E) a *Plot*, as of a Field, Wood, Park, Forreſt, and the like,

15 *A Circle is a plain Figure contained under one line, which is called a* Circumference, *unto which all lines drawn from one point within the Figure, and falling upon the Circumference thereof are equal one to the other.*

As the figure A B C D E is a Circle, contained under the crooked line B C D E, which line is called the Circumference: In the middle of this Figure is a point A, from which point all lines drawn to the Circumference thereof are equall, as the lines A B, A C, A F, A D: and this point A is called the center of the Circle.



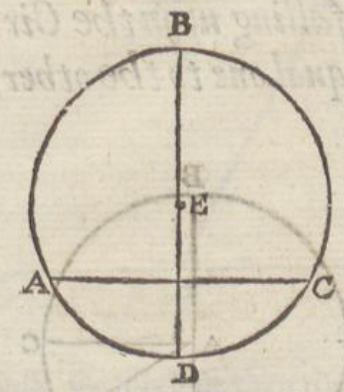
16 *A* Diameter *of a circle is a right line drawn by the Center thereof, and ending at the Circumference; on either side dividing the Circle into two equall parts.*

So the line B A D (in the former Figure) is the Diameter thereof, becauſe it paſſeth from the point B on the one ſide of the Circumference, to the point D on the other ſide of the Circumference, and paſſeth alſo by the point A, which is the center of the Circle. And moreover, it divideth the circle into two equall parts, namely, B C D being on one ſide of the Diameter, equall, to B E D on the other ſide of the Diameter. And this obſervation was firſt made by *Thales Miletius*, for, ſaith he. If a line drawn by the center of any Circle do not divide it equally, all the lines drawn from the center of that Circle to the Circumference cannot be equall.

17 *A* Semicircle *is a figure contained under the Diameter, and that part of the Circumference, cut off by the Diameter.*

As in the former Circle, the figure B E D is a Semicircle, becauſe it is contained of the right line B A D, which is the Diameter, and of the crooked line B E D, being that part of the circumference which is cut off by the Diameter: alſo the part B C D is a Semicircle.

18 *A* Section *or portion of a Circle, is a Figure contained under a right line, and a part of the circumference, greater or leſs then a Semicircle.*



So the Figure A B C, which conſiſteth of the part of the Circumference A B C, and the right line A C is a Section or portion of a Circle greater than a Semicircle.

Alſo the other figure A C D, which is contained under the right line A C, and the part of the circumference A D C, is a Section of a circle leſſe than a Semicircle.

¶ And here note, that by a Section, Segment, Portion, or Part of a Circle, is meant the ſame thing, and ſignifieth ſuch a part as is either greater or leſſer then a Semicircle, ſo that a Semicircle cannot properly be called a Section, Segment, or part of a Circle.

19 *Right lined figures are ſuch as are contained under right lines.*

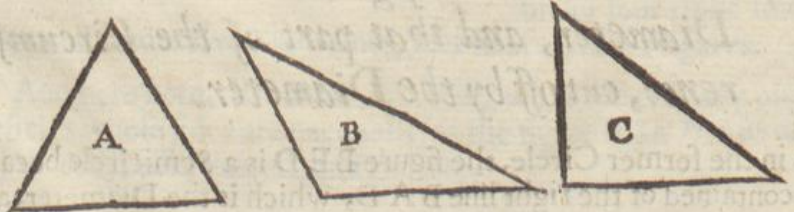
20 *Three ſided figures are ſuch as are contained under three right lines.*

21 *Four ſided figures are ſuch as are contained under four right lines.*

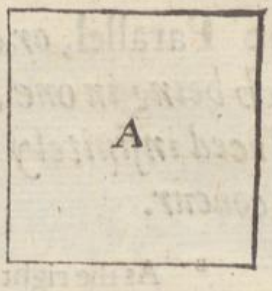
22 *Many ſided figures are ſuch as have more ſides than four.*

23 *All three ſided figures are called* Triangles.

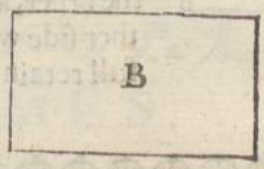
And ſuch are the Triangles A B C.



24 *Of four sided figures, a* Quadrant *or* Square *is that whose sides are equal and his angles right.* As the Figure A.

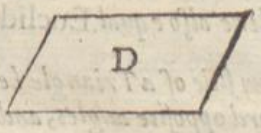


25. *A* Long Square *is that which hath right angles but unequal sides.* As the Figure B

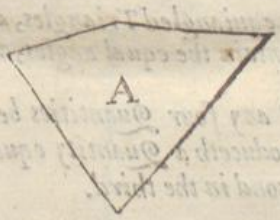


26. *A* Rhombus *is a Figure having four equall sides but not right angles.* As the Figure C.

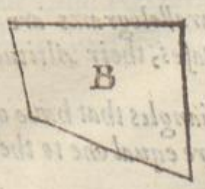
27 *A* Rhomboides *is a Figure whose opposite sides are equall, and whose opposite angles are also equall, but it hath neither equall sides nor equall angles.* As the Figure D.



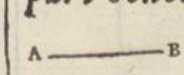
28 *All other Figures of foure sides (besides these) are called* Trapezias.



Such are all Figures of four sides in which is observed no equality of sides or angles, as the figures A and B, which have neither equall sides nor equall angles, but are described by all adventures without the observation of any order.



20 Parallel, *or* equidistant *right lines are such which being in one and the same Superficies, and produced infinitely on both sides, do never in any part concur.*



As the right lines A B and C D are parallel one to the other, and if they were infinitely extended on either side would never meet or concur together, but still retain the same distance.

Geometrical Theoremes.

1 *ANy two right lines crossing one another, make the contrary or vertical angles equal.* Euclid.15.1.

2 *If any right line fall upon two parallel right lines, it maketh the outward angles on the one, equal to the inward angles on the other, and the two inward opposite angles on contrary sides of the falling line also equal.* Euclid.29.1.

3 *If any side of a Triangle be produced, the outward angle is equal to the two inward opposite angles, and all the three angles of any Triangle are equal to two right angles.* Euclid.32.1.

4 *In equiangled Triangles, all their sides are proportional, as well such as contain the equal angles, as also the subtendent sides.*

5 *If any four Quantities be proportional, the first multiplyed in the fourth, produceth a Quantity equal to that which is made by multiplication of the second in the third.*

6 *In all right angled Triangles, the square of the side subtending the right angle, is equal to both the squares of the conteining sides.* Euclid.47.1.

7 *All Parallelograms are double to the Triangles that are described upon their Bases, their Altitudes being equal.* Euclid.41.1.

8 *All Triangles that have one and the same Base, and lie between two parallel lines, are equal one to the other.* Euclid.37.1.

GE-

GEOMETRICALL PROBLEMES

PROBLEME I.

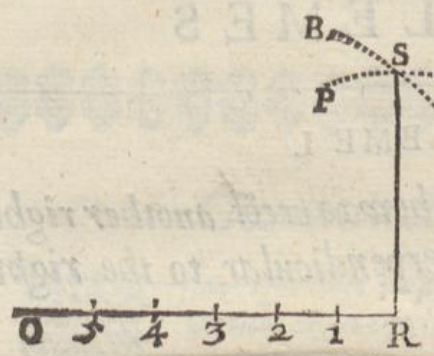
Upon a right line given, how to erect another right line, which shall be perpendicular to the right line given.

THE right line given is A B, upon which from the point E it is required to erect the perpendicular E H.

Opening your Compasses at pleasure to any convenient distance, place one foot in the assigned point E, and with the other make the marks C and D, Equidistant on each side the given point E. Then opening your Compasses again to any other convenient distance wider then the former, place one foot in C, and with the other describe the arch G G, also (the Compasses remaining at the same distance) place one foot in the point D, and with the other describe the arch F F, then from the point where these two arches intersect or cut each other (which is at H) draw the right Line HE which shall be perpendicular to the given right line A B, which was the thing required to be done.

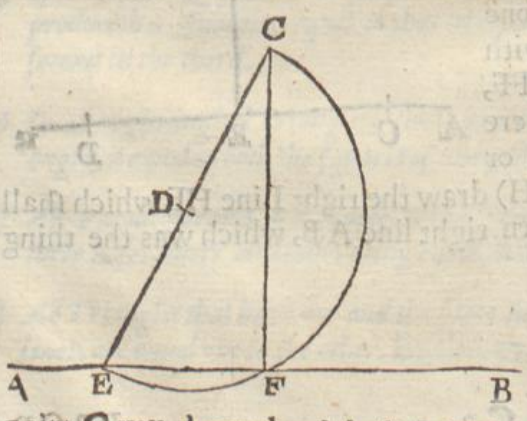
PROB. II.

How to erect a Perpendicular on the end of a right line given.

LEt O R be a line given, and let it be required to erect the perpendicular R S. First, upon the line O R, with your Compasses opened to any small distance, make five small divisions beginning at R, noted with 1, 2, 3, 4, 5. Then take with your Compasses the distance from R to 4, and placing one foot in R, with the other describe the arch P P. Then take the distance R 5, and placing one foot of The Compasses in 3, with the other foot describe the arch B B, cutting the former arch in the point S, Lastly from the point S, draw the line R S, which shall be perpendicular to the given line O R.

PROB. III.

How to let fall a perpendicular, from any point assigned, upon a right line given.

THE point given is C, from which point it is required to draw a right line which shall be perpendicular to the given right line A B.



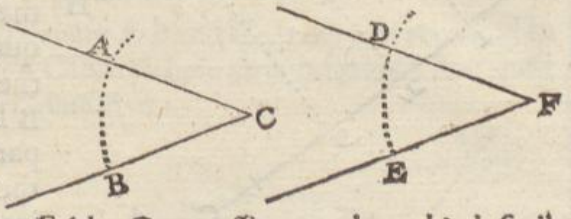
First, from the given point C, to the line A B, draw a line by chance, as C E, which divide into two equall parts in the point D, then placing one foot of the Compasses in the point D, with the distance D C, describe the Semicircle C F E, cutting the given line A B in the point F. Lastly, if from the point C you draw the right line C F, it shall be a perpendicular to the given line A B, which was required.

PROB.

PROB. IV.

How to make an angle equall to an angle given.

LEt the angle given be A C B, and let it be required to make another angle equall thereunto.

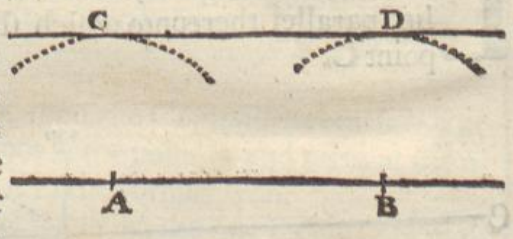


First, draw the line E F at pleasure, then upon the given angle at C, (the Compasses opened to any distance) describe the ark A B, also; upon the point F (the Compasses un-altered) describe the arke D E: then take with your Compasses the distance A B, and set the same distance from E to D. Lastly, draw the line D F, so shall the angle D F E be equall to the given angle A C B.

PROB. V.

A right line being given, how to draw another right line which shall be parallel to the former, at any distance required.

THe line given is A B, unto which it is required to draw another right line parallel thereunto, at the distance A C, or B D.



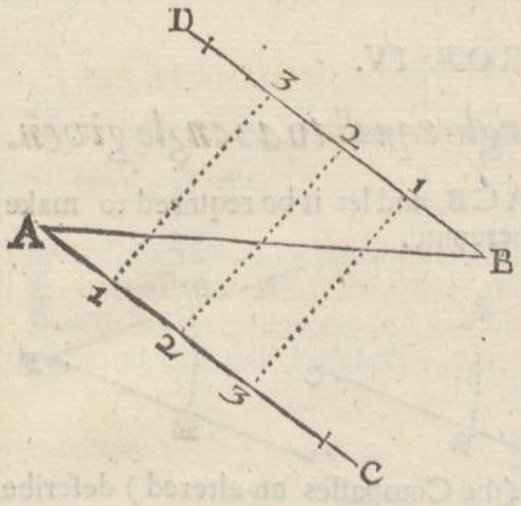
First, Open your Compasses to the distance A C or A D, then placing one foot in A, with the other describe the arke C; also place one foot in B, and with the other describe the Arch D. Lastly, Draw the line C D so that it may only touch the arks C and D so shall the line C D be parallel to the line A B, and at the distance required.

PROB VI.

To divide a right line given into any number of equall parts.

LEt A B be a right line given, and let it be required to divide the same into four equall parts.

First,

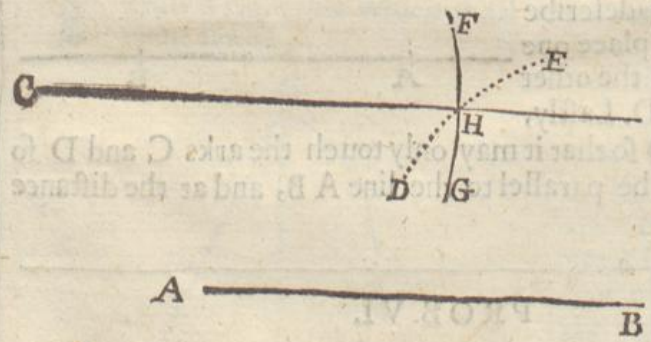


First, from the end of the given line A, draw the line A C, making any angle, then from the other end of the given line, which is at the point B, draw the line B D parallel to A C, (or make the angle A B D equall to the Angle C A B;) then upon the lines AC and B D set off any three equall parts which (is one lesse then the number of parts into which the line A B is to be divided) on each line, as 1 2 3, then draw lines from 1 to 3, from 2 to 2, and from 3 to 1, which lines, crossing the given line A B, shall divide it into four equall parts as was required.

PROB, VII.

A right line being given, how to draw another right line parallel thereunto, which shall also passe through a point assigned.

LEt A B be a line given, and let it be required to draw another line parallel thereunto which shall passe through the given point C.



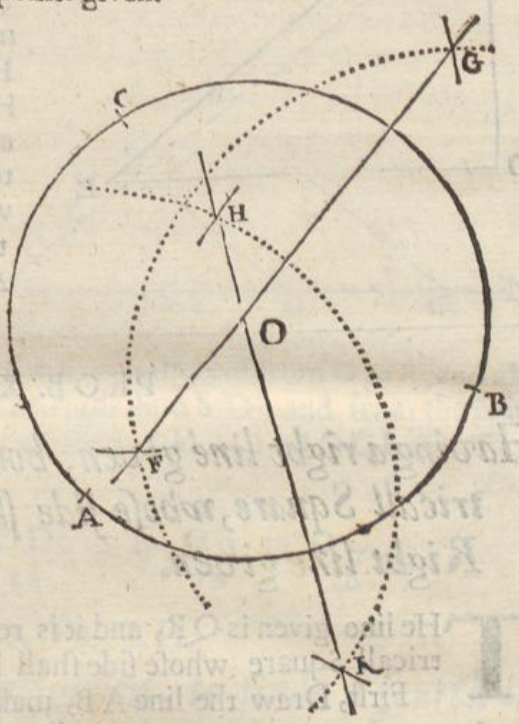
First, Take with your compasses the distance from A to C, and placeing one foote thereof in B, with the other describe the ark D E; then take in your compasses the whole line AB, and placing one foot in the point C, with the other describe the arke F G, crossing the former arke D E in the point H. Lastly, if you draw the Line C H it shall be parallel to A B.

PROB.

PROB. VIII.

Having any three points given, which are not situate in a right line, how to finde the center of an arch of a Circle which shall pass directly through the three given points.

THe three points given are A B and C, now it is required to finde the center of a Circle, whose circumference shall pass through the three points given.



First, open your Compasses to any distance greater then half the distance between B and C, then place one foot in the point B, and with the other describe the arch F G, then the compasses remaining at the same distance, place one foot in C, and with the other turned about make the marks F and G in the former arch, and draw the line F G at length if need be.

Again, opening the Compasses to any distance greater then half A B, place one foot in the point A, and with the other describe the arch H K, then, the Compasses remaining at the same distance, place one foot in the point B, and turning the other about make the marks H K in the former arch.

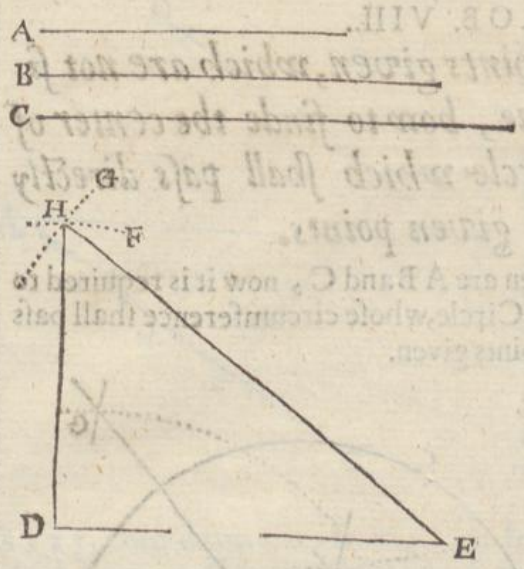
Lastly, draw the right line H K cutting the line F G in O, so shall O be the center upon which if you describe a circle at the distance of O A, it shall pass directly through the three given points A B C, which was required.

PROBLEME IX.

Any three right lines being given, so that the two shortest together be longer then the third, to make thereof a Triangle.

LEt it be required to make a Triangle of the three lines A B and C, the two shortest whereof, *viz.* A and B together, are longer then the third line C.

First,



First, Draw the line D E equall to the given line B, then take with your Compasses the line C, and setting one foot in E, with the other describe the arch H G, also, take the given line A in your Compasses, and placing one foot in D, with the other describe the arch H F, cutting the former arch H G in the point H. Lastly, if from the point H you draw the lines H E and H D, you shall constitute the Triangle H D E, whose sides shall be equall to the three given lines A B C.

PROB. X.

Having a right line given, how to make a Geometricall Square, whose side shall be equall to the Right line given.

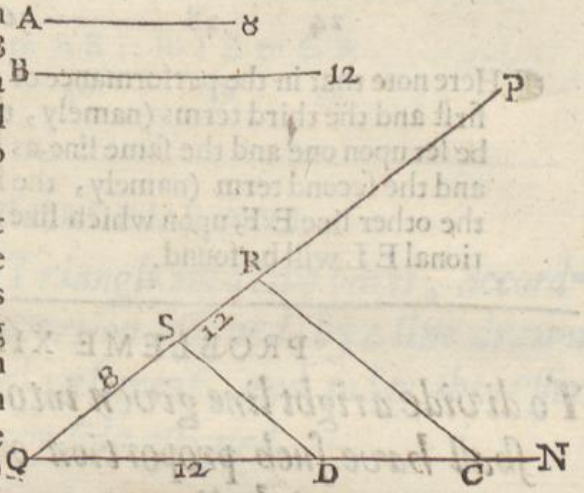
THe line given is Q R, and it is required to make a Geometricall Square whose side shall be equall to the line Q R. First, Draw the line A B, making it equall to the given line Q R, then *(by the first or second Probleme)* upon the point B raise the perpendicular B C, making the line B C equall to the given line Q R also. Then taking the line Q R in your Compasses, place one foot in C, and with the other describe the arch D, also the Compasses so resting, place one foot in A, and with the other describe another arch crossing the former in the point D. Lastly, draw the lines D C and D A, which shall include the Geometricall square A B C D.

PROB.

PROB XI.

Two right lines being given how to finde a third right line which ſhall be in proportion unto them.

LEet the two given lines be A and B required to find a third line which ſhall be in proportion unto them.



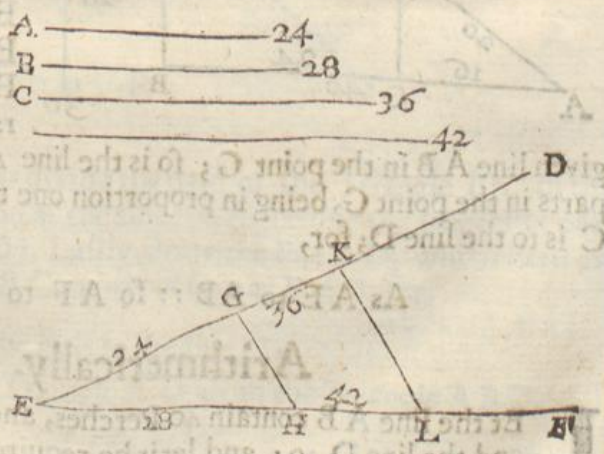
Firſt, Draw two right lines making any angle at pleaſure, as the lines O P and O N, making the angle P O N; then taking the line A in your Compaſſes, ſet the length thereof from O to S, alſo, take the line B in your Compaſſes, and ſet the length thereof from O to R, and alſo from O to D, then draw the right line S D, and from the point R draw the right line R C parallel to S D, ſo ſhall O C be the third proportional required.

As O S to O D :: ſo O R to O C.
8 12 12 18

PROB. XII.

Three right lines being given, to finde a fourth in proportion to them.

THE three lines given are A B C, unto which it is required to finde a fourth proportionall line. This is to perform the rule of three in lines.



As in the laſt Problem, you muſt draw two lines making any angle, as the angle D E F. Then take the line A in your Compaſſes, and ſet it from E to G, then take the line B in your Compaſſes and ſet

that length from E to H. Then take the third given line in your Compasses, and set that from E to K, and through that point K draw the line K L parallel to G H, so shall the line E L be the third proportional required; for,

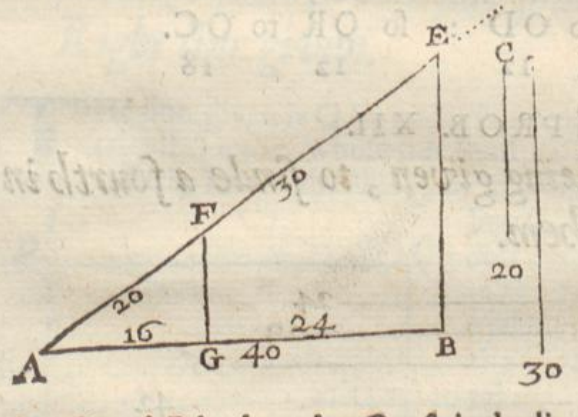
As E G to E H :: so E K to E L.
24 28 36 42.

¶ Here note that in the performance of this Probleme, that the first and the third terms (namely, the lines A and C) must be set upon one and the same line, as hereupon the line E D, and the second term (namely, the line B) must be set upon the other line E F, upon which line also the fourth proportional E L will be found.

PROBLEME XIII.

To divide a right line given into two parts, which shall have such proportion one to the other as two given right lines.

THe line given is A B, and it is required to divide the same into two parts, which shall have such such proportion one to the other, as the line C hath to the line D.



First, from the point A, draw the line A E, at pleasure, making the angle E A B; then take in your Compasses the line C, and set it from A to F, also take the line D, and set it from F to E, and draw the line EB, then from the point F, draw the line F G parallel to EB, cutting the given line A B in the point G; so is the line A B divided into two parts in the point G, being in proportion one to the other, as the line C is to the line D; for,

As A E to A B :: so A F to A G.

Arithmetically.

LEt the line A B contain 40 Perches, and let the line C be 20, and the line D 30; and let it be required to divide the line A B into two parts, being in proportion one to the other, as the line C is to the line D.

First,

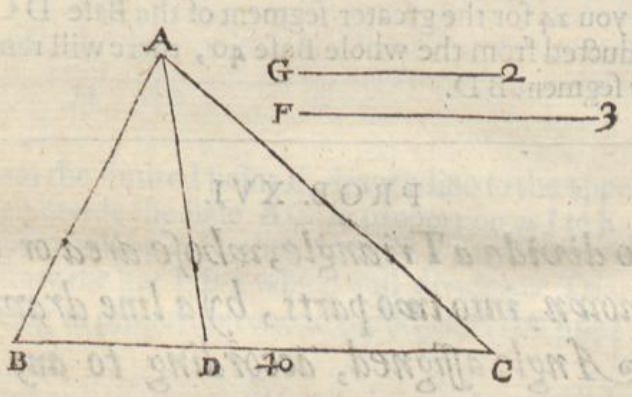
First, Add the lines C and D together, their sum is 50, then say by the Rule of Proportion: If 50 (which is the sum of two given terms) give 40 the whole line A B, what shall 30, the greater given term give? Multiply and divide, and you shall have in the quotient 24 for the greater part of the line A B, which being taken from 40 the whole line, there remains 16 for the other part A G; for,

As A E to A B :: so F E to G B.
50 40 30 24

PROBLEME XVI.

How to divide a Triangle into two parts, according to any proportion assigned, by a line drawn from any Angle thereof, and to lay the lesser part towards any side assigned.

LEt A B C be a Triangle given, and let it be required to divide the same, by a line drawn from the angle A, into two parts, the one bearing proportion to the other, as the line F doth to the line G, and that the lesser part may be towards the side A B.



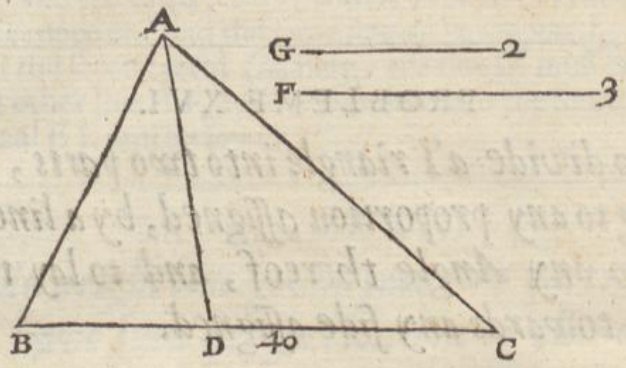
By the last *Probleme* divide the base of the Triangle B C in the point D, in proportion as the line F is to the line G, (the lesser part being set from B to D). Lastly, draw the line A D, which shall divide the Triangle A B C in proportion as F to G; for,

As the line F, is to the line G;
So is the Triangle A D C; to the Triangle A B D.

PROB. XV.

The Base of the Triangle being known, to perform the foregoing Probleme by Arithmetick.

SUppose the Base of the Triangle B C to be 40, and let the proportion into which the Triangle A B C is to be divided, be as 2 to 3.



First, Add the two proportional terms together, 2 and 3, which makes 5, then say by the Rule of Proportion: If 5 (the sum of the proportional terms,) give 40 (the whole base B C) what shall 3 (the greater term given)? Multiply and divide, and the quotient will give you 24 for the greater segment of the Base D C, which being deducted from the whole Base 40, there will remain 16 for the lesser segment B D.

PROB. XVI.

How to divide a Triangle, whose area or content is known, into two parts, by a line drawn from an Angle assigned, according to any proportion required.

LEt the Triangle ABC contain 8 Acres, and let it be required to divide the same into two parts, by a line drawn from the Angle A, the one to contain 5 Acres, and the other 3 Acres.

First, Measure the whole length of the Base, which suppose 40, then say, If 8 Acres (the quantity of the whole Triangle) give 40, (the whole Base,) what parts of the Base shall 5 Acres give? Multiply and divide the Quotient will be 25 for the greater Segment of the Base C D, which being deducted from 40 (the whole Base,) there will remain 15 for the lesser Segment of the Base B D, then

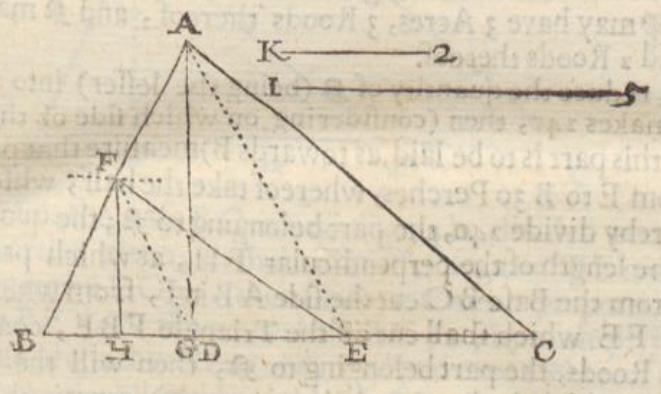
draw

draw the line A D, which ſhall divide the Triangle A B C according to the proportion required.

PROB. XVII.

How to divide a Triangle given into two parts, according to any proportion aſſigned, by a line drawn from a point limited in any of the ſides thereof: and to lay the greater or leſſer part towards an Angle aſſigned.

THe Triangle given is ABC and it is required from the point E, to draw a line that ſhall divide the Triangle into two parts, being in proportion one to the other as the line I is to the line K, and to lay the leſſer part towards B.



Firſt, From the limited point E, draw a line to the oppoſite Angle at A; then divide the Baſe B C in proportion as I to K, which point of diviſion will be at D, then draw D F parallel to AE. Laſtly, from F draw the line F E, which will divide the Triangle into two parts being in proportion one to the other, as the line I is to the line K.

PROB. XVIII.

To perform the foregoing Probleme Arithmetically.

IT is required to divide the Triangle ABC, from the point E, into two parts in proportion as 5 to 2.

Firſt, Divide the Baſe BC according to the given proportion, then (becauſe the leſſer part is to be laid towards B) meaſure the diſtance from E to B, which admit 30, then ſay by the Rule of Proportion; If E B 30, give D B 15 what ſhall AG 29 (the perpendicular

lar of the Triangle) give? Multiply and divide, the Quotient will be 14½, at which distance draw a parallel line to BC, namely F, then from F draw the line F.E, which shall divide the Triangle according to the required proportion,

PROB. XIX.

How to divide a Triangle, whose area or content is known, into two parts, by a line drawn from a point limited in any side thereof, according to any number of Acrees, Roods and Perches.

IN the foregoing Triangle ABC, whose area or content is five Acres, 1 Rood, let the limited point be E in the base thereof, and let it be required from the point E to draw a right line which shall divide the Triangle into two parts between ♍ and ♎, so that ♍ may have 3 Acres, 3 Roods thereof, and ♎ may have 1 Acre and 2 Roods thereof.

First, reduce the quantity of ♎ (being the lesser) into Perches, which makes 240, then (considering on which side of the limited point E this part is to be laid, as towards B) measure that part of the Base from E to B 30 Perches, whereof take the half, which is 15, and thereby divide 240, the part belonging to ♎; the quotient will be 16, the length of the perpendicular FH, at which parallel distance from the Base BC cut the side AB in F, from whence draw the line FE which shall cut off the Triangle FBE, containing 1 Acre, 2 Roods, the part belonging to ♎, then will the Trapezia AFEC (which is the part belonging to ♍) contain the residue, namely, 3 Acres, 3 Roods.

PROB. XX.

How to divide a Triangle according to any proportion given, by a line drawn parallel to one of the sides given.

THE following Triangle ABC is given, and it is required to divide the same into two parts by a line drawn parallel the side AC, which shall be in proportion one to the other, as the line I is to the line K.

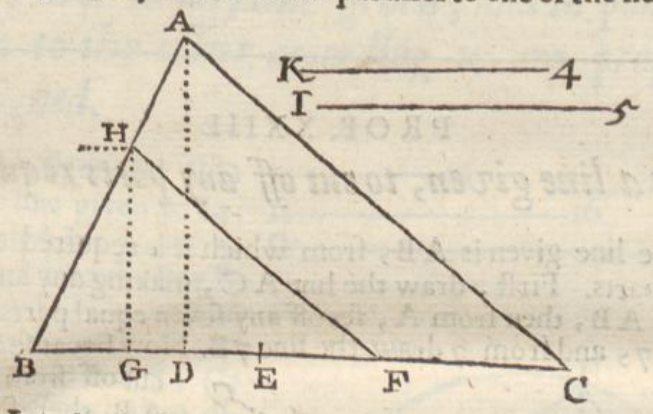
First *(by the 13 Probleme)* divide the line BC in E, in porportion as I to K, then *(by the 24 Probleme following)* finde a mean proportional between BE and BC, which let be BF from which point F, draw the line FH parallel to AC, which line shall divide the Triangle into two parts, *viz.* the Trapezia AHFC, and the Tri-

Triangle H F B, which are in proportion one to the other as the line I is to the line K,

PROB. XXI.

To perform the foregoing Probleme Arithmetically.

LEt the Triangle be A B C, and let it be required to divide the same into two parts, which shall be in proportion one to the other, as 4 to 5, by a line drawn parallel to one of the sides.



First, Let the base B C containing 54 be divided according to the proportion given, so shall the lesser segment B E contain 24, and the greater E C 30; then find out a mean proportionall line between B E 24, & the whole base B C 54, by multiplying 54 by 24, whose product will be 1296, the square root whereof is 36, the mean proportionall sought, which is B F, then, by the rule of proportion say: If B F 36, give B E 24, what A D 36? the answer is H C 24, at which distance draw a parallel line to the base, to cut the side A B in H, from whence draw the line H F parallel to A C, which shall divide the Triangle as was required,

PROB. XXII.

To divide a Triangle of any known quantity, into two parts, by a line drawn parallel to one of the sides, according to any number of Acres, Roods, and Perches.

THe Triangle given is A B C, whose quantity is 8 Acres, 0 Roods, 16 Perches, and it is required to divide the same (by a line drawn parallel to the side A C) into two parts, *viz.* 4 Acres, 2 Roods, 0 Perches, and 3 Acres, 2 Roods, 16 Perches.

First,

First, Reduce both quantities into perches (as is hereafter taught) and they will be 720, and 576, then reduce both those numbers, by abbreviation, into the least proportional terms, *viz.* 5 and 4, and according to that proportion, divide the base B C 54 of the given Triangle in E, then seek the mean proportional between B E and B C, which proportional is B F 36, of which 36 take the halfe, and thereby divide 576, the lesser quantity of Perches, the Quotient will be H G 32, at which parallel distance from the base, cut off the line A B in H, from whence draw the line H F parallel to the side A C, which shall divide the Triangle given according as was required.

PROB. XXIII.

From a line given, to cut off any parts required.

THe line given is A B, from which it is required to cut off $\frac{3}{7}$ parts. First, draw the line A C, making any angle, as C A B, then from A, set off any seven equal parts, as 1 2 3 4 5 6 7, and from 7 draw the line 7 B. Now because $\frac{3}{7}$ is to be cut off from the line A B, therefore from the point 3, draw the line 3 D parallel to 7 B cutting the line A B in D, so shall A D be $\frac{3}{7}$ of the line A B, and D B shall be $\frac{4}{7}$ of the same line; for,

As A 7, is to A B :: so is A 3, to A D.

PROB. XXIV.

To find a mean proportional between two lines given.

IN the following figure, let the two lines given be A aud B, between which it is required to find a mean proportional.

Let the two given lines A and B, be joyned together in the point E, making one right line, as C D which divide into two equal parts in the point G, upon which point G, with the distance G C or G D, describe the Semicircle C F D; then, from the point E, (where the two lines are joyned together) raise the perpendicular E F, cutting the Perifery of the Semicircle in F, so shall the line

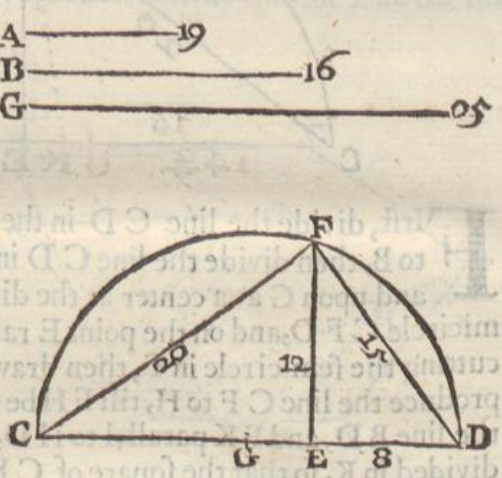
E F

EF be a mean proportional between the two given lines A and B; for,

As ED to EF :: so EF to CF.
9 12 12 16

PROB. XXV.

How to find two lines which together shal be eqnal in power to any line given, and in power the one to the other according to any proportion assigned.

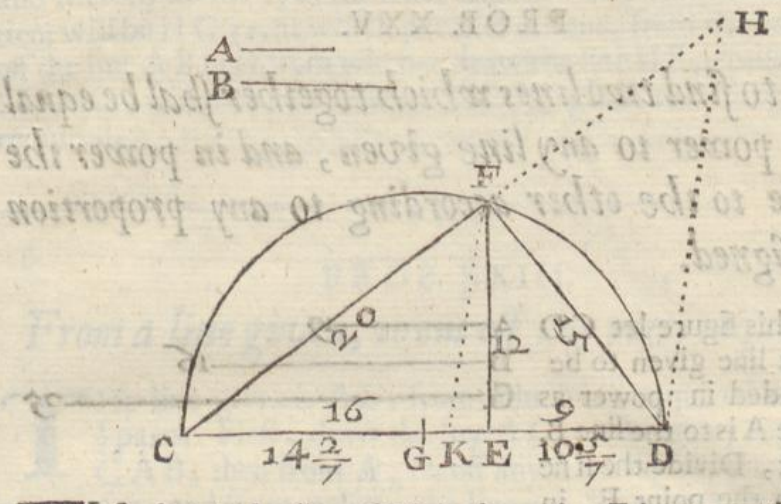


IN this figure let CD be a line given to be divided in power as the line A is to the line B.

First, Divide the line CD in the point E, in proportion as A to B, *(by the 13 Probleme)* then divide the line CD into two equal parts in the point G, and on G, at the distance G C or G D, describe the semicircle CF, D, and upon the point E, raise the perpendicular E F, cutting the Semicircle in F: Lastly draw the lines C F and D F, which together in power wall be equall to the power of the given line C D, and yet in power one to the other as A to B.

☞ PROB. XXVI.

How to divide a line a line in power according to any proportion given.



FIrſt, divide the line C D in the point E in proportion as A to B, then divide the line C D in two parts in the point G, and upon G as a center at the diſtance G D, deſcribe the ſemicircle C F D, and on the point E raiſe the perpendicular of E F cutting the ſemicircle in F, then draw the lines C F and D F, and produce the line C F to H, till F H be equal to F D, and draw the the line B D, and F K parallel to H D, then ſhall the line C D be divided in K, ſo that the ſquare of C K ſhall be to the ſquare of K D, as C E to E D, or as B to A.

PROB. XXVII.

How to enlarge a line in power, according to any proportion aſſigned.

IN the Diagram of the 25th. Probleme, let C E be a line given, to be enlarged in power as the line B to the line G.

Firſt, *(by the 13th. Probleme)* find a line in proportion to the given line C E, as B is to G, which will be C D, upon which line deſcribe the ſemicircle C F D, and on the point E, erect the perpendicular E F; then draw the line C F, which ſhall be in power to C E, as G to B.

PROB.

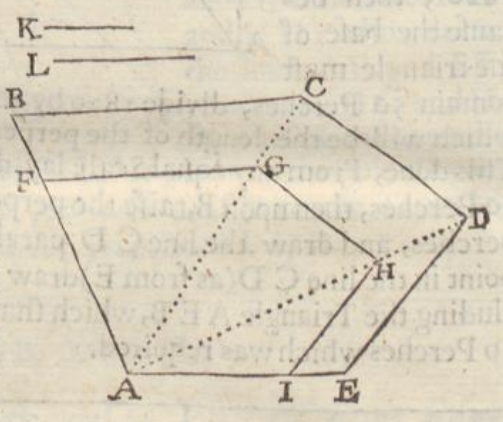
PROB. XXVIII.

To enlarge or diminish a Plot given, according to any proportion required.

LEt A B C D E be a Plot given, to be diminished in power a L to K.

Divide one of the sides (as A B) in power as L to K, in such sort, that the power of A F, may be to the power of A B, as L to K. Then from the angle A, draw lines to the points C and D, that done, by F draw a parallel to B C, to cut A C in G, as F G. Again, from G, draw a parallel to D C, to cut in A D in H. Lastly, from H, draw a parallel to D E, to cut A E in I, so shall the plot A F G H I be like A B C D E, and in proportion to it, as the line L, to the line K which was required.

Also, if the lesser Plot were given, and it were required to make a greater in proportion to it as K to L. Then from the point A, draw the lines A C and A D, at lenght, also increase A F and A I: that done, inlarge A F in power as K to L, which set from A to B, then by B draw a parallel to F G to cut A C in C, as B C. Likewise from C draw a parallel to G H, to cut A D in D, as C D. Lastly, a parallel from D to H I, as as D E, to cut A I being increased in E, so shall you include the Plot A B C D E; like A F G H I, and in proportion thereunto, as the line K is to the L, which was required.



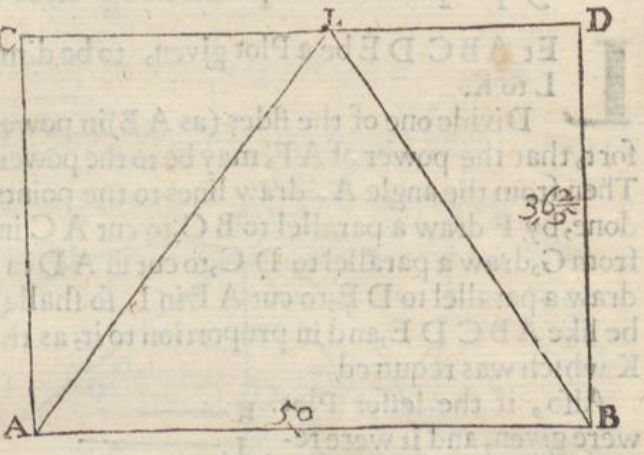
PROB. XXIX.

How to make a Triangle which shall contain any number of Acres, Roods and Perches and whose base shall be equal to any (possible) number given.

IF it be required to make a Triangle which shall contain 5 Acres, two Roods, 30 Perches, whose base shall contain 50 Perches, you must first reduce your 5 Acres, 2 Roods, 30 Perches, all into Perches in this manner.

First, (because 4 Roods make one Acre) multiply your 5 Acres by 4 which makes 20, to which add the two odd Roods, so have

you 22 Roods in your 5 Acres, 2 Roods. Then (becauſe 40 Perches make one Rood) multiply your 22 Roods by 40, which makes 880 Perches, to which add the 30 odd Perches, and you ſhall have 910, and ſo many Perches are contained in 5 Acres, 2 Roods, 30 Perches.

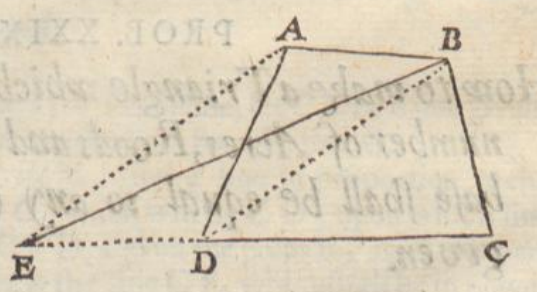


Now to make a Triangle which ſhall contain 910 perches, & whoſe baſe ſhall be 50 Perches, do thus, Double the number of perches given, namely 910, and they make 1820, then becauſe the baſe of the triangle muſt contain 50 Perches, divide 1820 by 50, the quotient will be $36\frac{2}{5}$, which will be the length of the perpendicular of your Triangle. This done, From any equal Scale lay down the line A B equall to 50 Perches, then upon B, raiſe the perpendicular B D equal to $36\frac{2}{5}$ perches, and draw the line C D parallel to A B: then, from any point in the line C D (as from E) draw the lines E A annd E B, including the Triangle A E B, which ſhall contain 5 Acres, 2 Roods, 30 Perches which was required.

PROB. XXX.

How to reduce a Trapezia into a Triangle, by a line drawn from any angle thereof.

THe Trapezia given is A B C D, and it is required to reduce the ſame into a Triangle.



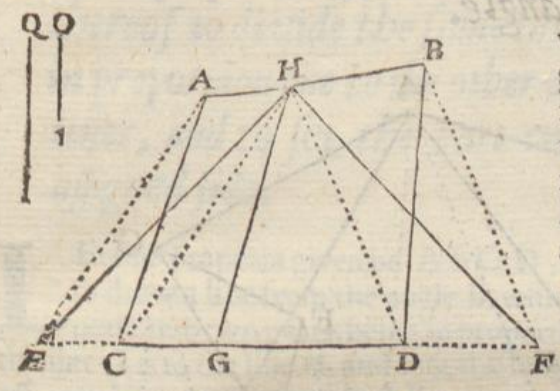
Firſt, Extend the line D C, and draw the Diagonall B D, thenfrom the point A, draw the line A E parallel to B D, extending it till it cut the ſide C D in the point E. Laſtly, from B, draw the line B E, conſtituting the Triangle E B C, which ſhall be equal to the Trapezia A B C D.

PROB.

PROB. XXXI.

How to reduce a Trapezia into a Triangle, by lines drawn from any point in any of the sides thereof

LEt A B C D be a Trapezia given, and let H be a point in one of the sides thereof from which point H let it be required to draw lines which shall reduce the Trapezia into a Triangle.



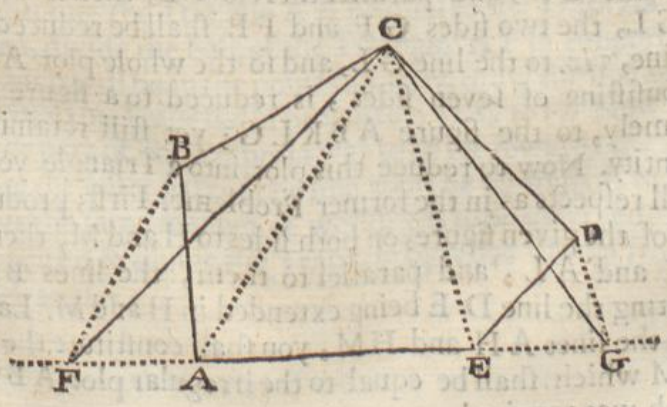
First, Extend the side which is opposite to the given point, namely, the side C D, both wayes to E and F, and then from the point H, draw lines to the Angles C and D, as the lines H G and H D; also, draw the lines A E and B F parallel to H C and H D, cutting the extended line C D in the points E and F. Lastly, If from the point H you draw the lines H E and H F you shall constitute the Triangle H E F, which shall be equal to the Trapezia A B C D.

PROB. XXXII.

How to reduce an irregular Plot of five sides into a Triangle.

THe irregular Plot given is A B C D E, and it is required to reduce the same into a Triangle.

First, extend the side A E both wayes to F and G, and from the Angle C, draw the lines C A and C E, to the Angles A and E. Then from the point B, draw the line B F parallel to C A

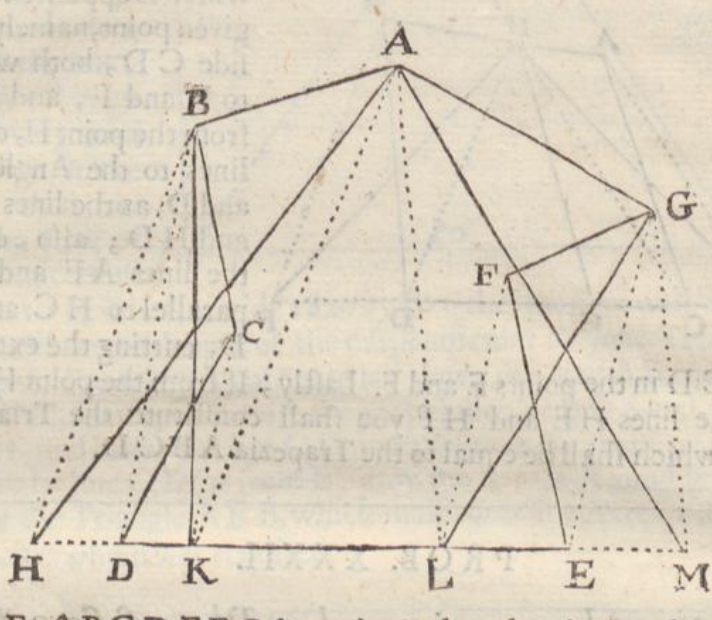


cutting

cutting the extended side A E, in F; also from the point D, draw the line D G parallel to C E, cutting also the extended side in G. Lastly, from the angle C, draw the lines C F and C G, constituting the Triangle C F G, which is equal to the Plot A B C D E.

☞ PROB. XXXIII.

How to reduce an irregular Plot of 6, 7, or 8 sides into a Triangle.



LEt A B C D E F G be an irregular plot given, to be reduced into a Triangle.

I have chosen this figure where the angles C and D are without the field, because it often comes in practice, and hath not been taught by any to my knowledge.

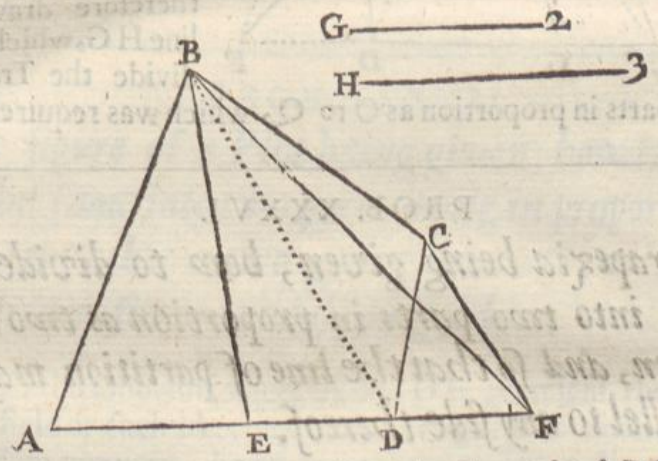
First, draw the lines B D, and parallel thereto the lines C K, then if you draw the line B K, the two sides B C and C D shall be reduced to one right line, *viz.* to the line B K. Also draw the line G E, and parallel thereto F L, then if you draw the line G L, the two sides G F and F E shall be reduced to one straight line, *viz.* to the line G L, and so the whole plot A B C D E F G consisting of seven sides, is reduced to a figure of five sides, namely, to the figure A B K L G; yet still retaining the same quantity. Now to reduce this plot into a Triangle you must work in all respects as in the former Probleme. First, produce the side D E of the given figure, on both sides to H and M, then draw lines A K and A L, and parallel to them, the lines B H and G M, cutting the line D E being extended in H and M. Lastly, if you draw the lines A H and H M, you shall constitute the Triangle A H M which shall be equal to the irregular plot A B C D E F G which was required.

¶ And here note that the number of sides be never so many, yet this way of reduction will bring them to Triangles, and the more outward angles there are in the Plot, the more troublesome will it be to effect.

PROB. XXXIV.

A Trapezia being given, how from any angle thereof to divide the same into two parts being in proportion one to the other as two given right lines, and to set the part cut off towards an assigned side.

LEt the Trapezia given be A B C D, and let it be required to draw a line from the angle B, which shall divide the Trapezia into two parts, being in proportion one to the other, as the line G is to the line H, and that the lesser part of the figure cut off, may be towards the side A B.



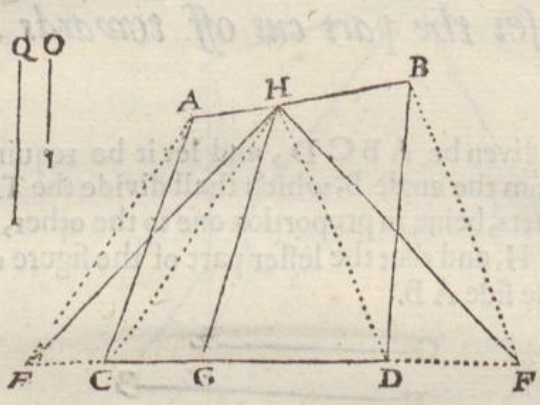
First, *(by the 29 Probleme)* reduce the Trapezia A B C D into a Triangle, by drawing the line B F from the assigned angle, thereby constituting the Triangle A B F, equal to the Trapezia ABCD: this done, divide the base of the Triangle A F in proportion as G to H, which will be in the point E. Lastly, draw the line BE, which shall divide the Trapezia in proportion as G to H. Now because the lesser part of the Trapezia was to be set towards the side A B, therefore the lesser part of the line must be set from A to E. Here note that the same manner of working is to be observed, if it had been required to divide the Trapezia by a line drawn from any of the other angles.

PROB.

PROB. XXXV.

A Trapezia being given, how, from a point limited in any side thereof, to draw a line which shall divide the same into two parts in proportion as two given lines.

THe Trapezia given is A B C D, and it is required from the point H, to draw a line which shall divide the Trapezia in proportion as O to Q.



First, Prolong the side C D, and reduce the whole Trapezia into the Triangle H E F by the 30 *Probleme*, then divide the line E F in proportion as O to Q, which wil fall in the point G, therefore draw the line H G, which shall divide the Trapezia into two parts in proportion as O to Q, which was required.

PROB. XXXVI.

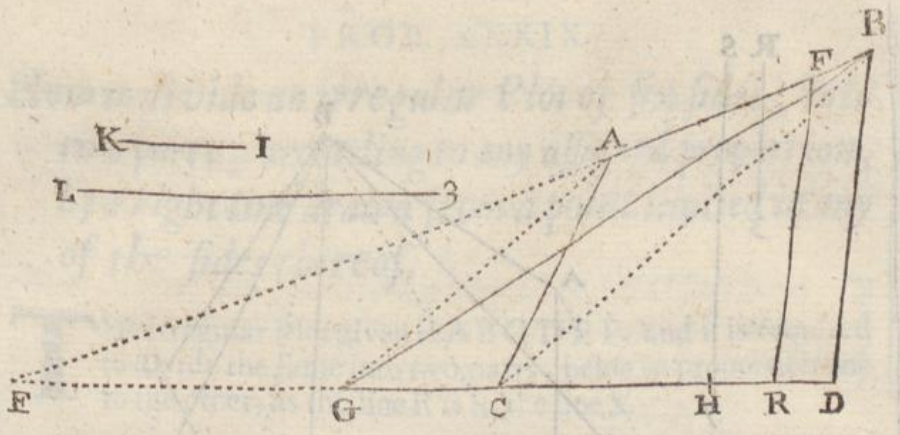
A Trapezia being given, how to divide the same into two parts in proportion as two lines given, and so that the line of partition may be parallel to any side thereof.

THe Trapezia given is A B C D, and it is required to divde the same into two parts, which shall be in proportion one to the other as the line K is to the line L, and that the line of partition may be parallel to the side B D.

Consider first, through which sides of the Trapezia the line of partition will pass, as in this figure it will pass through the sides A B and C D (because parallel to B D,) therefore, extend the sides A B and C D, till they concur in E; then *(by the 32 Probleme)* reduce the Trapezia A B C D into the Triangle B G D, whose base is G D, which line G D, divide the point H in proportion as K to L; so that,

As K to L :: So DH to HG.

This



This done, finde a mean proportional between E D and E H *(by the 24 Probleme)* as E R. Laſtly, through this point R, draw the line R F parallel to B D, which ſhall divide the Trapezia into two parts being in proportion one to the other, as the line K is to the line L, and with a line parallel to the ſide BD, which was required.

But if it had been required to divide the Trapezia by a line drawn parallel to the ſide CD, then the lines C A and DB muſt have been extended, but the reſt of the work muſt be performed as is before taught.

PROB. XXXVII.

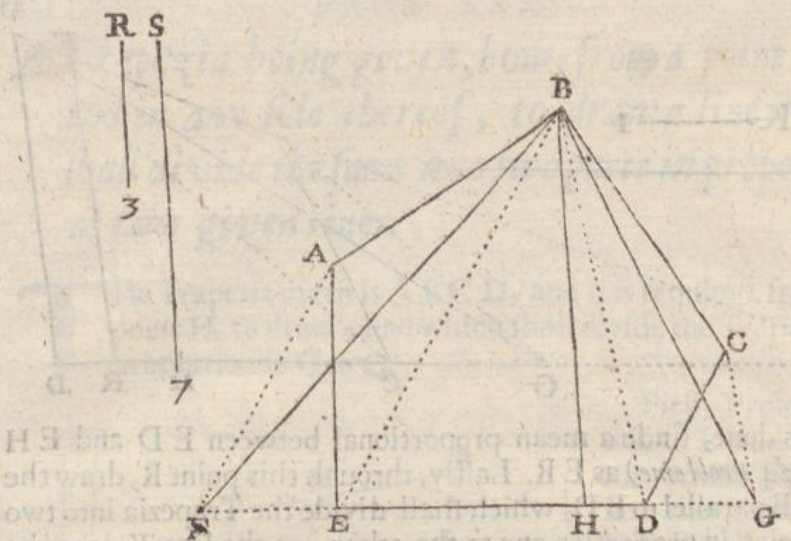
The figure of a Plot being given, how to divide the ſame into two parts being in proportion one to the other as two given lines are, with a line drrwn from an angle aſſigned.

LEt the following figure A B C D E repreſent the Plot of a field or ſuch like, and let it be required to divide the ſame into two parts, being in proportion one to the other as the line R is to the line S, by a line drawn from the Angle B.

Firſt, Reduce the Plot A B C D E into the Triangle B F G, *(by the 31 Probleme)* ſo ſhall the line F G be the baſe of a Triangle equal to the given Plot, then *(by the 13th Probleme)* divide this line F G into two parts in the point H, in proportion one to the other, as the line R is to the line S; ſo that,

As R to S :: ſo G H to HF.

Laſtly, draw the line B H, which ſhall divide your given Plot into two parts which ſhall have ſuch proportion one to the other, as the line R hath to the line S.

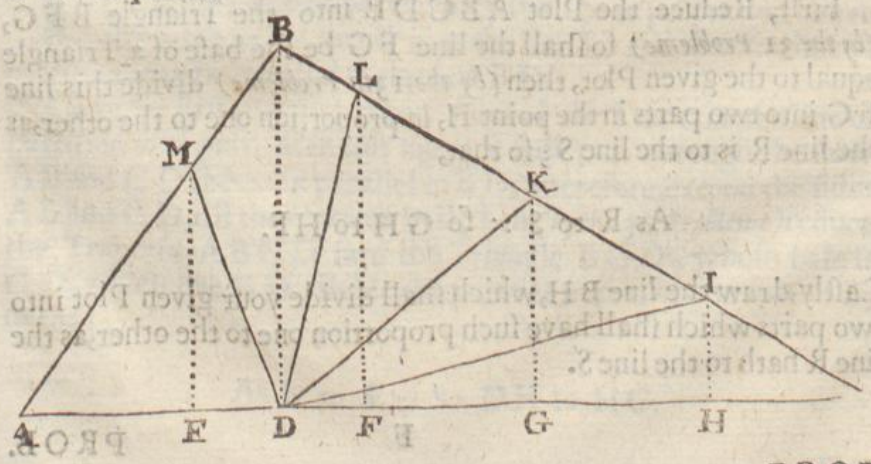


PROB. XXXVIII.

How to divide a Triangle into any number of equal parts, by lines drawn from a point given in any side thereof.

LEt it be required to divide the Triangle, A B C into five equal parts, by lines drawn from the point D.

First, From the given point D, to the opposite angle B, draw the line D B, then divide the side A C of the Triangle into five equal parts, at E F G and H, and through each of those points draw lines parallel to DB, as E M, F L, G K, and H I: then from the point D, draw the lines D I, D K, D L, and D M, which shall divide the Triangle A B C into five equal parts from the point D, as was required.

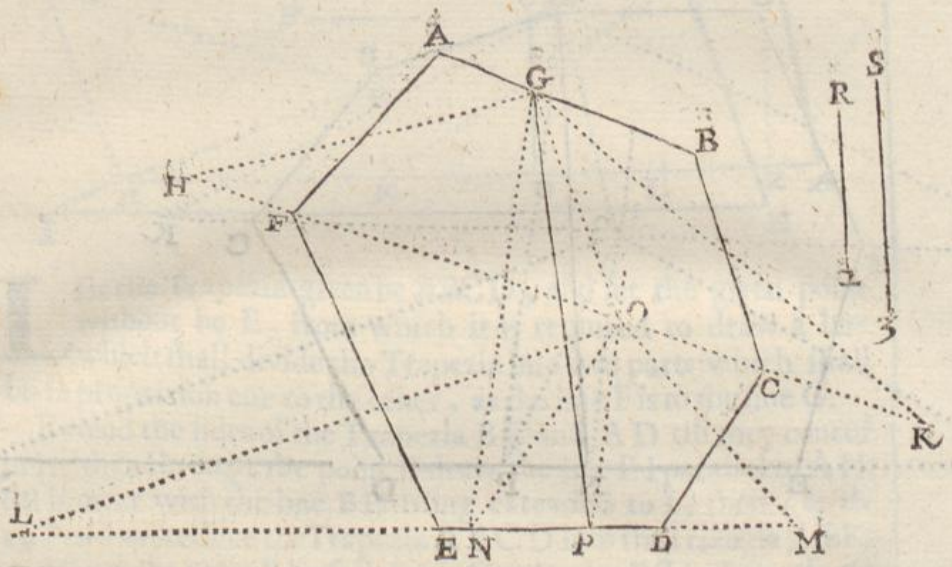


PROB.

PROB. XXXIX.

How to divide an irregular Plot of six sides, into two parts, according to any assigned proportion, by a right line drawn from a point limited in any of the sides thereof.

THe irregular Plot given is A B C D E F, and it is required to divide the same into two parts, being in proportion one to the other, as the line R is to the line S.



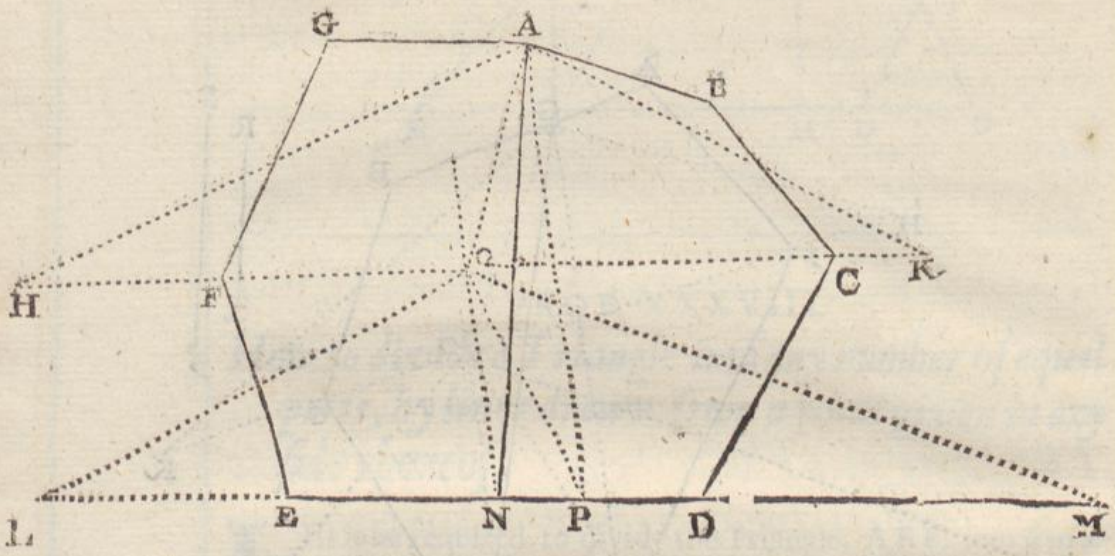
First, Draw the right line H K, and *(by the 30th. Probleme)* reduce the Trapezia A B F G into the Triangle H G K, then divide the base thereof, namely, H K, into two parts in proportion as R to S, which will be in the point O, then draw the line G O, which will divide the Trapezia A B F C into two parts in proportion one to the other, as the line R is to the line S.

Secondly, From the point O *(by the 31 Probleme)* reduce the Trapezia F C E D into the Triangle O L M, and divide the base thereof, namely, L M, in the point N, in proportion as R to S, and draw the line O N, which will divide the Trapezia F C E D into two parts in proportion as R to S: and by this means is the whole Plot A B C D E F divided into two parts in proportion as R to S, by the lines G O and O N. But it is required to resolve the Probleme by one right line only drawn from the point G, therefore, from the point G, draw the line C N, and through the point O, draw the line O P parallel to G N: and lastly, from G, draw the right line G P, which shall divide the whole Plot A B C D E F into two parts, being in proportion one to the other as the line T is to the line S.

PROB. XL.

How to divide an irregular Plot according to any proportion, by a line drawn from any Angle thereof.

LEt A B C D E F G be an irregular Plot, and let it be required to divide the same into two equal parts, by a line drawn from the angle A.



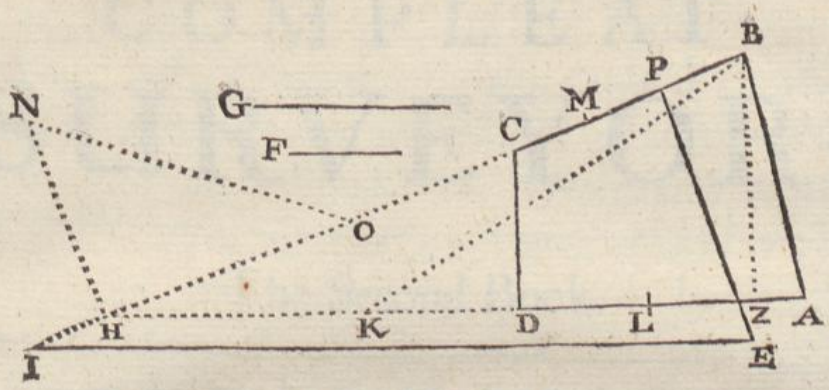
First, draw the line H K dividing the Plot into two parts, namely, into the five sided figure A B C F G, and into the Trapezia, F C E D, then *(by the 31 Probleme)* reduce the five sided figure A B C F G into the Triangle H A K, the base whereof H K divide into two equal parts in O, and draw the line O A, which shall divide the five sided figure A B C F G into two equal parts. Then *(by the 30th. Probleme)* reduce the Trapezia F C D E into the Triangle O L M, and divide the base thereof L M into two equal parts in the point P, and draw the line O P, which will divide the Trapezia F C D E into two equal parts by the lines A O and O P, but to perform the Probleme by one right line only, do thus, from the point A, draw the line A P, and parallel thereunto, through the point O, draw the line O N. Lastly, if you draw a right line from A to N, it shall divide the whole Plot into two equal parts.

¶ Here note that whatsoever hath been said concerning the dividing of figures in proportion to right lines, the same may be effected in numbers, so that from any Plot you may cut off any number of Acres, Roods, or Perches.

PROB.

☞ PROB. XLI.

How to divide a Trapezia into two parts, by a line drawn from a point without, which parts shall be in proportion one to the other, as two given lines.



LEt the Trapezia given be ABCD, and let the given point without be E, from which it is required to draw a line which shall divide the Trapezia into two parts which shall be in proportion one to the other, as the line F is to the line G.

Extend the sides of the Trapezia B C and A D till they concur in H, then through the point E draw the line E I parallel to A H, till it meet with the line B H being extended to I, then *(by the 29 Probleme)* reduce the Trapezia A B C D into the Triangle A BK, and from the point B let fall the perpendicular B Z, then *(by the 13th. Probleme)* divide the base of the Triangle A K into two parts in proportion as F to G, which point of Division will fall in L. This done *(by the 12th. Probleme)* find a fourth line which shall be in proportion to the three lines *i.e.* H L, and H B, that is, as I E : to H L :: so H B : to H M, so is H M the fourth proportional : then *(by the 24th. Probleme)* find a mean proportional between the lines I H, H M, which is H N, then set H N perpendicular upon B H, and divide HM into two equal parts in O, then draw the line ON, which you shall set from O to P. Lastly, if you draw the line E P, it shall divide the Trapezia A B C D in two parts, which shall be in proportion one to the other, as the line F is to the line G.

The end of the first Book.

B
P
M
C
O
N
E
O
A
K
D
F
H
I

THE COMPLEAT SURVEYOR:

The Second Book.

THE ARGUMENT.

IN this *Book* is conteined both a general and particular deſcription of all the moſt neceſſary *Inſtruments* belonging to *Surveying*, as the *Theodolite*, *Circumferentor*, and *Plain Table*, with all the appurtenances thereunto belonging, as the *Staff*, *Sockets*, *Screws*, *Index*, *Label*, and other neceſſaries. Now, whereas theſe three *Inſtruments* are the moſt convenient for all manner of practices in *Surveying*, I have ſo ordered the matter, that in this *Book*, after the *Theodolite*, and *Circumferentor* are particularly deſcribed, as they have uſually been made; I come to the deſcription of the *Plain Table*, and therein have

have ſhewed how that *Inſtrument* may be ordered to perform the work of any of the other; ſo that whatſoever may be done by the *Theodolite, Circumferentor*, or any other *Inſtrument* the ſame may be effected by the *Plain Table* onely, as it is there contrived, with the ſame eaſe, diſpatch, and exactneſs, and in many reſpects better, as in *Chapter* I. doth plainly appear: ſo that this *Inſtrument* onely is ſufficient for all manner of practices whatſoever. And beſides the fore-mentioned *Inſtruments* for *Menſuration* there is deſcribed divers other *Inſtruments* belonging therennto, as *Chains, Scales, Protractors*, and the like; all which are deſcribed according to the beſt contrivance yet known. Vnto theſe *Inſtruments* I have (in this ſecond Edition) added the deſcription and uſe of another *Inſtrument* very portable; the which will perform with exactneſs all the uſes that can be effected, either by *Circumferentor, Semicircle, Theodolite*, or *Peractor*.

A

A DESCRIPTION OF *INSTRUMENTS.*

CHAP. I.

Of INSTRUMENTS *in general.*

THe particular description of the several Instruments that have from time to time been invented for the practice of Surveying, would make a Treatise of it self, and in this place is not so necessary to be insisted on, every of the Inventors, in their construction. To omit therefore the description of the *Topographical Instrument* of Mr. *Leonard Diggs*, the *Familiar Staff* of Mr. *John Blagrave*, the *Geodetical Staff* and *Topographical Glass* of Mr. *Arthur Hopton*, with divers other Instruments invented & published by *Gemma Frisius*, *Orontius*, *Clavius*, *Stoflerus*, and others; I shall immediately begin with the description of those which are the ground and foundation of all the rest, and are now the only Instruments in most esteem amongst Surveyors, and those are chiefly these three, the *Theodolite*, the *Circumferentor*, and the *Plain Table*. Now, as I would not confine any man to the use of one particular *Instrument* for all employments, so I would advise any man not to cumber himself with multiplicity, since these three last named are sufficient for all occasions. And if I should confine any man to the use of any of these Instruments (as, for a shift, any one of them will perform any kind of work in Surveying) yet in that I should do him injury, for in many cases one Instrument may make a quicker dispatch, and be altogether as exact as another: As in laying down of a spacious businesse, I would

advise him to use the *Circumferenter* or *Theodolite*, and for Townships and small Inclosures the *Plain Table*, so altering his Instrument according as the nature or quality of the ground he is to measure doth require.

These three special Instruments have been largely described already by divers, as namely, by Mr. *Diggs*, Mr. *Hopton*, Mr. *Rathborn*, and last of all in *Planometria*; yet in this place it will be very necessary to give a particular description of them again, because if any man have a desire to any particular Instrument, he may give the better directions for the making thereof.

For the description which I shall make of these three Instruments in particular, it shall be agreeable to those Instruments as they are usually made; with some small addition or alteration: But when I come to the description of the *Plain Table*, after that I have described it according to the vulgar way, I will then shew you a new *metamorphosis* of that Instrument, making it the most absolute and universal Instrument yet ever invented, so that having that one Instrument (made according to the following directions) you shall have need of no other for the due, exact, and speedy performance of any thing belonging to the Art of Surveying, For, the frame of the Table being graduated according to that description, will be an absolute *Theodolite*, and perform the work thereof with the same facility and exactness, and whatsoever may be done by the limbe of the *Theodolite*, the same the degrees on the frame of the Table will as well perform.

The Plain Table used as the Theodolite.

Likewise, the Index and Sights, together with the Box and Needle, being taken from the Table, and screwed to the Staffe (as in the description thereof it is so conveniently ordered) will be an absolute *Circumferentor*, and in some respects better then the ordinary one hereafter described, because the Sights thereof stand at a greater distance, so that thereby the visual line may be the better directed.

The Plain Table used as a Circumferentor.

And this Instrument (as now contrived) though it be called the *Plain Table* only, yet you see that it contains both the other, and therefore in advising any man to the use thereof chiefly, I do not confine him to one, but to all Instruments, and therefore do not contradict my former expression.

The Plain Table, not one, but all Instruments.

Besides, there is another great convenience which doth ensue by the degrees on the Tables frame; for in taking the plot of a field according to the following directions by the Plain Table, you may at the same time perform the same work by the degrees on the frame of the Table, if at the drawing of every line you observe the degrees cut by the Index, and note them upon the paper. This I say is a great convenience, for at one observation you perform two works with the same labour, as in the uses of these Instruments severally a Surveyor by this contrivance, which with practise will appear of themselves.

CHAP.

CHAP. II.

Of the Theodolite, *the description thereof, and the detection of an errour frequently committed in the making thereof, with the manner how to correct the same.*

THe *Theodolite* is an Instrument consisting of four parts principally. The first whereof is a Circle divided into 360 equal parts, called degrees, and each degree sub-divided into as many other equal parts as the largeness of the Instrument will best permit: For the diameter of this Circle, it may be of any length, but those usually made in brass are about twelve or fourteen Inches, and the limbe thereof divided as aforesaid into 360 degrees, and sub-divided into other parts by diagonal lines drawn from the outmost and inmost concentrique Circles of the limbe; in the drawing of which concentrique Circles, they use to draw them equidistant, which is erroneous, as shall appear hereafter.

The second part of this Instrument is the Geometrical Square; which is described within the Circle, and the sides thereof divided into certain equal parts, but there are few of them made now with this Square, for the degrees themselves will better supply that want, it being only for taking of heights and distances. Yet if any man be desirous to have this Square upon his Instrument: there is a more convenient way to set it on then that which Master *Diggs* sheweth, namely, upon the limbe of the Instrument; the manner how is very well known to the Instrument maker.

The third part of this Instrument is the Box and Needle, so conveniently contrived to stand upon the Center of the Circle, upon which Center also the Index of the Instrument must turn about; and sometimes over the Box and Needle there is a Quadrant erected for the taking of heights and distances.

The fourth part of this Instrument, to set it upon a staff when you make use thereof. In the making of this Instrument, it were necessary to have two back-sights fixed at each end of one of the Diameters, for the readier laying out of any angle without moving of the Instrument.

CHAP. III.

The description of the Circumferentor.

THis Instrument hath been much esteemed by many, for portability thereof, it being usually made to contain in length about eight inches, in breadth 4 inches, and in thickness about three quarters of an inch; one side whereof is divided into divers equal parts, most fitly of ten or twelve in an inch; so that it may be used as the Scale of a *Protractor*, the Instrument it self being fitting to protract the plot on paper by help of the Needle, and the degrees of angles, and length of lines taken in the field. On the upper side of this Instrument is turned a round hole, three inches, and a half Diameter, and about half an inch deep, in which is placed a Card divided commonly into 120 equal parts or degrees, and each of those into three, which makes 360 answerable to the degrees of the *Theodolite*, in which Card is also a Dial drawn to find the hour of the day, and Azimuth of the Sun; within the Box, is hanged a Needle touched with a Load-stone, and covered over with a cleer glass to preserve it from the weather.

On the upper part of this Instrument is also described a Table of natural Sines, collected answerable to the Card in the box, that is to say, if the Card be divided but into 120 parts, the Sines must be so also; but if into 360, the Sines must be the absolute degrees of the Quadrant.

To this Instrument also belongeth two Sights, one double in length to the other, the longest containing about seven inches, being placed and divided in all respects, as those hereafter mentioned in the description of the Plain Table. On the edge of the shorter sight toward the upper part thereof, is placed a small wyer representing the Center of a supposed Circle, the Semidiameter whereof is the distance from the Wyer to the edge of the Instrument underneath the same, which parts is imaginarily divided into sixty equal parts, and according to those divisions is the right line of divisions on the edge of the Instrument divided, and numbred by 5, 10, 15, from the perpendicular point to the end thereof: And also from the same point on the upper edge of the Instrument is perfected the degrees of the Quadrant, supplying the residue of those which could not be expressed on the long sight, from 28 to 90 by tens.

There is also belonging to these divisions a little Ruler, at one end whereof is a little hole to put it upon the wyer, on the edge of the shorter sight; and at the other end of this Ruler is placed a smal sight, directly over the fiducial edge thereof; which edge is likewise divided according to those divisions on the edge of the Instrument. To this short sight is added a plummet to set the Instrument horizontal. And this short Ruler, with the divisions thereof, and those on the edge of the Instrument serve for taking of altitudes chiefly, and for the reducing of Hypothennsal to Horizontal lines.

CAAP.

CHAP. IV.

A Description of the Plain Table, *how it hath been formerly made, and how it is now altered, it being the most absolute Instrument of any other for a Surveyor to use, in that it performeth whatsoever may be done either by the* Theodolite, Circumferentor, *or any other Instrument, with the same ease and exactness.*

THe Table it self is a Parallelogram, containing in length about fourteen inches and a half,& in breadth eleven inches: it is composed of three several boards, which may be taken asunder,for ease and convenience in carriage. For the binding of these three boards fast when the Table is set together, there belongeth a joynted frame, so contrived,that it may be taken off,and put on the Table at pleasure: this frame also is to fasten a sheet of paper upon the Table, when you are to describe the plot of any field,or other inclosure by the Table. This frame must have upon it, neer the inward ledge, Scales of equal parts on both sides, for the speedy drawing of parallel lines upon the paper; and also for the shifting of your paper, when one sheet will not hold your whole work.

Unto this Table belongeth a Ruler or Index,containing in length about sixteen Inches or more, it being full as long as from angle to angle of your Table; it ought to be about two inches in bredth,and one third part of an Inch in thickness.Upon this Ruler or Index two sights must be placed;one whereof is double in length to the other, the longer containing in length about twelve inches, the other six: on the top of this shorter sight is placed a brass pin,and also a thrid and plummet to place your Instrument horizontal. Through the longer sight must be made a slit, almost the whole length thereof, These two sights thus prepared, are to be perpendicularly erected upon the Index;in such sort,that the wyer on the top of the shorter sight, and the slit on the longer sight stand precisely over the fiducial edge of the Index.The space or distance of these two sights one from the other, is to be equal to the divided part of the longer sight. Upon the longer sight is to be placed a Vane of brass, to be moved up and down at pleasure, through which a small hole is to be made, answerable to the slit in the same sight, and the edge of the Vane.

By these sights thus placed on the Index there is projected the Geometrical Square, whose side is the divided part of the long sight (or the distance between the two sights.) In the middle of the

the long ſight (through the whole bredth thereof there is drawn a line called the line of Level, dividing the ſide of the projected Square into two equal parts: alſo the ſame ſide is on this ſight divided into a hundred equal parts, which are numbered upwards and downwards, from the line of Level, by fives and tens to fifty, on either ſide, which diviſions are called the Scale.

There is alſo on the ſame ſight another ſort of diviſion, repreſenting the hypothenuſal Lines of the ſame Square, as they increaſe by Unites, and are likewiſe numbered upwards and downwards from the line of Level, from one to twelve, by 1, 2, 3, &c. ſometimes ſignifying 101, 102, 103, &c. theſe diviſions ſhew how much any hypothenuſal or ſlope line drawn over the ſame Square. exceedeth the direct horizontal line, being the ſide of the ſame Square

On this ſight there is a third ſort of diviſions, repreſenting the degrees of a Quadrant (or as many as the ſame ſight is capable to receive, which are about 25) numbered from the line of Level upward and downward by fives and tens to 25, which diviſions are called the Quadrant.

Unto this Inſtrument, as unto all others belong theſe neceſſary parts as the Socket, the Staffe, the Box, and Needle, &c.

¶ According to this deſcription, have Plain Tables formerly been made, but if unto it be added theſe additional parts & alterations (which make it leſſe cumberſome then before) it will be the moſt exact, abſolute and univerſal Inſtrument for a Surveyour that was ever yet invented.

Firſt, Let the frame be ſo fitted to the Table, that it may go on eaſily, either ſide being upwards; ſo that as one ſide is divided into equal parts (as in the deſcription the other ſide may have projected upon it the 180 degrees of a Semicircle, from a Center noted in the ſuperficies of the Table, which degrees muſt be numbered from the left hand towards the right (when the Center is next to you) by fives and tens to 180, and then beginning again, ſet 190, and ſo ſucceſſively to 360. Theſe degrees thus inſerted are of excellent uſe in wet or ſtormy weather, when you cannot keep a ſheet of paper upon your Table, either in reſpect of rain or winde. Alſo theſe degrees will make the Plain Table to be an abſolute: Theodolite ſo that you may work with theſe degrees as if they were the degrees of a Theodolite.

Secondly, Upon the Index or Rulet before ſpoken of, (inſtead of the ſights before deſcribed) let there be placed two ſights, both of one length, and back-ſighted; one having a ſlit below, and a thrid above; and the other, a ſlit above, and a thrid below, ſerving to look backward and forward at pleaſure without turning about the Inſtrument, when the Needle is at quiet. The expedition that theſe back-ſights will make, will beſt appeare by practice; for uſing theſe you ſhall need (in going about a field) to plant your Inſtrument but at every ſecond angle. Thirdly,

Thirdly, for the ready taking of heights, and the reducing of Hypothenusal to Horizontal lines (instead of the divisions on the sights before mentioned) let there be projected a Tangent line along the side of the Ruler, whose divisions must touch the very edg thereof, so that a Label or Ruler of Box or Brasse, which is hanged on a pin sticking in the side of one of the back-sights, and having another small sight at the end thereof, may move justly a long the side of the Index; then (the Instrument standing horizontal) if you look through this smal sight, and by the Pin on which the Label hangeth, moving the Label too and fro, till you espie the mark you look at, then will the Label shew you what Degree of the Tangent line is cut thereby. This on line thus projected upon the side of the Ruler performeth all the uses of those divided sights, and is far better, and lesse cumbersome then them or a Quadrant (such as I formerly described in *Planometria* because the degrees are larger. This line of Tangents is projected on the Index from the foot of the fathermost sight, all along the Ruler to the foot of the nethermost sight, and up the side thereof and is numbred from 1 to 90, by 10, 20, 30, 40, 50, &c. ending at the foot of the furthermost sight; from whence the line proceeded.

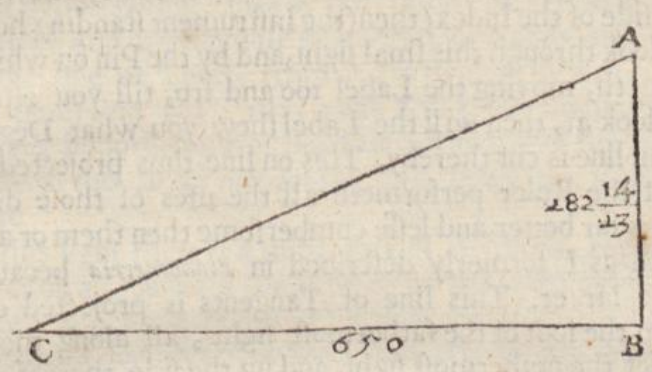
The use of this line of Tangents in taking of Heights is shewed in the fourth Book, and is used with the Tables of Sines and Logarithms treated of in the third Book, without which Tables, (of something equivalent thereunto) this line of Tangents will be of little use, therefore it will be convenient to have upon the Index of your Table the lines of Artificial Numbers, Sines, and Tangents, by which you may work any proportion required very speedily and exactly, so that if you be destitute of your Tables, these Lines will sufficiently help you.

There is yet another way by which you may take any altitude, or reduce Hypothenusal to Horizontal lines, only by Vulger Arithmetick, without the help of Tables, by having a line of equal parts divided on the edge of the Index, and another line of the same equal parts on the Label, by which lines, and Vulgar Arithmetick, an Altitude may very well be taken.

Now because I intend only to shew in general the use of these equal parts, I will therefore do it in this place, because I shall have occasion to speake no more thereof hereafter: The use thereof briefely) is thus.

Suppose that the line A B were some Hill or Tower, whose Altitude you require; standing at C, and looking through the sights in your Label till you espie the top of the Tower at A, there find the Label to cut 230 of the equal parts; then measuring the distance from your station at C, to the foot of the Tower at B, you finde it to contain 650 foot, then to finde the altitude A B, say;

As 230, the parts cut by the Labell,
Is to 100;
So is 650, the measured distance C B,
To $282\frac{14}{23}$, for the altitude A B.



Therefore, multiply 650 by 100, and divide that Product by 230, the Quotient will be $282\frac{14}{23}$, for the altitude A B.

Now for the reducing of Hypothenusal to Horizontal lines, having measured the Hypothenusal line with your Chain, the proportion will be:

As the equal parts cut on the Label,
Are to the equal parts cut on the Index;
So is the length of the Hypothenusal line measured,
To the length of the Hypothenusal line required.

I thought good to give the Reader a view of the several wayes there are to perform these conclusions, leaving every man at liberty to use that which he best liketh, or all if he please, for all the lines may very well be put upon one Instrument without any confusion of lines: but the way which I shall chiefly insist upon in the prosecuting of this Work, shall be by the line of Tangents, as being (in my opinion) the best of all. Now when I come to shew you the use of this line of Tangents, with the Tables of Sines and Logarithms in the resolving of Triangles, I will also shew you how to perform the same Propositions by the lines of Artificial Numbers, Sines, and Tangents, and therefore I would advise every man to have these so necessary lines upon his Index also.

Fourthly, Unto this Instrument also belongeth a Box and Needle, which is to be fastned to the side of the Table by help of two screws, so that it may be taken off and put on at pleasure. In the bottom of this Box must be placed a Card divided into 360 degrees numbred (if you please) after the usual manner, from the North Eastward, but the Card by which all the Examples in this Book

were

were framed was numbered from the North Westward by 10, 20 30, &c. to 360, contrary to the common custome.

There belongeth also to this Instrument a Socket of Brasse to be screwed on the back side of the Table, into which must be put the head of the three legg'd Staff, this Staff ought to be joynted in the middle, so that it may be the more portable For the Socket it may be a plain one, but a Ball and Socket with an endless screw is the best of all, for by help thereof you may place the Table (or any other Instrument) either Horizontall, Verticall, or in any other position.

☞ Note, that this Instrument (if made according to these directions) is the most absolute Instrument for a Surveyor to use.

☞ CHAP. V.

The description of an Instrument which will perform the work of the Theodolite *or* Circumferentor, *but especially of the* Peractor, *with great ease and exactness, and for portability exceedeth any of the forementioned.*

THe Instrument consisteth of a rectangled *Parallelepipedon*, of what length, breadth and depth you please, but a convenient length will be about 15 or 16 Inches, the breadth about 3 Inches, and the depth about one Inch. On one of the broader Superficies, and in the middle thereof, let there be cut out a little narrow Box about an Inch and half broad, and in length according to the length you intend your Needle, in the middle of this Box let there be drawn a Meridian line marked with a *Flowre-deluce* for the North point, by this means you may have your Needle longer then in the cõmon *Circumferentor*, before described; upon the same side of the broader superficies of this *Parallelepipedon*, let there be at each end therof, cut two other places in which to lay the Sights when they are taken out of the Index for convenience in carriage, so the Sights being laid therein, will be preserved and lie in a little room.

On one of the narrower sides of the said *Parallelepipedon*, within three quarters of an Inch of the extream ends thereof, let there be made to Mortizes about half an Inch square, and about an Inch deep.

Then prepare a joynted frame consisting of three sides, such as the frame of a Plain Table to fold in, that it may lie in a little room, one of which sides must be as long as both the other, so that being folded together, it lie upon the former *Parallelepipedon*. The two shorter ends of this frame (when you use the Instrument in the

field) must be put into the two former Mortizes, to a certain distance, and there fixed with two screws, so will the frame represent a rectangled Parallelogram, the three sides of this frame must be divided in all respects as the frame of a Plain Table, by divisions transferred And if you please, you may have the other side divided into two quadrants, each divided into 90 degrees, from 00 to 90, and from 90 to 00, so may you by this means make the instrument capable of performing the uses of a Card divided into 4 nineties, for the North-east, South-west, North-east, & South-east Quarters of the Heavens, which degrees in this case will be very large, and effect that manner of work with more exactness then by a smaller Card.

¶ Here note, that in the description of the former Instruments, that when I mention a Card, every man is at liberty to have what Card liketh him best, as a Card of 360 degrees, or 120 parts, or into four nineties, according as Master *Norwood* adviseth; but in my opinion, a Card which hath all these Divisions is the most absolute, and this may very easily be done without confusion, if three Circles be made concentrick, for one and the same divisions will very well serve for the 360 degrees, and the four nineties, and the innermost for the 120 parts, and to avoid mistakes it will not be amiss to have the middlemost concentrick Circle to be coloured with some distinct transparent colour, or numbred with red figures.

Unto this Instrument there also belongeth an Index and Sights, and if you make two Mortizes in the extream ends of the *Parallelipipedon*, wherein to set the sights, and cause a Tangent line to be drawn by the edge of the *Parallelepipedon*, the Instrument (with a Label) will be very commodious for the taking of heights.

This Instrument being thus made, and set upon a staff, will be very convenient for all purposes.

☞ CHAP. VI.

The description of an Instrument called a Cross.

THis Instrument is of good use in small inclosures of many sides, the use whereof shall be shewed hereafter in the fourth Book.

It is only two Rulers of Wood, in length about 14 Inches, crossing one the other in the midst at right angles, and having at each end of both the Rulers back-sights, which serves only to set out right angles in the field it self.

CHAP.

CHAP. VII.

Of Chains, *the several sorts thereof.*

OF Chaines there are divers sorts, as namely, Foot Chains, each link containing a Foot or 12 Inches, and so the whole Pole or Perch will contain 16½ Links or Feet, answering to the Statute denomination.

Some Chains have each Pole divided into ten equal parts, and these are called Decimal Chains, and this gross division may be convenient in some practises.

The Chain now used, and most esteemed amongst Surveyors, are especially two, namely, that generally used by Master *Rathborn* which hath every Perch divided into 100 Links, and that of Master *Gunter* which hath four Poles divided into 100 Links, so that each Link of Master *Gunters* Chain is as long as four of Master *Rathborns*.

Now because these Chains are most esteemed of and used by Surveyors, I wil therfore make a general description of them both, leaving every man at liberty to take his choise.

Of Master *Rathborns* Chain.

THe Chain which Mr. *Rathborn* ordinarily used (as himself saith) contained in lengh two Statute Poles or Perches, each Pole containing in length 16½ feet, which is 198 Inches; then each Pole was divided into 10 equal part called *Primes*, every of which contained in length 19⅘ Inches; again, every of those *Primes* was sub-divided into 10 other equal parts called *Seconds* so that every of these *Seconds* contained in length 1$\frac{49}{50}$ Inch, so that the whole Pole, Perch, Unite, or Commencement (as he calleth it) was divided into 130 equal parts or Links called *Seconds*.

The Chain (or one Pole thereof) being thus divided, at the end of every 50 Links or half Pole, let a large Curtain ring be fastned so shall you have in a whole Chain of two Perches long, three of these Rings, the middle most being the division of the two Poles. Then at the end of every *Prime*, that is at the end of every ten Links let a smaller Curtaine Ring be fastened.

By this distinction of Rings, the Chain is divided into these three denominations *Unites Primes*, and *Seconds* whose Characters are these ···, so that if you would expresse 40 *Unites*, 8 *primes* and 7 *Seconds*, they are thus to be written, 4087, by which you may perceive that those Figures which have no pricks over them are *Unites* or *Integers*, and the figure under the first point *Primes*, and under the next *Seconds*: so also, three *Unites*, seven *Primes*, and two *Seconds*, will stand thus, 3$\dot{7}\ddot{8}$.

Beſides theſe diviſions Maſter *Rathborn* for his own uſe, ſewed at the end of every two *Primes* and a halfe (which is a quarter of a Pole) a ſmall red cloth, and at every ſeven *Primes* and a halfe (being three quarters of a Pole) the like of yellow: or other diſcernable colour, which much helped him in the ready reckoning of the ſeveral Rings upon the Chain, remembring this Rule: That if it be the next Ring ſhort of the Red, it is two *Primes*: if the next over, three, if the next ſhort of the yellow ſeven *Primes* if the next over eight; if the next ſhort of the great halfe Ring it is four, the next over ſix: and if the next ſhort of the middle great Ring, it is nine, and if the next over one.

¶ But here is to be noted, that if you uſe this diſtinction by colours, you muſt alwayes work with one end of the Chain from you.

This Chain being thus divided and marked, you have every whole Pole equal to ten *Primes*, or 100 *Seconds*: every three quatters of a Pole equal to ſeven *Primes* and a half, or 75 *Seconds*: every half Pole equal to five *Primes*, or 50 *Seconds*: and laſtly, euery quarter of a Pole equal to two *Primes* and a halfe, or 25 *Seconds*.

And here is to be noted, that in the ordinary uſe of this Chain, for meaſuring and platting, you need take notice only of *Unites* and *Primes*, which is exact enough for ordinary uſe, but in caſe that ſeparation or diviſion of Lands into ſeveral parts, you may make uſe of *Seconds*.

Of Maſter *Gunters* Chain.

AS every Pole of Maſter *Rathborns* Chain was divided into the Links, ſo Maſter *Gunters* whole Chain (which is alwayes made to contain four Poles) is divided into 100 Links one of theſe Links being four times the length of the other. Now if this Chain be made according to the Statute, each Perch to contain $16\frac{1}{2}$ Feet, then each Link of this Chain will contain 7 Inches, and $\frac{22}{100}$ of an Inch, and the whole Chain 729 Inches, or 68 Foot.

In meaſuring with this Chain, you are to take notice only a Chains and Links, as ſaying ſuch a line meaſured by the Chain contains 72 Chain, 48 Links, which you may expreſſe more briefly thus, 7 ,48, and theſe are all the Denominations which are neceſſary to be taken notice of in Sutveying of Land.

For the ready counting of the Links of this Chain, there ought to be theſe diſtinctions namely, In the middle thereof, which is at two Poles end, let there be hanged a large Ring, or rather a plate of braſſe like a Rhombus, ſo is the whole Chain (by this plate) divided into two equal parts.

Se-

Secondly, Let each of these two parts be divided into two other equal parts by smaller Rings or Circular plates of brasse, so shall the whole Chain be divided into four equal Parts or Perches, each Perch containing 25 Links.

Thirdly, At every ten Links set be fastened a lesser Ring then the former, or else a Plate of some other fashion, as a Semicircle or the like. And lastly, at every fist link (if you please) may be fastened other marks, so by this means you shall most easily and exactly count the Links of your Chain without any trouble. The Chain being thus distinguished, it mattereth not which end thereof be carried forward, because the notes of distinction proceed alike on both sides from the middle of the Chain.

¶ Here note, that in all the examples in this Book, the lines are supposed to be measured by this four Pole Chain of Master *Gunter*, it being the best of any other: the manner how to cast up the content of any plot measured there with, shall be hereafter taught in its due place.

Cautions to be observed in the use of any *Chain.*

IN measuring a large distance with your Chain, you may casually mistake or misse a Chain or two in keeping your accounnt, from whence will ensue a considerable errour: Also in measuring of distances (when you go not a long by a hedge side) you can hardly keepe your Instrument, Chain and Marke, in right line, which if you do not, must necessarily make your measured distance greater then in reality it is. For the avoyding of either of these mistakes, you ought to provide ten small sticks or arrows, which let him that leadeth the Chain carry in his hand before, and at the end of every Chaine, stick on of these Arrows into the ground, which let him that followeth the Chain take up, so going on till the whole number of Arrows be spent and then you may conclude that you have measured ten Chains without any further trouble, and these ten Chains (if the distance you are to measure be large) you may call a Change, and so you may denominate every large distance by Changes, Chains and Links. Or you may at the end of every ten Chains set up another kind of stick, by which (standing at the Instrument) you may see whether your eye, the stick, and the Mark to which you are to measure be in a right line or not, and accordingly guide those that carry the Chain, with the more exactnesse to direct it to the Mark intended.

How

How to reduce any number of *Chains* and *Links*, into *Feet.*

IN the practice of many Geometrical Concluſions, as in the taking of Heights and Diſtances, hereafter taught, it is requiſite to give your meaſure (in ſuch caſes) in Feet or Yards, and not in Poles or Perches; yet becauſe your Chain is the moſt neceſſary Inſtrument to meaſure withal, I thought it convenient in this place to ſhew you how to reduce any number of Chains and Links into Feet, which is thus.

Multiply your number of Chains and Links together as one whole number, by 66, cutting off from the product the two laſt figures towards the right hand, ſo ſhall the reſt of the product be Feet, and the two figures cut off ſhall be hundred parts of a Foot.

EXAMPLE.

Let it be required to know how many Feet are contained in five Chains, 32 Links. Firſt, Set down your five Chains, 32 Links as is before taught, and as you ſee in the firſt Example, with a Comma between the Chains and Links, then multiplying this five Chains, 32 Links by 66, the product will be 35112, from which, cut off the two laſt figures toward the right hand with a Comma, then wil the number be 351,12, which is 351 Feet and $\frac{12}{100}$ parts of a foot, and ſo many Feet are contained in five Chains, 32 Links.

Example I.	*Example II.*
5,32	9,05
66	66
3192	5430
3192	5430
351,12	597,30

But let the number of Chains be what they will, if the number of Links be leſs then 10, as in the ſecond Example it is nine Chains five Links, you muſt place a Cypher before the five Links as there you ſee, and then multiplying that number (*viz.* 9,05.) by 66, the product wil be 59730 from which taking the two laſt figures there will remain 597 Feet, and $\frac{30}{100}$ parts of a Foot. The like may be done for any other number of Chains and Links whatſoever.

According to theſe Examples is made the Table following, which ſheweth how many Feet are contained in any number of Chains Links from five Links to eight Chains, for every fift Link, which is ſufficient for ordinary uſe, by which Table you may ſee that in ſix Chains 40 Links, is contained 422 Feet, and $\frac{40}{100}$ of a Foot, Alſo in five Chains 55 Links is contained 366 Feet: and $\frac{30}{100}$ parts of a Foot: and ſo of any other.

A *Table* shewing how many Feet, and parts of a Foot are contained in any number of Chains and Links between five Links and eight Chains.

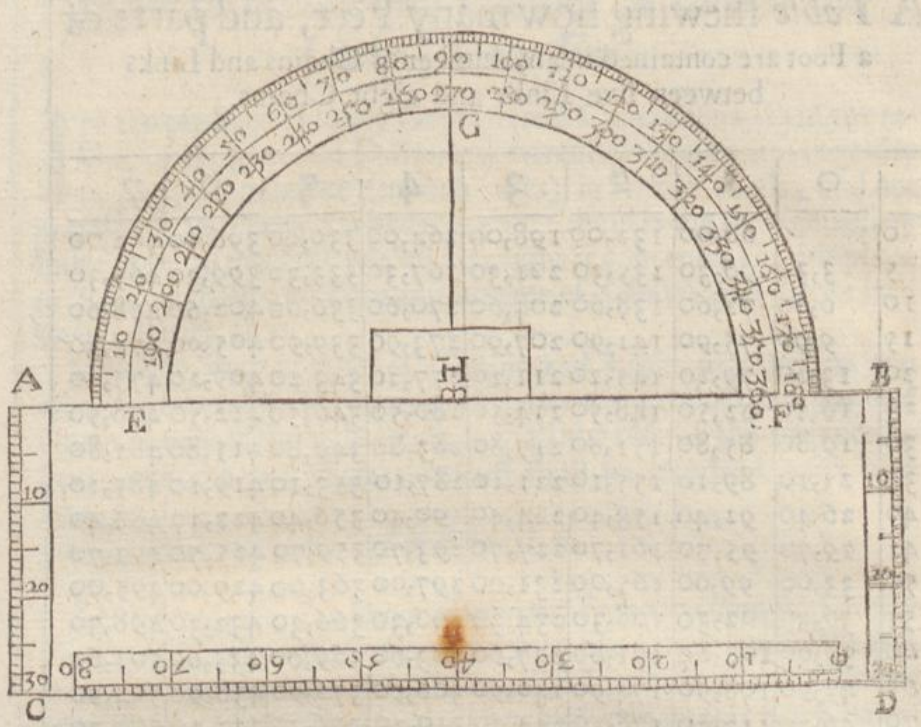
	0	1	2	3	4	5	6	7
0		66,00	132,00	198,00	264,00	330,00	396,00	462,00
5	3,30	96,30	135,30	201,30	267,30	333,30	399,30	465,30
10	6,60	72,60	138,60	204,60	270,60	336,60	402,60	468,60
15	9,90	75,90	141,90	207,90	273,90	339,90	405,90	471,90
20	13,20	79,20	145,20	211,20	277,20	343,20	409,20	475,20
25	16,50	82,50	148,50	214,50	280,50	346,50	412,50	478,50
30	19,80	85,80	151,80	217,80	283,80	349,80	415,80	481,80
35	23,10	89,10	155,10	221,10	287,10	353,10	419,10	485,10
40	26,40	92,40	158,40	224,40	290,40	356,40	422,40	488,40
45	29,70	95,70	161,70	227,70	293,70	359,70	425,70	491,70
50	33,00	99,00	165,00	231,00	297,00	363,00	429,00	495,00
55	36,30	102,30	168,30	234,30	300,30	366,30	432,30	498,30
60	39,60	105,60	171,60	237,60	303,60	369,60	435,60	501,60
65	42,90	108,90	174,90	240,90	306,90	372,90	438,90	504,90
70	46,20	112,20	178,20	244,20	310,20	376,20	442,20	508,20
75	49,50	115,50	181,50	247,50	313,50	379,50	445,50	511,50
80	52,80	118,80	184,80	250,80	316,80	382,80	448,80	514,80
85	56,10	122,10	188,10	254,10	320,10	386,10	452,10	518,10
90	59,40	125,40	191,40	257,40	323,40	389,40	455,40	521,40
95	62,70	128,70	194,70	260,70	326,70	392,70	458,70	524,79

CHAP. VIII.

Of the Protractor.

A Protractor is an Instrument by which you may protract or lay down upon paper or otherwise, the true symetry or proportion of any field, having made observation of the sides and angles thereof by some of the Instruments before described. This Instrument cõsisteth of two parts, the one is a Semicircle divided into degrees, as is the frame of the Table, and the other is a Scale divided into equal parts, the Semicircle being to lay down the angles, and the Scale to plot the sides. This Instrument ought to be made of a piece of thin brass well polished, the edges thereof being very smooth, and the Scale thereof, namely, the right angled Parallelogram, or long square containing in length from A to B about four Inches and three quarters, and in breadth from A to C about one and a half. Let the two ends of the Scale, namely, the sides, A C and B D be divided into equal parts of 16 or 20 in an Inch, and let the side C D be divided according to a Scale of 10 or 12 in an Inch.

The

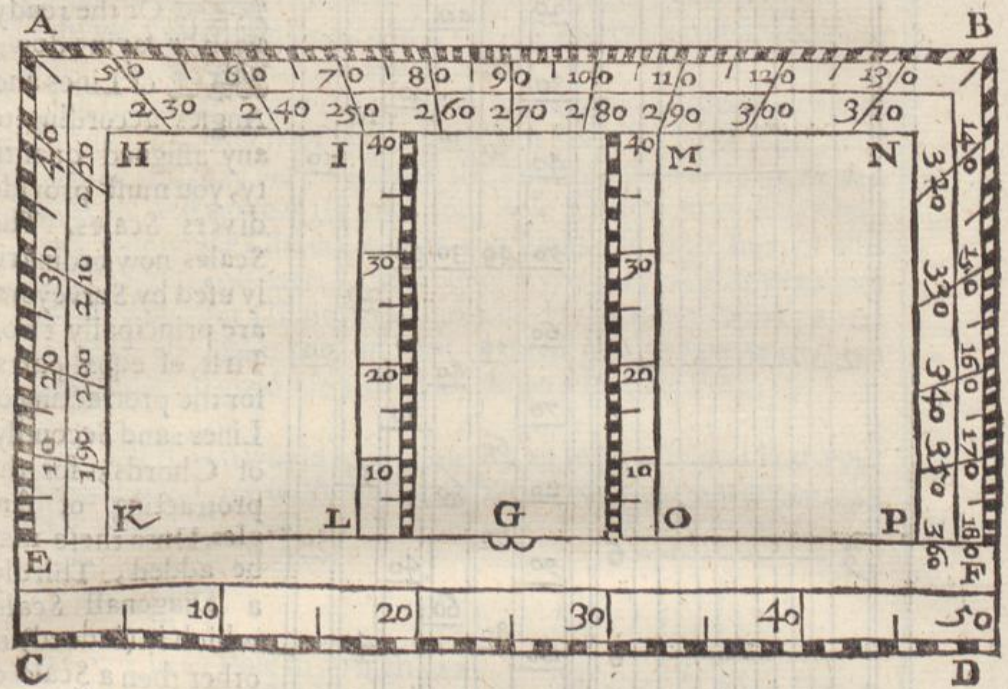


The Scale being thus divided, on the middle of the line A B, as at H, describe the Semicircle EGF, which divide into two Quadrants in the point G, by help of the perpendicular HG: then divide each of those Quadrants into 90 equal parts called degrees, so shall the whole Semicircle contain 180 degrees, which must be numbered by 10,20,30,40, &c. to 180, from E by G to F, and the same way also from 180 to 360, as you see done in the Figure, the numbers of the first Semicircle from 00 to 180 being for the East side of the Protractor, and the other numbers from 180 to 360 for the West side.

Now you are to note, that the line A B always representeth the Meridian line, and is somtimes noted with the letters S and N for South and North, but then it is necessary that the Protractor be divided on either side the plate, which this double numbering avoideth, for the line AB being taken for the Meridian in general, the Semicircle of the Protractor may be turned any way (either upward or downward) and so one Semicircle being divided will be sufficient; yet if any man be desirous, he may have it made according to his own fancie, but this manner of numbering (in my opinion) is the best, it being most agreeable to your Instruments.

The

☞ The Protractor here described is that which is commonly made and used, but this (the description whereof followeth) in my judgement was the best contrivance I have seen, the first whereof being made for my loving friend *Will. Forster* now in *Ireland* which is as followeth.

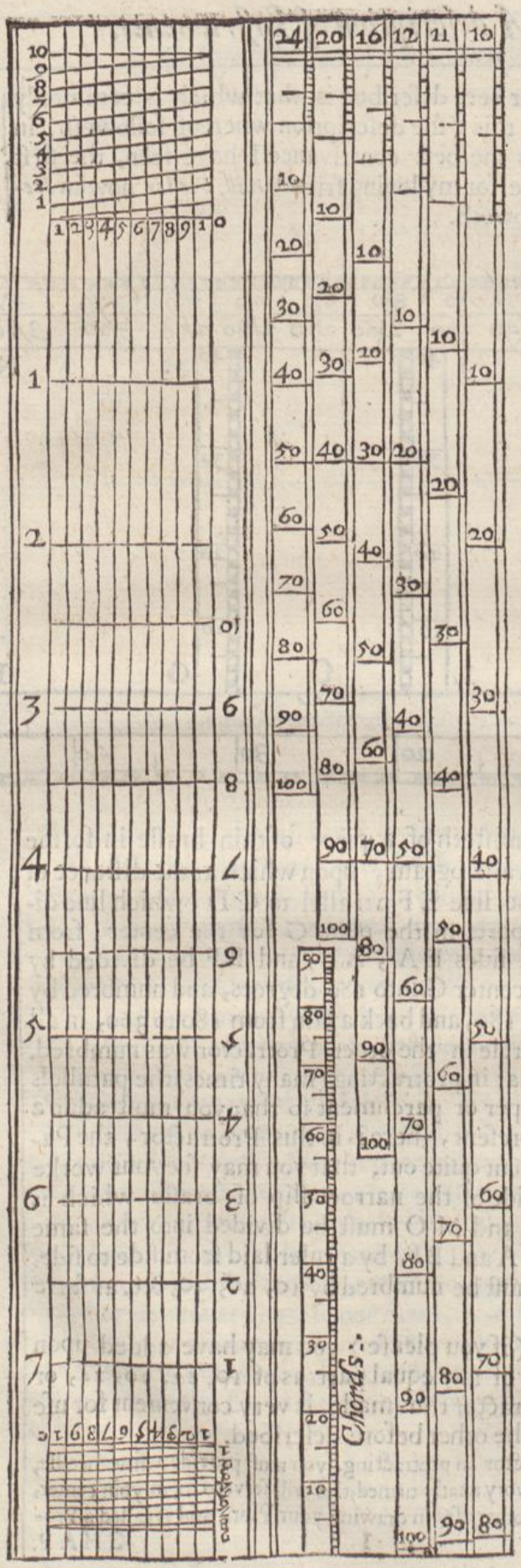


The Protractor consisteth of a piece of thin brasse in forme of a rectangled Parallelogram, upon which at the distance of halfe an inch draw the line E F parallel to C D, which line divide into two equal parts in the point G for the center, from which center let the sides E A, A B, and B F be divided by lines issuing from the center G into 180 degrees, and numbred by 10, 20, 30, 40, &c. to 180, and back again from 180 to 360, in all respects as the semicircle in the other Protractor was numbred.

¶ Now because that in protracting (many times) the parallels will fall off of your paper or parchment so that you must adde a piece thereto for the present, there is in this Protractor, the Parallelogram I M O L cut quite out, that you may see your worke through, and either side of the narrow slip of brasse which is cut out, namely I L and M O must be divided into the same parts with the sides E A and B F, by a ruler laid from side to side, and these two sides must be numbred by 10, 20, 30, &c. as farre as they will extend.

To this Protractor (if you please) you may have added upon the edge C D a Scale of any equal part as of 10, 12, 20, 24, or 30 in an inch, this Protractor thus made, is very convenient for use and much exceedeth the other before described.

To use with your Protractor in protracting, you must provide a fine needle, put into a piece of Box or Ivory neatly turned, this will serve to fix in your center, note your degrees, and for other uses in drawing your Plot, and is called a Protracting pin.



CHAP. IX.

Of Scales.

FOr the ready laying down of Lines and Angles according to any assigned quantity, you must provide divers Scales. The Scales now ordinarily used by Surveyors, are principally two: First, of equal parts, for the protracting of Lines: and Secondly, of Chords, for the protracting of Angles. Unto these may be added, Thirdly, a Diagonall Scale, which is (indeed) no other then a Scale of equall parts more scrupulously divided. If you desire a convenient Scale, let it be made in this manner, to contain in length about 8 or 9 Inches, and in breadth one Inch and a quarter: on one side thereof let be placed divers Scales, as of 10, 11, 12, 16, 20, 24, and 30 in an Inch.

¶ Here is to be noted, that when I say a Scale of 12 in an Inch, you are to understand a part of a line divided into 10 equall parts, 12 of which parts would make an

an Inch, and the like is to be understood of any other number of equal parts whatsoever.

On the same side of the Ruler let be placed a line of Chords extended up to 90, and numbred as you see in the figure by 10, 20, 30, &c. to 90. This Scale will be of good use for many purposes, as to divide the circumference of a circle, and to protract angles in some cases better then the Protractor.

On the other side of the Ruler let be drawn a Diagonal Scale, of 10 in an Inch, which will be an excellent Scale for large Plots, out of which you may very well take the hundred part of an Inch, and this Scale will agree with your four Pole Chain exceeding well, for as your whole Chain contains 100 Links, so each Inch of this Scale contains 100 parts, so that out of it you may take any number measured by your Chain, to a Link, and lay it down upon paper. You may also have half an Inch divided into 100 parts, which Scale will be of good use also to lay down a smaller Plot.

☞ But if you would have your Scales to be answerable to your Chain, and to agree with the divisions thereof, then you are to take notice that

A Scale of	Pole in an inch must be a Scale of		in 4 inches or		in one inch
10		10		$2\frac{1}{2}$	
11		11		$2\frac{3}{4}$	
12		12		3	
16		16		4	
20		20		5	
24		24		6	
30		30		$7\frac{1}{2}$	

Then will each of those parts represent a Chain, and if you subdivide the last single part into ten, those parts shall represent links.

These Scales, also the lines of numbers Signes and Tangents, and reducing Scale hereafter mentioned, may very conveniently be placed on the Index of the plain Table.

To use with this Scale, you must provide a pair of neat Compasses of Brass, with steel points, filed very small, and also a neat pair of Compasses with three points, & Screws to alter the points, so that you may draw lines or Circles with black lead, or any coloured Inke, which will be very necessary and convenient in beautifying of your Plots after Protraction.

CHAP. X.
Of a Field Book.

IT wil be sufficient in this place only to describe the manner how a Field-Book ought to be ruled: Let the Book contain any quantity of paper, more or lesse, and in what volume you please, but a long folio is the best. Let it be ruled, towards the left Margine of every page, with five ines in red inke, so shall you have four Columns, in the first whereof you must note down the degrees cut either by the Index on the frame of the Table, or else by the Needle on the Card of the Circumferentor, or degrees of the Peractor, at every angle you observe, and the second Column is to note the minutes or parts of a Degree, for you are to note, that every degree on the frame of the Table, or in the Card of the Circumferentor, is supposed to be divided into 60 other parts called Minutes, which cannot be expressed by reason of the smalness of the Instruments, and therefore must only be estimated, yet if your Instrument be large enough, you may have each degree divided into three equal parts, so shall every

The manner how a Field-book ought to be ruled.

Degrees.	*Minutes*	*Chains*	*Links.*	
326	45	16	87	

part contain 20 minutes. The other two Columns serve to note down the lengths measured by your Chain, as the Chains and Links.

Now suppose that making any observation in the Field either with the Degrees on the frame of the Table, or with the Circumferentor, and that observing any angle, (as is hereafter taught) you finde the Index of the Plain Table, or the Needle in the Circumferentor, to cut 326 degrees, 45 minutes, these 326 degrees must be set down in the first Column of your Field-Book, and the 45 minutes in the second Column, as you see here done. Also if you measure any length in the Field with your Chain, as sup-

pose

pose some distance measured to contain 16 Chains, 87 Links, the 16 Chains must be set in the third Column, and the 87 Links in the fourth Column, under their respective Titles, as you see here done.

☞ But if you use a Card of four nineties according to M. *Norwood* then your four Columns will represent the four Quarters of your Card, namely the South, North, East, and West, and then you must have two other Columnes also one for the degrees and minutes, the other for the lengths of lines, the manner whereof you shall see in the fourth Book when we come to examples,

CHAP. XI.

Of Instruments for Reducing of Plots.

FOr the reducing of Plots from one forme to another, there hath been divers Instruments invented. One that performeth that work very well, is a ruler having certain proportional Scales thereupon; with a sliding vein of brass to move from end to end thereof, this Instrument well made and the lines thereupon fitted to your proportion, will be very easie and exact; the manner of using it and the way of proportioning of it, shall be shewed hereafter. This Instrument though it be not generall, yet it may easily be fitted to 5 or 6 severall proportions, which for that purpose is sufficient. The Scale of equal parts, which I described in *Planometria* being too particular I shall here reject. Another Instrument for the performance of this worke, is a Parallelogram, the making whereof is well known to the Instrument-maker.

The end of the second Book.

THE COMPLEAT SURVEYOR:

The Third Book.

THE ARGUMENT.

THis third *Book* is as it were a *Key* to thoſe that follow, the *ſubject* whereof is *Trigonometry*. Now foraſmuch as the whole *Art* of meaſuring *heights* and *diſtances*, and *plotting* and *protracting* of *Land*, and all other *lineall* and *ſuperficial dimenſions* are grounded upon the reſolution of *Plain Triangles*, I hold it convenient (before I come to the *practice of Surveying* or to ſhew the uſe of any *Inſtrument* in taking of *heights* & *diſtances*) to ſay ſomthing concerning *Plain Triangles* (at leaſt ſo much as is neceſſary for a *Surveyor* to know) although that *Subject* be handled

handled by divers able *Mathematicians* already, whose *Works* are extant: *viz. Pitiscus, Snelius*, the Lord *Nepair*, Master *Gunter*, Master *Norwood*, Master *Gellibrand*, &c. Now because the *readiest way of resolving Triangles* is by *Signes, Tangents*, and *Logarithms*, I have therefore added brief *Tables* for that purpose, *viz* a *Table* of *Signes*, to every tenth *minute* of the *Quadrant*, and a *Table* of *Logarithmes* from 1, to 1000, omitting the Table of Tangents, partly because they are of little or no use in *Surveying*, and also because there are divers *Books* extant wherein they are at large, so that those who desire to make a further scrutiny into *Trigonometry*, may peruse the forementioned *Authours*. In this *Book* I have only insisted upon such *Cases* as may come in use in *Surveying*, and therefore have omitted divers, yet those which I have insisted on, are performed both by the *Tables* following in this *Book*, and also by the *Lines of Artificial Numbers, Sines* and *Tangents* before spoken of in the description of the *Index* of the *Plain Table* in the last *Book*.

TRI-

TRIGONOMETRIE.

CHAP. I.

The Explanation and Use of the Table of SINES.

BEfore I come to the menſuration of Triangles, it will be neceſſary to explain and ſhew the uſe of the Tables of *Sines* and *Logarithms* following, by which Tables the ſides or angles of right lined Triangles may be readily and exactly meaſured, ſo that in any plain Triangle, if there be any three parts thereof given, a fourth may be eaſily diſcovered.

The Table of Sines conſiſteth of two Rows or Columns, the firſt whereof ſheweth the Degrees and Minutes of the Quadrant, having over the head thereof theſe two letters, *D. M.* ſtanding for Degrees and Minutes: In the ſecond Column is the Artificiall *Sines* anſwering to every Degree and 10th Minute of the Quadrant, having the word *Sine* over the head thereof. The uſe of this Table will appear by the following *Propoſitions*.

PROP. I.

Any Degree and Minute being given, to find the Sine thereof.

FIrſt, Seek the Degree and Minute in the firſt Column of the Table, under *D. M.* and right againſt it, in the next Column towards the right hand, under the word *Sine*, you ſhall have your degree.

EXAMPLE. I.

Suppose it were required to find the Sine of 20 degrees, First, you must seek 20 in the first Column of the Table under *D. M.* and right again 20 in the second Column under the word *Sine*, you shall find 9,533405, which is the Sine of 20 degrees.

In the same manner you shall find the Sine of 50 degrees to be 9,884254, and the Sine of 76 degrees to be 9,986904.

EXAMPLE. II.

Let it be required to find the Sine of 40 degrees, 30 minutes. First, you must find 40, 30 (which is 40 degrees 30 minutes) in the first Column, under the letters *D. M.* and against it you shall find 9,812544, which is the Sine of 40 degrees, 30 minutes.

Also the Sine of 62 degrees 10 minutes, will be found to be 9,946604, and the Sine of 86 degrees 30 minutes will be 9,999189, and in this manner may you find the artificial Sine of any number of degrees and minutes expressed in the Table.

PROP. II.

Any Sine being given, to find the number of degrees and minutes thereunto belonging.

EXAMPLE.

LEt 9,866470 be a Sine given, and let it be required to find the degree and minute of the Quadrant answering thereunto. First, seek in the second Column amongst the Sines for 9,866470, and against it (on the left hand) you shall find 47 degrees 20 minutes, which is the arch of the Quadrant answering thereunto.

Again, Let it be required to find the arch answering to this Sine 9,821264, having found 9,821264 in the second Column under the word *Sine*, against it you shall find 41 degrees 30 min. and that is the arch or degree answering thereunto.

¶ But in case you have a number given which you cannot exactly find in the Table, you must then in stead thereof, take the neerest in the Table. As if your number given were 9,675859, if you look in the Table for this number it cannot be found there, but the neerest thereunto is 9,676328, which is the Sine of 28 degrees 20 minutes, which you must take instead thereof.

THE

The Table of Sines.

D.	M.	Sines
0	0	0,000000
	10	7,463726
	20	7,764754
	30	7,940842
	40	8,065776
	50	8,162681
1	0	8,241855
	10	8,308794
	20	8,366777
	30	8,417919
	40	8,463665
	50	8,505045
2	0	8,542819
	10	8,577566
	20	8,609734
	30	8,639679
	40	8,667689
	50	8,693998
3	0	8,718800
	10	8,742259
	20	8,764511
	30	8,785675
	40	8,805852
	50	8,825130
4	0	8,843584
	10	8,861283
	20	8,878285
	30	8,894643
	40	8,910404
	50	8,925609
5	0	8,940296
	10	8,954499
	20	8,968249
	30	8,981573
	40	8,994497
	50	9,007044
6	0	9,019235
	10	9,031089
	20	9,042625
	30	9,053859
	40	9,064806
	50	9,075480
7	0	9,085894
	10	9,096062
	20	9,105992
	30	9,115693
	40	9,125187
	50	9,134479
8	0	9,143555
	10	9,152451
	20	9,161164
	30	9,169702
	40	9,178072
	50	9,186280
9	0	9,194332
	10	9,202234
	20	9,209992
	30	9,217609
	40	9,225092
	50	9,232444
10	0	9,239670
	10	9,246795
	20	9,253761
	30	9,260633
	40	9,267395
	50	9,274049
11	0	9,280599
	10	9,287048
	20	9,293399
	30	9,299655
	40	9,305819
	50	9,311899
12	0	9,317879
	10	9,323780
	20	9,329599
	30	9,335337
	40	9,340996
	50	9,346579
13	0	9,352088
	10	9,357524
	20	9,362889
	30	9,368185
	40	9,373414
	50	9,378577
14	0	9,383675
	10	9,388711
	20	9,393685
	30	9,398600
	40	9,403455
	50	9,408254
15	0	9,412996
	10	9,417684
	20	9,422317
	30	9,426899
	40	9,431429
	50	9,435918
16	0	9,440338
	10	9,444720
	20	9,449054
	30	9,453342
	40	9,457584
	50	9,461782
17	0	9,465935
	10	9,460446
	20	9,474115
	30	9,478142
	40	9,482128
	50	9,486075
18	0	9,489982
	10	9,493851
	20	9,497682
	30	9,501476
	40	9,505234
	50	9,508955
19	0	9,512642
	10	9,516294
	20	9,519911
	30	9,523495
	40	9,527046
	50	9,530565
20	0	9,534052
	10	9,537507
	20	9,540931
	30	9,544325
	40	9,547689
	50	9,551024
21	0	9,554329
	10	9,557606
	20	9,560855
	30	9,564075
	40	9,567269
	50	9,570435
22	0	9,573575
	10	9,576689
	20	9,579777
	30	9,582840
	40	9,585877
	50	9,588890
23	0	9,591878
	10	9,594842
	20	9,597783
	30	9,600700
	40	9,603594
	50	9,606465

The Table of Sines.

D.	M.	Sines
24	0	9,609313
	10	9,612148
	20	9,614944
	30	9,617727
	40	9,620488
	50	9,623229
25	0	9,625948
	10	9,628647
	20	9,631326
	30	9,633984
	40	9,636623
	50	9,639242
6	0	9,641842
	10	9,644423
	20	9,646984
	30	9,649527
	40	9,652052
	50	9,654558
27	0	9,657047
	10	9,659517
	20	9,661970
	30	9,664406
	40	9,666824
	50	9,669225
28	0	9,671609
	10	9,673977
	20	9,676328
	30	9,678663
	40	9,680982
	50	9,683284
29	0	9,685571
	10	9,687842
	20	9,690098
	30	9,692339
	40	9,694564
	50	9,696774
30	0	9,698970
	10	9,701151
	20	9,703317
	30	9,705469
	40	9,707606
	50	9,709730
31	0	9,711839
	10	9,713935
	20	9,716013
	30	9,718085
	40	9,720140
	50	9,722181

D.	M	Sines
32	0	9,724210
	10	9,726225
	20	9,728227
	30	9,730216
	40	9,732193
	50	9,734157
33	0	9,736109
	10	9,738048
	20	9,739975
	30	9,741889
	40	9,743792
	50	9,745683
34	0	9,747562
	10	9,749429
	20	9,751284
	30	9,753128
	40	9,754960
	50	9,756781
35	0	9,358591
	10	9,760390
	20	9,762177
	30	9,763954
	40	9,765720
	50	9,767474
36	0	9,769219
	10	9,770952
	20	9,772675
	30	9,774388
	40	9,776090
	50	9,777781
37	0	9,779463
	10	9,781134
	20	9,782796
	30	9,784447
	40	9,786088
	50	9,787720
38	0	9,789342
	10	9,790954
	20	9,792557
	30	9,794149
	40	9,795733
	50	9,797307
39	0	9,798872
	10	9 800427
	20	9,80197
	30	9,803510
	40	9,805038
	50	9,806557

D.	M.	Sines
40	0	9,808067
	10	9,809569
	20	9,810061
	30	9,812544
	40	9,814019
	50	9,815485
41	0	9,816943
	10	9,818392
	20	9,819832
	30	9,821264
	40	9,822688
	50	9,824104
42	0	9,825511
	10	9,826910
	20	9,828301
	30	9,829682
	40	9,831058
	50	9,832425
43	0	9,833783
	10	9,835134
	20	9,836477
	30	9,837812
	40	9,839140
	50	9,840459
44	0	9,841771
	10	9,843079
	20	9,844372
	30	9,845662
	40	9,846944
	50	9,848218
45	0	9,849485
	10	9,850745
	20	9,851997
	30	9,853242
	40	9,954480
	50	9,855710
46	0	9,856934
	10	9,858150
	20	9,859360
	30	9,860562
	40	9,861757
	50	9,862946
47	0	9,864127
	10	9,865302
	20	9,866470
	30	9,867631
	40	9,868785
	50	9,869933

The Table of Sines.

D.	M.	Sines
48	0	9,871073
	10	9,872208
	20	9,873335
	30	9,874456
	40	9,875571
	50	9,876678
49	0	9,877780
	10	9,878875
	20	9,879965
	30	9,881045
	40	9,882121
	50	9,883191
50	0	9,884254
	10	9,885311
	20	9,886361
	30	9,887406
	40	9,888444
	50	9,889476
51	0	9,890503
	10	9,891522
	20	9,892536
	30	9,893544
	40	9,894546
	50	9,895542
52	0	9,896532
	10	9,897516
	20	9,898494
	30	9,899467
	40	9,900433
	50	9,901391
53	0	9,902349
	10	9,903298
	20	9,904241
	30	9,905179
	40	9,906111
	50	9,907037
54	0	9,907958
	10	9,908873
	20	9,909782
	30	9,910686
	40	9,911584
	50	9,912477
55	0	9,913364
	10	9,914246
	20	9,915123
	30	9,915994
	40	9,916859
	50	9,917719

D.	M.	Sines
56	0	9,918574
	10	9,919424
	20	9,926268
	30	9,921107
	40	9,921940
	50	9,922768
57	0	9,923591
	10	9,924409
	20	9,925222
	30	9,926029
	40	9,926831
	50	9,927628
58	0	9,928420
	10	9,929207
	20	9,929989
	30	9,930766
	40	9,931537
	50	9,932304
59	0	9,933066
	10	9,933822
	20	9,934574
	30	9,935320
	40	9,936062
	50	9,936799
60	0	9,937531
	10	9,938257
	20	9,938980
	30	9,939697
	40	9,940409
	50	9,941116
61	0	9,941819
	10	9,942517
	20	9,943210
	30	9,943898
	40	9,944582
	50	9,945261
62	0	9,945935
	10	9,946604
	20	9,947269
	30	9,947929
	40	9,948584
	50	9,949235
63	0	9,949881
	10	9,950522
	20	9,951159
	30	9,951791
	40	9,952419
	50	9,953042

D.	M.	Sines
64	0	9,953660
	10	9,954274
	20	9,954883
	30	9,955488
	40	9,956088
	50	9,956684
65	0	9,957276
	10	9,957862
	20	9,958445
	30	9,959023
	40	9,959596
	50	9,960165
66	0	9,960730
	10	9,961290
	20	9,961846
	30	9,962398
	40	9,962945
	50	9,963488
67	0	9,964026
	10	9,964560
	20	9,965090
	30	9,965615
	40	9,966136
	50	9,966653
68	0	9,967166
	10	9,967674
	20	9,968178
	30	9,968678
	40	9,969173
	50	9,969665
69	0	9,970152
	10	9,970634
	20	9,971112
	30	9,971588
	40	9,972858
	50	9,972524
70	0	9,972986
	10	9,973443
	20	9,973897
	30	9,974346
	40	9,974792
	50	9,975283
71	0	9,975670
	10	9,976103
	20	9,976532
	30	9,977956
	40	9,977377
	50	9,977794

The Table of Sines.

D.	M.	Sines
72	0	9,978206
	10	9,978615
	20	9,979019
	30	9,979419
	40	9,979816
	50	9,980208
73	0	9,980596
	10	9,980980
	20	9,981361
	30	9,981737
	40	9,982109
	50	9,982477
74	0	9,982842
	10	9,983202
	20	9,983558
	30	9,983910
	40	9,984259
	50	9,984603
75	0	9,984943
	10	9,985280
	20	9,985613
	30	9,985942
	40	9,986266
	50	9,986587
76	0	9,986904
	10	9,987217
	20	9,987526
	30	9,987832
	40	9,988133
	50	9,988430
77	0	9,988724
	10	9,989014
	20	9,989299
	30	9,989581
	40	9,989860
	50	9,990134

D.	M	Sines
78	0	9,990404
	10	9,990671
	20	9,990934
	30	9,991193
	40	9,991447
	50	9,991699
79	0	9,991947
	10	9,992190
	20	9,992430
	30	9,992666
	40	9,992898
	50	9,993127
80	0	9,993351
	10	9,993572
	20	9,993789
	30	9,994003
	40	9,994212
	50	9,994418
81	0	9,994620
	10	9,994818
	20	9,995012
	30	9,995203
	40	9,995390
	50	9,995573
82	0	9,995753
	10	9,995928
	20	9,996100
	30	9,996269
	40	9,996433
	50	9,996594
83	0	9,996751
	10	9,996904
	20	9,997053
	30	9,997199
	40	9,997341
	50	9,997480

D.	M.	Sines
84	0	9,997614
	10	9,997732
	20	9,997873
	30	9,997996
	40	9,998106
	50	9,998232
85	0	9,998344
	10	9,998453
	20	9,998558
	30	9,998659
	40	9,998757
	50	9,998851
86	0	9,998941
	10	9,999027
	20	9,999110
	30	9,999189
	40	9,999265
	50	9,999336
87	0	9,999404
	10	9,999469
	20	9,999529
	30	9,999586
	40	9,999640
	50	9,999689
88	0	9,999735
	10	9,999778
	20	9,999816
	30	9,999851
	40	9,999882
	50	9,999910
89	0	9,999934
	10	9,999954
	20	9,999971
	30	9,999983
	40	9,999993
	50	9,999998

Chap.

CHAP. II.

The Explanation and Use of the Table of Logarithms.

THe Table of Logarithms following consisteth of two Rows or Columns, the first of which (namely that towards the left hand, having the word *Num.* at the head thereof) containeth all absolute numbers increasing by a Unite in continual proportion from 1, to 1000.

In the other Column is placed the Logarithms of those absolute numbers; which Logarithms are numbers so fitted to proportional numbers, that themselves retain equal differences.

By this Table, the Logarithme of any absolute number under 1000, may be readily found: Or if any Logarithme, whose absolute number exceedeth not 1000, be given, this Table will plainly discover what absolute number answereth thereunto. The use of this Table will appear by the Propositions following.

PROP. I.

A number being given, to find the Logarithme thereof.

LEt it be required to find the Logarithm of 223, First, seek 223 in the first Column of the Table under the word *Num.* and against it in the second Column you shall find 2,348305, which is the Logarithm thereof.

Also, Let it be required to find the Logarithm of 629, if you seek 629 in the first Column, against it in the second you shall find 2,798651, which is the Logarithm thereof.

PROP. II.

A Logarithme *being given, how to find the absolute number thereunto belonging.*

LEt 2,731589 be a Logarithm given, whose absolute number you require: you must first seek this number in the second Column of the Table, under the word *Logar*, against which you shall find 539, which is the absolute number answering to that Logarithme.

¶ But in this Table, as in the Table of *Sines*, if you cannot find the direct Logarithm which you look for in the Table, you must take the nearest thereunto.

THE

The Table of Logarithms.

Num.	*Logarith.*	*Num.*	*Logarith.*	*Num.*	*Logarith.*
1	0,000000	51	1,707570	101	2,004321
2	0,301030	52	1,716003	102	2,008600
3	0,477121	53	1,724276	103	2,012837
4	0,602060	54	1,732394	104	2,017033
5	0,698970	55	1,740363	105	2,021189
6	0,778151	56	1,748188	106	2,025306
7	0,845098	57	1,755875	107	2,029384
8	0,903090	58	1,763428	108	2,033424
9	0,954242	59	1,770852	109	2,037426
10	1,000000	60	1,778151	110	2,041393
11	1,041393	61	1,785330	111	2,045323
12	1,079181	62	1,792392	112	2,049218
13	1,113943	63	1,799341	113	2,053078
14	1,146128	64	1,806180	114	2,056905
15	1,176091	65	1,812913	115	2,060698
16	1,204120	66	1,819544	116	2,064458
17	1,230449	67	1,826075	117	2,068186
18	1,255272	68	1,832509	118	2,071882
19	1,278754	69	1,838849	119	2,075547
20	1,301030	70	1,845098	120	2,079181
21	1,322219	71	1,851258	121	2,082785
22	1,342423	72	1,857332	122	2,086359
23	1,361728	73	1,863323	123	2,089905
24	1,380211	74	1,869232	124	2,093422
25	1,397940	75	1,875061	125	2,096910
26	1,414973	76	1,880814	126	2,100371
27	1,431364	77	1,886491	127	2,103804
28	1,447158	78	1,892095	128	2,107209
29	1,462398	79	1,897627	129	2,110589
30	1,477121	80	1,903089	130	2,113943
31	1,491362	81	1,908485	131	2,117271
32	1,505150	82	1,913814	132	2,120574
33	1,518514	83	1,919078	133	2,123852
34	1,531479	84	1,924279	134	2,127105
35	1,544068	85	1,929419	135	2,130334
36	1,556302	86	1,934498	136	2,133539
37	1,568202	87	1,939519	137	2,136721
38	1,579783	88	1,944483	138	2,139879
39	1,591065	89	1,949390	139	2,143015
40	1,602060	90	1,954242	140	2,146128
41	1,612784	91	1,959041	141	2,149219
42	1,623249	92	1,963788	142	2,152288
43	1,633468	93	1,968483	143	2,155336
44	1,643453	94	1,973128	144	2,158362
45	1,653212	95	1,977724	145	2,161368
46	1,662758	96	1,982271	146	2,164353
47	1,672098	97	1,986772	147	2,167317
48	1,681241	98	1,991226	148	2,170262
49	1,690196	99	1,995635	149	2,173186
50	1,698970	100	2,000000	150	2,176091

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
151	2,178977	201	2,303196	251	2,399674
152	2,181844	202	2,305351	252	2,401401
153	2,184691	203	2,307496	253	2,403121
154	2,187521	204	2,309630	254	2,404834
155	2,190332	205	2,311754	255	2,406540
156	2,193125	206	2,313867	256	2,408239
157	2,195899	207	2,315970	257	2,409933
158	2,198657	208	2,318063	258	2,411619
159	2,201397	209	2,320146	259	2,413299
160	2,204119	210	2,322219	260	2,414973
161	2,206826	211	2,324282	261	2,416641
162	2,209515	212	2,326336	262	2,418301
163	2,212187	213	2,328379	263	2,419956
164	2,214844	214	2,330414	264	2,421604
165	2,217484	215	2,332438	265	2,423246
166	2,220108	216	2,334454	266	2,424882
167	2,222716	217	2,336459	267	2,426511
168	2,225309	218	2,338456	268	2,428135
169	2,227887	219	2,340444	269	2,429752
170	2,230449	220	2,342227	270	2,431364
171	2,232996	221	2,344392	271	2,432969
172	2,235528	222	2,346353	272	2,434569
173	2,238046	223	2,348305	273	2,436163
174	2,240549	224	2,350248	274	2,437751
775	2,243038	225	2,352183	275	2,439333
176	2,245513	226	2,354108	276	2,440909
177	2,247973	227	2,356026	277	2,442479
178	2,250420	228	2,357935	278	2,444045
179	2,252853	229	2,359835	279	2,445604
180	2,255273	230	2,361728	280	2,447158
181	2,257679	231	2,363612	281	2,448706
182	2,260071	232	2,365488	282	2,450249
183	2,262451	233	2,367356	283	2,451786
184	2,264818	234	2,369216	284	2,453318
185	2,267172	235	2,371068	285	2,454845
186	2,269513	236	2,372912	286	2,456365
187	2,271842	237	2,374748	287	2,459889
188	2,274158	238	2,376577	288	2,459392
189	2,276462	239	2,378398	289	2,460898
190	2,278754	240	2,380211	290	2,462398
191	2,281083	241	2,382017	291	2,463893
192	2,283301	242	2,383815	292	2,465383
193	2,285557	243	2,385606	293	2,466868
194	2,287802	244	2,387389	294	2,468347
195	2,290035	245	2,389166	295	2,469822
196	2,292256	246	2,390935	296	2,471292
197	2,294466	247	2,392697	297	2,472756
198	2,296665	248	2,394452	298	2,474216
199	2,298853	249	2,396199	299	2,475671
200	2,301029	250	2,397940	300	2,477121

The Table of Logarithms.

Num.	*Logarith.*
301	2,478566
302	2,480007
303	2,481443
304	2,482874
305	2,484299
306	2,485721
307	2,487138
308	2,488551
309	2,489958
310	2,491362
311	2,492760
312	2,494155
313	2,495544
314	2,496929
315	2,498311
316	2,499687
317	2,501059
318	2,502427
319	2,503791
320	2,505149
321	2,506505
322	2,507856
323	2,509203
324	2,510545
325	2,511883
326	2,513218
327	2,514548
328	2,515874
329	2,517196
330	2,518514
331	2,519828
332	2,521138
333	2,522444
334	2,523746
335	2,525045
336	2,526339
337	2,527629
338	2,528916
339	2,530199
340	2,531479
341	2,532754
342	2,534026
343	2,535294
344	2,536558
345	2,537819
346	2,539076
347	2,540329
348	2,541579
349	2,542825
350	2,544068

Num.	*Logarith.*
351	2,545307
352	2,546543
353	2,547775
354	2,549003
355	2,550228
356	2,151449
357	2,552668
358	2,553883
359	2,555094
360	2,556303
361	2,557507
362	2,558709
363	2,559907
364	2,561101
365	2,562293
366	2,563481
367	2,564666
368	2,565848
369	2,567026
370	2,568202
371	2,569374
372	2,570543
373	2,571709
374	2,572872
375	2,574031
376	2,575188
377	2,576341
378	2,577492
379	2,578639
380	2,579784
381	2,580925
382	2,582063
383	2,583199
384	2,584331
385	2,585461
386	2,586587
387	2,587711
388	2,588832
389	2,589949
390	2,591065
391	2,592177
392	2,593286
393	2,594393
394	2,595496
395	2,596597
396	2,597695
397	2,598790
398	2,599883
399	2,600973
400	2,602059

Num.	*Logarith.*
401	2,603144
402	2,604226
403	2,605305
404	2,606381
405	2,607455
406	2,608526
407	2,609594
408	2,610660
409	2,611723
410	2,612784
411	2,613842
412	2,614897
413	2,615950
414	2,617000
415	2,618048
416	2,619093
417	2,620136
418	2,621176
419	2,622214
420	2,623249
421	2,624282
422	2,625312
423	2,626340
424	2,627366
425	2,628389
426	2,629409
427	2,630428
428	2,631444
429	2,632457
430	2,633468
431	2,634477
432	2,635484
433	2,636488
434	2,637489
435	2,638489
436	2,639486
437	2,640481
438	2,641475
439	2,642465
440	2,643453
441	2,644439
442	2,645422
443	2,646404
444	2,647383
445	2,648360
446	2,649335
447	2,650308
448	2,651278
449	2,652246
450	2,653213

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
451	2,654177	501	2,699838	551	2,741152
452	2,655138	502	2,700704	552	2,741939
453	2,656098	503	2,701568	553	2,742725
454	2,657056	504	2,702430	554	2,743509
455	2,658011	505	2,703291	555	2,744293
456	2,658965	506	2,704151	556	2,745075
457	2,659916	507	2,705008	557	2,745855
458	2,660865	508	2,705864	558	2,746634
459	2,661813	509	2,706718	559	2,747412
460	2,662758	510	2,707570	560	2,748188
461	2,663701	511	2,708421	561	2,748963
462	2,664642	512	2,709269	562	2,749736
463	2,665581	513	2,710117	563	2,750508
464	2,666518	514	2,710963	564	2,751279
465	2,667453	515	2,711807	565	2,752048
466	2,668386	516	2,712649	566	2,752816
467	2,669317	517	2,713491	567	2,753583
468	2,670246	518	2,714329	568	2,754348
469	2,671173	519	2,715167	569	2,755112
470	2,672098	520	2,716003	570	2,755875
471	2,673021	521	2,716838	571	2,756636
472	2,673942	522	2,717671	572	2,757396
473	2,674861	523	2,718502	573	2,758155
474	2,675778	524	2,719331	574	2,758912
475	2,676694	525	2,720159	575	2,759668
476	2,677607	526	2,720986	576	2,760422
477	2,678518	527	2,721811	577	2,761176
478	2,679428	528	2,722634	578	2,761928
479	2,680336	529	2,723456	579	2,762679
480	2,681241	530	2,724276	580	2,763428
481	2,682145	531	2,725095	581	2,764176
482	2,683047	532	2,725912	582	2,764923
483	2,683947	533	2,726727	583	2,765669
484	2,684845	534	2,727541	584	2,766413
485	2,685742	535	2,728354	585	2,767156
486	2,686636	536	2,729165	586	2,767898
487	2,687529	537	2,729974	587	2,768638
488	2,688419	538	2,730782	588	2,769377
489	2,689309	539	2,731589	589	2,770115
490	2,690196	540	2,732394	590	2,770852
491	2,691081	541	2,733197	591	2,771587
492	2,691965	542	2,733999	592	2,772322
493	2,692847	543	2,734799	593	2,773055
494	2,693727	544	2,735599	594	2,773786
495	2,694605	545	2,736397	595	2,774517
496	2,695482	546	2,737192	596	2,775246
497	2,696356	547	2,737987	597	2,775974
498	2,697229	548	2,738781	598	2,776701
499	2,698101	549	2,739572	599	2,777427
500	2,698970	550	2,740363	600	2,778151

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
601	2,778874	651	2,813581	701	2,845718
602	2,779596	652	2,814248	702	2,846337
603	2,780317	653	2,814913	703	2,846955
604	2,781037	654	2,815578	704	2,847573
605	2,781755	655	2,816241	705	2,848189
606	2,782473	656	2,816904	706	2,848805
607	2,783189	957	2,817565	707	2,849419
608	2,783904	658	2,818226	708	2,850033
609	2,784617	659	2,818885	709	2,850646
610	2,785329	660	2,819543	710	2,851258
611	2,786041	661	2,820201	711	2,851869
612	2,786751	662	2,820858	712	2,852479
613	2,787460	663	2,821514	713	2,853089
614	2,788164	664	2,822168	714	2,853698
615	2,788875	665	2,822822	715	2,854306
616	2,789581	666	2,823474	716	2,854913
617	2,790285	667	2,824126	717	2,855519
618	2,790988	668	2,824776	718	2,856124
619	2,791691	669	2,825426	719	2,856729
620	2,792392	670	2,826075	720	2,857332
621	2,793092	671	2,826723	721	2,857935
622	2,793791	672	2,827369	722	2,858537
623	2,794488	673	2,820015	723	2,859138
624	2,795185	674	2,828659	724	2,859739
625	2,795880	675	2,829304	725	2,860338
626	2,796574	676	2,829947	726	2,860937
627	2,797268	677	2,830589	727	2,861534
628	2,797959	678	2,831229	728	2,862131
629	2,798651	679	2,831869	729	2,862728
630	2,799341	680	2,832509	730	2,863323
631	2,800029	681	2,833147	731	2,863917
632	2,800717	682	2,833784	732	2,864511
633	2,801404	683	2,834421	733	2,865104
634	2,802080	684	2,835056	734	2,865696
635	2,802774	685	2,835691	735	2,866287
636	2,803457	686	2,836324	736	2,866878
637	2,804139	687	2,836957	737	2,867467
638	2,804821	688	2,837588	738	2,868056
639	2,805501	689	2,838219	739	2,868643
640	2,806179	690	2,838849	740	2,869232
641	2,806558	691	2,839478	741	2,869818
642	2,807535	692	2,840106	742	2,870404
643	2,808211	693	2,840733	743	2,870989
644	2,808886	694	2,841359	744	2,871573
645	2,809559	695	2,841985	745	2,872156
646	2,810233	696	2,842609	746	2,872739
647	2,810904	697	2,843233	747	2,873321
648	2,811575	698	2,843855	748	2,873902
649	2,812245	699	2,844477	749	2,874482
650	2,812913	700	2,845098	750	2,875061

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
751	2,875639	801	2,903633	851	2,929929
752	2,876218	802	2,904174	852	2,935439
753	2,876795	803	2,904716	853	2,930949
754	2,877371	804	2,905256	854	2,931458
755	2,877947	805	2,905796	855	2,931966
756	2,878522	806	2,906335	856	2,932474
757	2,879096	807	2,906874	857	2,932981
758	2,879669	808	2,907411	858	2,933487
759	2,880242	809	2,907949	859	2,933993
760	2,880814	810	2,908485	860	2,934498
761	2,881385	811	2,909021	861	2,935003
762	2,881955	812	2,909556	862	2,935507
763	2,882525	813	2,910051	863	2,936011
764	2,883093	814	2,910624	864	2,936514
765	2,883661	815	2,911158	865	2,937016
766	2,884229	816	2,911690	866	2,937518
767	2,884795	817	2,912222	867	2,938019
768	2,885361	818	2,912773	868	2,938519
769	2,885926	819	2,913284	869	2,939019
770	2,886491	820	2,913814	870	2,939519
771	2,887054	821	2,914343	871	2,940018
772	2,887617	822	2,914872	872	2,940516
773	2,888179	823	2,915399	873	2,941014
774	2,888741	824	2,915927	874	2,941511
775	2,889302	825	2,916454	875	2,942008
776	2,889862	826	2,916980	876	2,942504
777	2,890421	827	2,917506	877	2,942999
778	2,890979	828	2,918030	878	2,943495
779	2,891537	829	2,918555	879	2,943989
780	2,892095	830	2,919078	880	2,944483
781	2,892651	831	2,919601	881	2,944976
782	2,893207	832	2,920123	882	2,945468
783	2,893762	833	2,920645	883	2,945961
784	2,894316	834	2,921166	884	2,946452
785	2,894869	835	2,921686	885	2,946943
786	2,895423	836	2,922206	886	2,947434
787	2,895975	837	2,922725	887	2,947924
788	2,896526	838	2,923244	888	2,948415
789	2,897077	839	2,923762	889	2,948902
790	2,897627	840	2,924279	890	2,949390
791	2,898176	841	2,924796	891	2,949878
792	2,898725	842	2,925312	892	2,950365
793	2,899273	843	2,925825	893	2,950851
794	2,899821	844	2,926342	894	2,951338
795	2,900367	845	2,9268857	895	2,951823
796	2,900913	846	2,927370	896	2,952308
797	2,901458	847	2,927883	897	2,952792
798	2,902003	848	2,928396	898	2,953276
799	2,902547	849	2,928908	899	2,953759
800	2,903089	850	2,929419	900	2,954243

The Table of Logarithms.

Num.	*Logarith.*	*Num.*	*Logarith.*	*Num.*	*Logarith.*
901	2,954725	935	2,970812	968	2,985875
902	2,955207	936	2,971276	969	2,986324
903	2,955688	937	2,971739	970	2,986772
904	2,956168	938	2,972203	971	2,987219
905	2,956640	939	2,972666	972	2,987666
906	2,957128	940	2,973128	973	2,988113
907	2,957607	941	2,973589	974	2,988559
908	2,958086	942	2,974050	975	2,989005
909	2,958564	943	2,974512	976	2,989449
910	2,959041	944	2,974972	977	2,989895
911	2,959518	945	2,975432	978	2,990339
912	2,959995	946	2,975891	979	2,990783
913	2,960471	947	2,976349	980	2,991226
914	2,960946	948	2,976808	981	2,991669
915	2,961421	949	2,977266	982	2,992111
916	2,961895	950	2,977724	983	2,992554
917	2,962369	951	2,978181	984	2,992995
918	2,962842	952	2,978637	985	2,993436
919	2,963315	953	2,979093	986	2,993877
920	2,963788	954	2,979548	987	2,994317
921	2,964259	955	2,980003	988	2,994756
922	2,964731	956	2,980458	989	2,995196
923	2,965202	957	2,980912	990	2,995635
924	2,965672	958	2,981366	991	2,996074
925	2,966142	959	2,981819	992	2,996512
926	2,966611	960	2,982271	993	2,996949
927	2,967079	961	2,982723	994	2,997386
928	2,967548	962	2,983175	995	2,997823
929	2,968016	963	2,983626	996	2,998259
930	2,968483	964	2,984077	997	2,998695
931	2,968949	965	2,984527	998	2,999133
932	2,969416	966	2,984977	999	2,999565
933	2,969882	967	2,985426	1000	3,000000
934	2,970347				

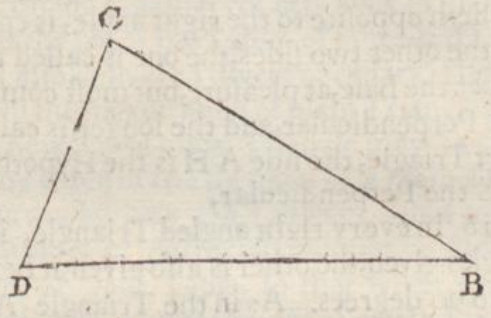
Chap.

CHAP. III.

The use of the Tables of Sines and Logarithms in the resolving of Plain Triangles.

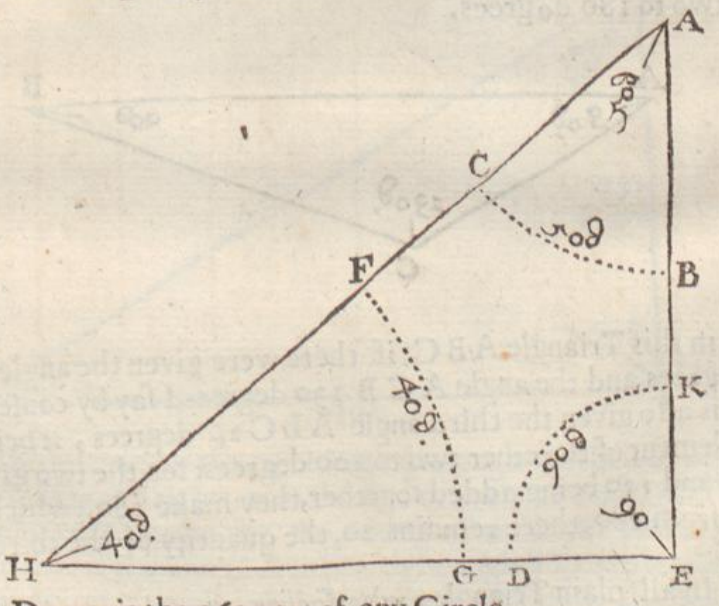
BEfore I come to shew how the quantity of the sides and angles of any Triangle may be found by help of the former Tables, it will be convenient first to deliver these following considerations and Theoremes, as necessaries thereunto.

1 A Triangle is a figure consisting of three sides and three angles, as is the figure D B C.



2 Any two sides of a Triangle are called the sides of the angle comprehended by them, as the sides C B and D B are the sides containing the angle C B D.

3 The measure of an Angle, is the quantity of an arch of a Circle described on the angular point, and cutting both the containing sides of the same angle, as in the Triangle following, the arch C B, is the measure of the angle at A; the arch K D is the measure of the angle at E; and the arch F G is the measure of the angle at H; each of these arches are described on the angular points A, H, E, and cut the containing sides.



4 A Degree is the 360 part of any Circle.

5 A Semicircle containeth 180 degrees.

6 A Quadrant containeth 90 degrees.

5 The complement of an angle lesse then a Quadrant, is so much as that angle wanteth of 90 degrees, as if the angle H A E should contain 50 degrees, the complement thereof would be 40 degrees, for if you take 50 from 90 there will remain 40.

8 The

8 The complemtnt of an angle to a Semicircle, is the remainder thereof to 180 degrees.

9 An angle is either Right, Acute, or Obtuse.

10 A Right angle is that whose measure is a Quadrant.

11 An Acute angle is lesse then a right angle.

12 An Obtuse angle is greater then a Quadrant.

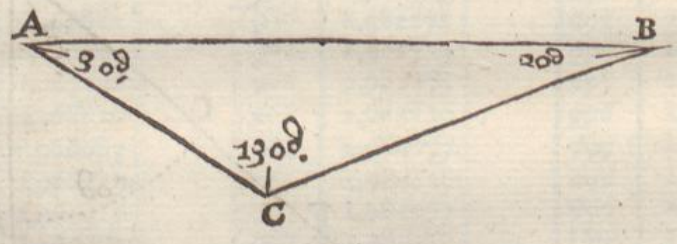
13 A Triangle is either Right angled, or Oblique angled.

14 A Right angled Triangle is that which hath one right angle, as the Triangle A H E is right angled at E.

15 In every right angled Triangle, that side which subtendeth or lieth opposite to the right angle, is called the Hypothenusal, and of the other two sides, the one is called the Perpendicular, and the other the Base, at pleasure, but most commonly the shortest is called the Perpendicular, and the longer is called the Base. So in the former Triagle, the side A H is the Hypothenusal, H E the Base, and A E the Perpendicular.

16 In every right angled Triangle, if you have one of the acute angles given, the other is also given, it being the complement thereof to 90 degrees. As in the Triangle A H E, suppose there were given the angle A H E 40 degrees, then by consequence the angle H A E must be 50 degrees, which is the complement of the other to 90 degrees.

17 The three angles of any right lined Triangle whatsoever, are equal to two right angles, or to 180 degrees; so that if in any right lined Triangle, you have any two of the angles given, yon have the third angle also given, it being the complement of the other two to 180 degrees.



So in this Triangle A B C, if there were given the angle B A C 30 degrees, and the angle A C B 130 degrees, I say by consequence there is also given the third angle A B C 20 degrees, it being the complement of the other two to 100 degrees: for, the two given angle 30 and 130 being added together, they make 160, which being taken from 180, there remains 20, the quantity of the third angle A B C.

18 In all plain Triangles whatsoever, the sides are in proportion one to the other, as the Sines of the angles opposite to those sides. So in the Triangle A B C, the Sine of the angle A C B, is in such proportion to the side A B, as the Sine of the angle C A B is to the side B C, and so of any other.

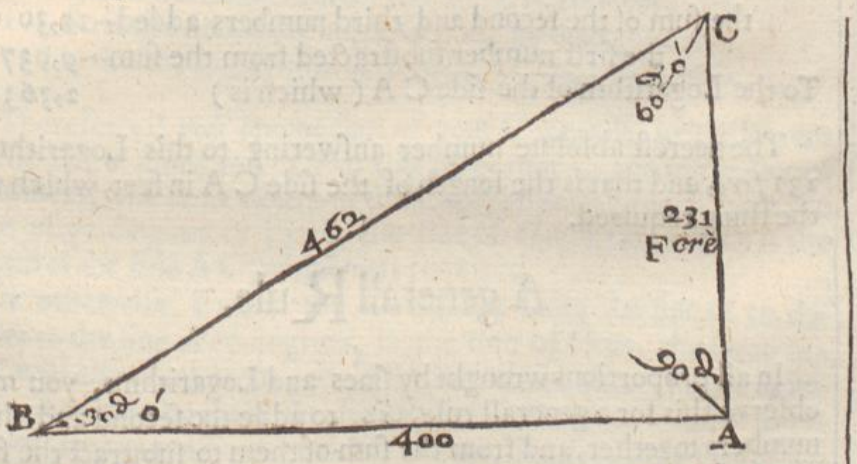
CHAP.

CHAP. IV.

Containing the doctrine of the dimension of right lined Triangles, whether right angled or oblique angled, and the severall Cases therein resolved, both by tables, and also by the Lines of Artificiall Numbers, Sines, and Tangents.

HAving in the foregoing Chapters of this Book explained and shewed the use of the Tables of Sines and Logarithms, and also delivered divers necessary Theorems relating to the mensuration of plain Triangles, I come now to shew how a plain Triangle may be resolved, that is, by having any three of the six parts of a plain Triangle given, to finde a fourth, both by the Tables of Sines and Logarithms, and also by the lines of Artificiall Numbers, Sines and Tangents on the Index of your Table, so that when your Tables are not ready at hand, you may make use of these Lines which will sufficiently supply the want of them.

In all the cases following, I have made use but of two Triangles for Examples, one right angled, and the other oblique angled, but in either of them I have expressed all the varieties that are necessary, so that any three parts being given in any of them, a fourth may be found at pleasure.



The severall cases of the right angled triangle will best be applied in the taking of heights, as is shewed in the next Book, and the oblique angled Triangle for the taking of distances there also taught; so that if the line C A in the right angled Triangle were a Tree, Tower, or Steeple and that you would know the height thereof, you must observe with your Instrument the Angle C B A, and measure the distance B A; so have you in the right angled Triangle A B C the Base A B, and the angle at the Base C B A, then may you (by the 1. Case) finde the side C A, which is the height of the thing required.

In the resolving of plain Triangles, there are severall Cases, of which; I will only insist on those that have most relation to the work in hand. And first,

Of Right angled plain Triangles.

CASE I.

In a right angled plain Triangle, the Base and the angle at the Base being given, to finde the Perpendicular.

IN the right angled Triangle following A B C, there is given, the Base thereof B A, 400 foot and the angle at the Base C B A 30 degrees, and it is required to finde the perpendicular C A.

Now because the angle C B A is given, the angle B C A is also given; it being the complement of the other to 90 degrees; and therefore the angle B C A is 60 degrees. Then to finde the perpendicular C A, the proportion is,

As the sine of the angle B C A, 60 degrees (which is) 9,937531

Is to the Logarithm of the side B A, 400 foot (which is) 2,602059
So is the sine of the angle C B A 30 degrees (which is) 9,698970

the sum of the second and third numbers added--12,301029
the first number substracted from the sum---9,937531
To the Logatithm of the side C A (which is) 2,363498

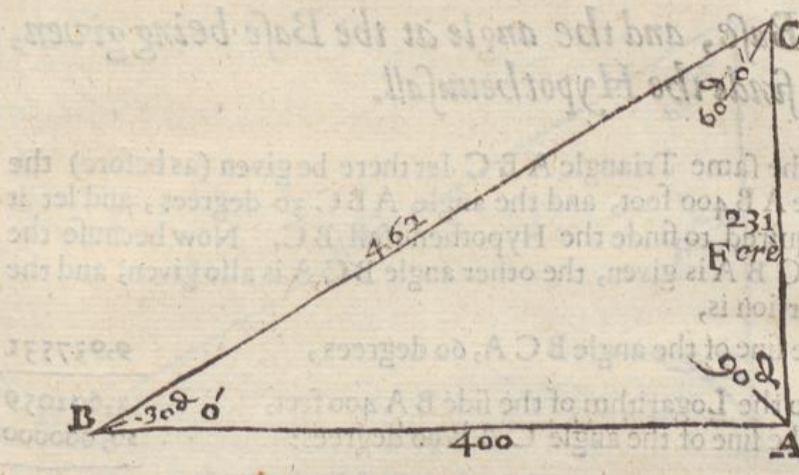
The neerest absolute number answering to this Logarithm is 231 *ferè*, and that is the length of the side C A in feet, which was the thing required.

A generall Rule.

In all proportions wrought by sines and Logarithms, you must observe this for a generall rule, *viz.* to adde the second and third numbers together, and from the sum of them to substract the first number, so shall the remainder answer your question demanded, as by the former work you may perceive, where the Logarithm of the side B A 2,602059 (which is the second term) is added to the sine of the angle C B A 9,698970, (which is the third term) and from the sum of them (namely from 12,301029 is substracted 9,937531, the sine of the angle B C A, which is the first number, and there remaineth, 2,363498, which is the Logarithme of 231 almost, and that is the length of the side required in feet.

The

The same manner of worke is to be obserued in all the Cases following as will plainly appear.



How to perform the same work, by the lines of Sines and Numbers.

These kinde of proportions are wrought more easily by help of the lines of artificiall Numbers, Sines and Tangents on the Index of your Table, and exact enough for any ordinary occasion, for the proportion being,

As the sine of the angle B C A, 60 degrees,
Is to the Logarithm of the side B A 400 feet,
So is the sine of the angle C B A, 30 degrees,
To the Logarithm of the side A C 231 feet, *ferè.*

Therefore, if you set one foot of your Compasses at 60 degrees in the line of Sines and extend the other foot to 400 in the line of Numbers; the same extent of the Compasses will reach from the Sine of 30 degrees to 231 in the line of Numbers, which is the length of the side A C, which was required

Or otherwise, Extend the Compasses from the sine of 30 degrees to the sine of 60 degrees, in the line of Sines, the same extent will also reach irom 400, in the line of Numbers, to 231 as before. And thus by these Artificiall Lines, the work is much abreviated there being need neither of pen, inke, paper, or Tables, but only of your Compasses.

CASE II.

The Base, and the angle at the Base being given, to finde the Hypotheunsall.

IN the same Triangle A B C let there be given (as before) the Base A B 400 foot, and the angle A B C 30 degrees, and let it be required to finde the Hypothenusall B C. Now because the angle C B A is given, the other angle B C A is also given, and the proportion is,

As the sine of the angle B C A, 60 degrees,	9,937531
Is to the Logarithm of the side B A 400 feet,	2,602059
So is the sine of the angle C A B 90 degrees:	10,000000
the sum of the second and third numbers added--	12,602959
the first number substracted from the sum---	9,937531
To the Logarithm of the side B C: which is,	2,665428

The absolute number answering to this Logarithm is 462, and so many feet is the Hypothenusal B C.

By the Lines of Sines and Numbers:

The manner of work is altogether the same with the former, for the proportion being.

As the Sine of the angle B C A 60 degrees,
Is to the length of the side B A 400 foot;
So is the sine of the angle C A B 90 degrees,
To the length of the side C B 462.

Extend the Compasses from the sine of 60 degrees to 400 in the line of Numbers, the same extent will reach from the Sine of 90 degrees to 462 in the line of Numbers, and that is length of the side B C.

Or you may extend the Compasses from the Sine of 60 degrees to the Sine of 90 degrees, the same extent will also reach from 400 to 462, as befor.

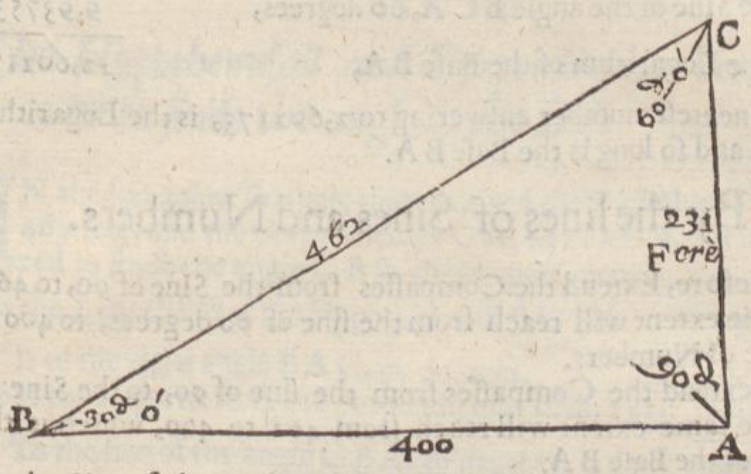
CASE III.

The Hypothenusall, and angle at the Base being given, to finde the Perpendicular.

IN the same Triangle, let there be given the Hypothenusal B C 462 feet, and the angle at the Base C B A 30 degrees, to find the perpendicular C A.

The

The angle C A B is a right angle or 90 degrees, therefore the proportion is,



As the Sine of the angle C A B 90 degrees,	10,0 00000
Is to the Logarithme of the side B C 462;	2,664642
So is the Sine of the angle C B A 30 degrees,	9,698970
To the Logarithme of the side C A	12,363612

The number answering to this Logarithme is 231 *ferè*, and that is the length of the side C A in feet.

Here the Work is somewhat abreviated, for the angle C A B being a right angle, and being the first term, when the second and third terms are added together, the first is easily subtracted from it by cancelling the figure next your left hand, as you see in the example; and so the rest of that number is the Logarithme of the number sought.

By the lines of Sines and Numbers.

Extend the Compasses from the Sine of 90 degrees to 462, the same extent will reach from the Sine of 30 degrees to 231.

Or extend the Compasses from the Sine of 90 degrees to the Sine of 30 degrees, the same extent will reach from 462 to 231; and that is the side C A.

CASE IV.

The Hypothenusall and angle at the Base being given, to finde the Base.

LEt there be given in the former Triangle the Hypothenusal B C, and the angle at the base C B A, and by consequence the angle B C A the complement of the other to 90; then to finde B A, the proportion is,

As

As the Sine of the angle C A B, 90 degrees	10,000000
Is to the Hypothenusall B C, 462	2,664642
So is the Sine of the angle B C A, 60 degrees,	9,937531
To the Logarithm of the Base B A,	12,602173

The neereſt number anſwering to 2,602173, is the Logarithm of 400, and ſo long is the Baſe B A.

By the lines of Sines and Numbers.

As before, Extend the Compaſſes from the Sine of 90, to 462, the ſame extent will reach from the ſine of 60 degrees, to 400 in the line of Numbers.

Or, extend the Compaſſes from the ſine of 90, to the Sine of 60, the ſame extent will reach from 462 to 400, which is the length of the Baſe B A.

CASE V.

The Perpendicular, and angle at the Baſe being given, to finde the Hypothenuſall.

IF the Perpendicular C A be given 231, and the angle at the Baſe C B A 30 degrees, the Hypothenuſall B C may be found thus; for,

As the ſine of the angle C B A, 30 degrees,	9,698970
Is to the Logarithm of the perpendicular C A 231	12,363612
So is the Sine of the angle C A B, 90 degrees,	10,000000
To the Logarithm of the Hypothenuſall B C	2,664642

Here, becauſe the angle C A B is a right angle, or 90 degrees, and comes in the third place, I therefore only put an unite before the ſecond term, and from that ſecond term ſubſtract the firſt terme, and the remainder is, 2,664642, the abſolute number anſwering thereunto is 462, the ſide B C.

By the lines of Sines and Numbers.

Extend the Compaſſes from the ſine of 30 degrees, to 231, the ſame extent will reach from the ſine of 90 degrees to 462.

Or, the diſtance between the Sine of 30 degrees and 90 degrees, will be equall to the diſtance between 231, and 462, which giveth the ſide required.

CASE

CASE VI.

The Hypothenusall and Perpendicular being given to finde the angle at the Base.

IN the foregoing Triangle there is given the Hypothenusall B C 462 feet, and the perpendicular C A, 231 feet, and it is required to finde the angle C B A, the proportion is,

As the Logarithm of the Hypothenusall B C 462	2,664642
Is to the right angle B A C, 90 degrees,	10,000000
So is the Logarithm of the perpendicular C A, 231,	12,363612
To the sine of the angle C B A, 30 degrees.	9.698970

By the Lines of Sines and Numbers.

Extend the Compasses from 462, to the sine of 90, the same extent will reach from 231 to the sine of 30 degrees.

Or, Extend the Compasses from 462 to 231, the same extent will reach from the sine of 90 degrees, to the sine of 30 degrees, which is the quantity of the enquired angle C B A.

Of obliquc angled plain Triangles.

CASE VII.

Having two angles and a side opposite to one of them given, to finde the side opposite to the other.

IN the Triangle Q R S, there is given the angle Q S R 24 deg. 20 min. and the angle Q R S 45 degrees 10 minutes, and the side Q S 303 feet, and it is required to finde the side Q R.

¶ Here note, that in oblique angled plain Triangles, as well as in Right angled, the sides are in proportion one to the other, as the Sines of the angles opposite to those sides. Therefore,

As the sine of the angle Q R S 45 deg. 10 min.	9,850745
Is to the Logarithm of the side Q S 303 feet,	2,481443
So is the sine of the angle Q S R 24 degrees 20 min.	9,614944
the sum of the second and third terms--	12,096387
the first terme substracted--	9,850745
To the Logarithm of the side Q R,	2.245642

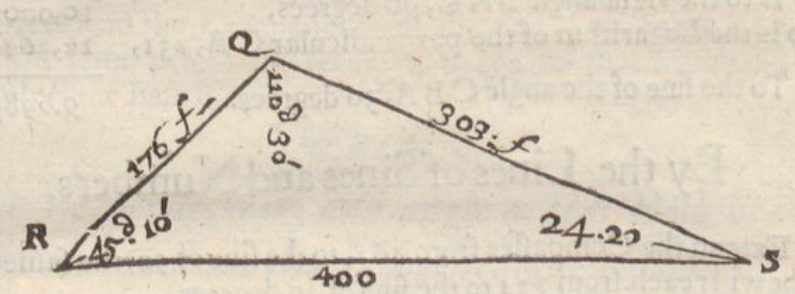
The neerest absolute number answering to this Logarithm is 176, and so many feet is the side Q R.

By the lines of Sines and Numbers.

The lines of Sines and Numbers will resolve these Triangles by the same manner of work as in the other before. For,

If you extend the Compasses from the Sine of 45 deg. 10 min. to 303, the same extent will reach from the Sine of 24 degrees 20 minutes, to 176, and so much is the side QR.

Or, Extend the Compasses from the Sine of 45 degrees 10 min. to 24 degtees 20 minutes, the same Extent will reach from 303, to 176, the length of the inquired side.



In like manner, if the Angle R Q S 110 degrees 30 minutes, and the Angle Q R S 45 degrees 10 minutes, and the side Q S 303 feet, had been given, and the side R S required, the manner of work had been the same; for,

As the sine of the Angle Q R S 45 degrees 10 min.	9,850745
Is to the Logarithm of the side Q S 303 feet,	2,481443
So is the Sine of R Q S 110 deg. 30 min. (or 69 deg. 30 m.)	9,971588
the sum of the second and third terms--	12,453031
the first terme substracted---	9,850745
To the Logarithm of the side R S,	2,602286

The absolute number answering to this Logarithm is 400, and so much is the side R S.

¶ In this case, because the angle R Q S is more then 90 degrees, you must therefore take the complement thereof to 180 degrees, so 110 degrees 30 minutes, being taken from 180 degrees, there remains 69 degrees 30 min. whose Sine is the same with 110 deg. 30 min. and being used in stead thereof, will effect the same thing.

By the lines of Sines and Numbers.

Extend the Compasses from the Sine of 45 degrees 10 min. to 303, the same extent will reach from the sine of 69 deg. 30 min. to 400. which is the side R S required.

Or

Or the Compasses being opened to the distance between the sine of 45 deg. 10 min. and 69 deg. 30 min. the same distance will reach from 303 to 400 as before.

CASE VIII.

Two sides and an angle opposite to one of them being given, to find the angle opposite to the other.

IN the same Triangle, let there be given, the side QS 303, and QR 176, together with the angle QSR 24 degrees 20 minutes, and let it be required to find the angle QRS, the proportion is,

As the Logarithm of the side QR 176,	2,245513
Is to the sine of the angle QSR, 24 deg. 20 min.	9,614944
So is the Logarithm of the side QS 303.	2,481443
The sum of the second and third numbers---	12,096387
The first number subtracted from the sum---	2,245513
To the sine of the angle QRS.	9,850374

The neerest degree answering to this sine is 45 degrees 10 min. which is the quantity of the angle QRS, required.

By the lines of Sines and Numbers.

Extend the Compasses from 176, to the sine of 24 degrees 20 minutes, the same extent will reach from 303 to 45 deg. 10 min. the angle QRS.

Or, the distance between 176 and 303 will be equal to the distance between 24 degrees 20 minutes, and 45 deg. 10 min.

CASE IX.

Having two sides, and the angle contained by them given, to find either of the other angles.

THis Case will seldome come in use in Surveying, because the thing required is an angle, which are most commonly given, they being observed by Instrument, and therefore in this place may be omitted, partly because the proposition is not wrought by Sines and Logarithms, but by Tangents and Logarithms; and there is no Tables of Tangents in this Book, to work the proportion by: Yet those that are desirous to resolve all kinde of Triangles by the proportionall lines, may have added to the lines of artificial sines and Numbers, a line of artificial Tangents, and these three lines

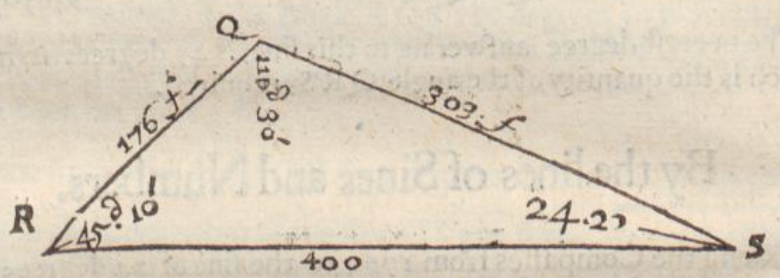
together, will resolve all Cases in Spherical, as well as in plain Triangles.

For the performance of this Probleme, suppose there were given the side Q S 303, and the side R Q 176, and the angle comprehended by them; namely, the angle R Q S 110 degrees 30 minutes, and it were required to find either of the other angles.

First, Take the sum and difference of the two given sides, their sum is 479, and their difference is 127. Then knowing that the three angles of all right lined Triangles are equal to two right angles, or 180 deg. (*by the* 17 *Theor. of Chap.* 3.) therefore the angle R Q S being 110 deg. 30 minutes, if you subtract this angle from 180 degrees, the remainder will be 69 deg. 30 min. which is the sum of the two unknown angles at R and S, the half whereof is 34 deg. 45 min.

The side Q S,	303
The side Q R	176
The sum of the sides,	479
The difference of the sides,	127

The half sum of the two unknown angles 34 deg. 45 min.



The sum and difference of the sides being thus found, and also the half sum of the two unknown angles, the proportion by which you must find the angles severally is,

As the Logarithm of the sum of the sides, 479,	2,680335
Is to the Logarithm of the difference of the sides, 127,	2,103804
So is the Tangent of the half sum of the two unknown angles 34 degrees, 45 minutes,	9,841187
the sum of the second and third numbers	11,944991
the first number subtracted	2,680335
To the Tangent of 10 degrees 25 minutes,	9,264656

These

These ten degrees 25 minutes, being added to the half sum of the two unknown angles, namely, to 34 degrees 45 minutes; the sum will be 45 degrees 10 minutes, the quantity of the angle QRS, which is the greater angle of the two: Also, these ten degrees 25 minutes, being substracted from the same half sum, there remaineth 24 degrees 20 minutes for the angle QSR, which is the lesser of the unknown angles: and thus are either of the enquired angles easily found.

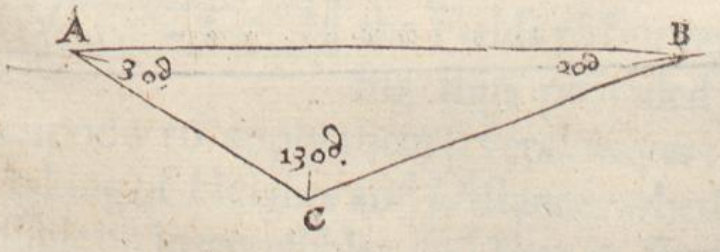
By the lines of Tangents and Numbers.

Extend the Compasses from the sum of the sides 479, to the difference of the sides 127, the same extent upon the line of Tangents wil reach from the Tangent of 34 degrees 45 minutes (which is the half sum of the two unknown angles) to the Tangent of ten degrees 25 minutes, and these ten degrees 25 minutes, added to, and subracted from the half sum, as before is shewed, will give the quantity of either of the two unknown angles.

CASE X.

The three sides of a right lined Plain Triangle being given, how to finde the Area, or the superficiall content thereof.

First, Add the three sides together, and from the half summe substract each side severally, to the end you may have the difference betwixt that halfe summe and each side: this done adde



the Logarithms of the said halfe summe, and of those differences together: and lastly, dividing the summe of those Logarithms by 2, you have the Logarithm of the superficiall content or area of the Triangle.

EXAMPLE.

Let the Triangle given be ABC, the sides thereof being 20, 13, 11, how much is the superficiall content thereof?

The sum of the sides is 44, the half summe is 22, the differences betwixt each side and that half are 2, 9, 11, which numbers rank in this order following.

The half sum,	22	1,342423
The differences,	2	0,301030
	9	0,954243
	11	1,041393
The sum of the Logarithms		3,639089
The Area or Content required, 66.		1,819544

And this Area, or superficial Content thus found, is alwayes of the same nature with the sides of the Triangle, that is to say, if the sides of the Triangle, be given in feet, then is the content found in feet; also, if the sides be Perches, you shall have the content in Perches, and so of any other measure whatsoever. I might add hereunto divers other Cases, but in this place at present let these suffice.

The end of the third Book.

THE COMPLEAT SURVEYOR:

The Fourth Book.

THE ARGUMENT.

IT hath hitherto been our busines to provide necessary Instruments, and to learn such things, which of necessity ought to be known before we enter the Fields to Survey. Being thus provided, wee come now to apply them several wayes: First, in taking of Heights and Distances whether accessible or in-accessible; and then in Surveying of Land. In this Book every kinde of work is performed three several ways, by three several *Instruments, viz.* the *Plain Table*, the *Theodolite*, and *Circumferentor*, by which the congruity and harmony of the several *Instruments* may be

easily discerned, and the truth of every *Example* may the better appear. Here is also divers ways of *Surveying* by one and the same *Instrument*, that is, to take the *Plot* of a *Field* several ways, and to measure all kind of *Grounds* whatsoever, whether *Woodland* or other. Here is also shewn how to take the *Plot* of a whole *Mannor*, and to keep your *account* in your *Field Book*, after the best and most easiest manner: with divers *Rules*, *Cautions* and *Directions*, throughout the whole *Book* inserted.

THE APPLICATION AND VSE of the ſeveral Inſtruments (before deſcribed) in the practice of SURVEYING.

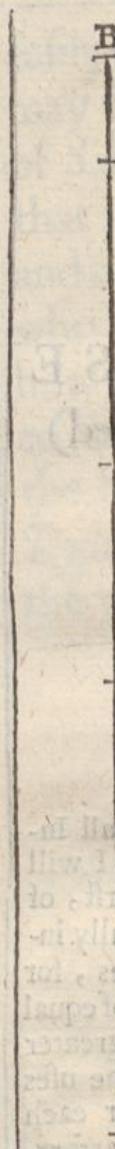
CHAP. I.

The uſe of the Scale.

HAving before deſcribed the ſeverall Inſtruments belonging to Surveying, I will now ſhew the uſe of them: and firſt, of the Scale. The Scale is principally intended for the laying out of lines, for which purpoſe the ſeveral Scales of equal parts are there divided, ſome of greater and ſome of leſſer quantities: the uſes of all the lines being the ſame, for each line is divided into certain equal parts repreſenting 11 Chains, & theſe grand diviſions are numbred with Arithmeticall Figures by 1, 2, 3, &c. to 10, then the uppermoſt large diviſion is again divided into ten other ſmaller parts, each part containing 10 links of your chain, each of which ſmaller parts you may ſuppoſe to be again divided into ten other leſſer parts, repreſenting ſingle Links of your Chain.

1 *Any length being meaſured by your Chain, how to lay down the ſame diſtance upon Paper.*

Suppoſe, that meaſuring a long a hedge with your Chain, you finde the length thereof to contain 5 Chains 60 Links: Now to take this diſtance from your Scale, and lay it down upon paper do thus. Firſt, Draw a line as AB, then place one foot of your Compaſſes upon your Scale at the figure 5. for your five Chains, and



extend the other foot to six of the smal divisions (which represents the 60 Links) then set this distance upon the line drawn from A to B, so shall the line A B contain 5 Chains 60 Links, if you take the distance from the Scale of 10 in an Inch.

But if you would have your line shorter, and yet to contain 5 Chains 60 links, then take your distance from a smaller Scale, as of 12, 16, 20, or 24 in an Inch, so shall the 5 Chains 60 Links end at C, if taken from the Scale of 12 in an iuch, or at D, by the Scale of 16, or at E by the Scale of 24: either of which lines will contain 5 Chains 60 Links, and be in proportion one to the other as the Scales from whence they were taken. And in this manner may any number of Chains and Links be taken from any of the Scales.

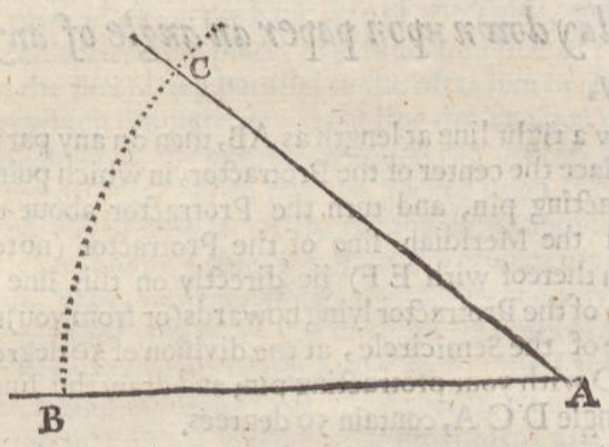
2 *A right line being given, to find how many Chains and Links are therein contained, according to any Scale assigned.*

Suppose A B were a line given, and it were required to find how many Chains and Links are contained therein, according to the Scale of 10 in an Inch. Take in your Compasses the length of the line A B, and applying it to your Scale of 10 in an Inch, you shall finde the extent of the Compasses to reach from 5 of the great divisions, to six of the lesser divisious, wherefore the line A B contains 5 chains and 60 Links: The like must be done for any line, and also by any of the other Scales.

Upon the Ruler there is (besides the several Scales of equal parts) a line or Scale of Chords, which is numbred by 10, 20, 30, &c. to 90, and this line serveth to protract or lay down angles; but in all the practice of Surveying a Protractor is much more convenient, yet for other uses this line may be very serviceable, and when a Protractor is wanting, it may supply that defect: the manner how to use it is thus.

3 *How to lay down upon paper, an angle containing any number of degrees and minutes by the line of Chords.*

Draw a line as pleasure, as A B, and from the point A, let it be required to protract an angle of 40 degrees 20 minutes. First, extend your Compasses upon the line of Chords, from the beginning thereof to 60 degrees alwayes, and with this distance, setting one foot



foot upon the point A, with the other describe the pricked arch B C, then with your Compasses take 40 degrees 20 minutes (which is the quantity of the inquired angle) out of the line of Chords, from the beginning thereof to 40 degrees 20 minutes then (the Compasses so resting) if you set one foot thereof upon B the other will reach upon the arch to C. Lastly, draw the line A C, so the angle CAB shall contain 40 degrees 20 minutes

4 *Any angle being given to finde what number of degrees and minutes are contained therein.*

Suppose C A B were an angle given, and that it were required to finde the quantity thereof. Open your Compasses (as before to 60 degrees of your Chord, and placing one foot in A, with the other describe the arch C B, then take in your Compasses the distance C B, and measuring that extent upon the line of Chords from the beginning thereof, you shall finde it to reach to 40 degrees 20 minutes, which is the quantity of the required angle.

If any angle given or required shall contain above 90 degrees, you must then protract it at twice, by taking first the whole line, and then the remainder.

CHAP. II.

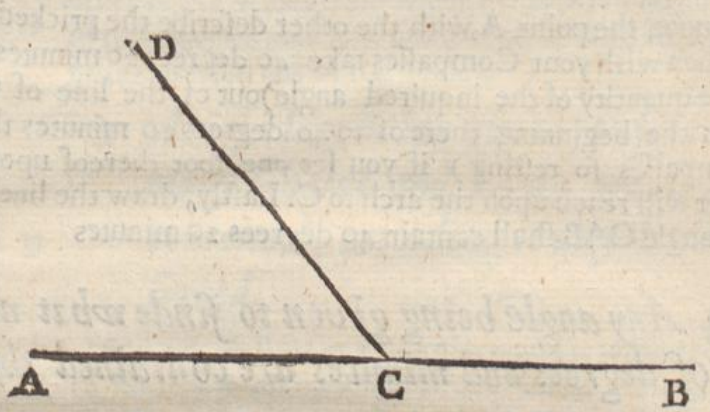
Of the use of the Protractor.

ALthough the chief uses of the Protractor may be performed by the line of Chords last spoken of, yet for avoiding superfluous lines and arches (which must otherwise be drawn all over your Plot) the Protractor is far more convenient, the use whereof is,

1. To

1 *To lay down upon paper an angle of any quantity.*

First, draw a right line at length as AB, then on any part thereof, as on C, place the center of the Protractor, in which point also fix your protracting pin, and turn the Protractor about upon the center, till the Meridian line of the Protractor (noted in the description thereof with E F) lie directly on this line A B, the Semicircle of the Protractor lying upwards (or from you) then close to the edge of the Semicircle, at the division of 50 degrees, mark the point D with your protracting pin; and draw the line CD, so shall the angle D C A, contain 50 degrees.



2 *Any angle being given, to find the quantity thereof by the Protractor.*

Suppose DCB were an angle given, and that it were required to finde the quantity thereof by the Protractor. First, you must apply the center of the Protractor to the point C, and the Meridian line thereof directly upon the line DC, then shall you finde the line CB to lie directly under 130 degrees of the Protractor, and such is the quantity of the angle D C B required.

CHAP. III.

Of the Plain Table, how to set the parts thereof together, and make it fit for the Field.

When you would make your Table fit for the field, lay the three boards thereof together, and also the ledges at each end thereof in their due places, according as they are marked. Then lay a sheet of white paper all over the Table which must be stretched over all the boards by putting on the Frame, which bindes both the paper to the boards, and the boards one to another.

Then

Then screw the Socket on the back side of the Table, and also the Box and Needle in its due place, the Meridian line of the Card (which is in the Box) lying parallel to the Meridian or Diameter of the Table; which diameter is a right line drawn upon the Table from the beginning of the degrees through the center, and so to the end of the degrees. Then put the Socket upon the head of the Staffe, and there screw it. Also, put the sights into the Index, and lay the Index on the Table, so is your Instrument prepared for use as a Plain Table or Theodolite, the difference only being in placing of the Index, for when you use your Instrument as a Plain Table, you may pitch your center in any part of the Table, which you shall think most convenient for the bringing on of the worke which you intend: But if you use your Instrument as a Theodolite, then the Index must be turned about upon the Center of the Table, for which purpose there is a piece of wier which goes through a small hole of brass fastened to the Index, and so into the center, by which means the Index keeps his constant place, only moving upon the center.

Your Instrument being thus ordered, you may use it either as a Plain Table or a Theodolite, but if you would use it as a Circumferentor, you need only screw the Box and Needle to the Index, and both of them to the head of the Staffe, with a brasse screw-pin fitted for that purpose, so that the Staffe being fixed in any place, the Index and Sights may turn about at pleasure without moving of the Staff, and now is your Instrument a good Circumferentor, nay better then that before described in the second Book.

Also, when you have occasion to measure any Altitude, hang the Labell upon the farther Sight, and thus are you exactly fitted for all occasions.

CHAP. IV.

How to measure the quantity of any angle in the field, by the Plain Table, Theodolite, *and* Circumferentor: *and also to observe an angle of Altitude.*

YOu must understand that when I mention the Plain Table, or perform any work thereby, that I mean the Table when it is covered with a sheet of paper upon which, al observations of angles that are taken upon the Table in the field do agree exactly in proportion with those of the field it selfe, but are not denominated by their quantities, but by their symetry or proportion.

Secondly, when I mention the Theodolite, or work by that In-

Instrument, I do not mean the Theodolite before described in the 2 *Chapter* of the 2 *Book*, but I mean the degrees described on the frame of the Table, which supplies the use thereof.

Thirdly, When I mention or make use of the Circumferentor, I mean the Index with the Box and Needle screwed to the Staff.

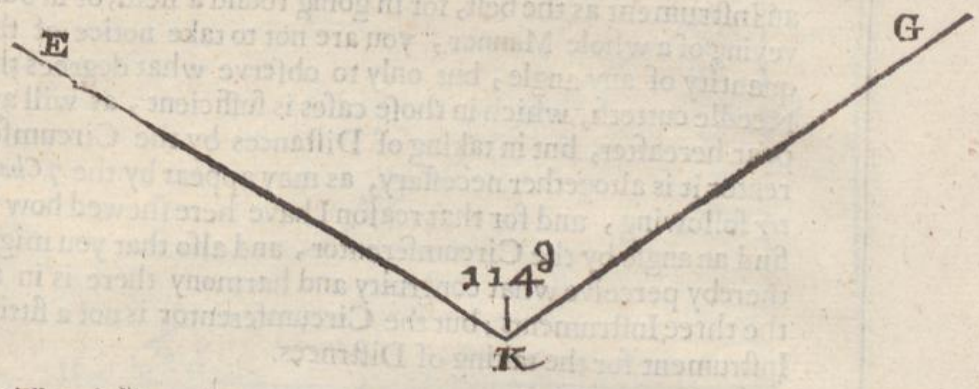
¶ Having thus given you a sufficient description of the severall Instruments and their parts, I come now to the use of them, shewing how any angle in the field may be measured by any of them. And,

1. *How to observe an angle in the Field by the* Plain Table.

Suppose E K and K G to be two hedges, or two sides of a field including the angle E K G, and that it were required to draw upon your Table, an angle equal thereunto. First, place your Instrument as neer the angular point K, as conveniencie will permit, turning it about till the North end of the Needle hang directly over the Flower-de-luce in the Box, and then screw the Table fast. Then upon your Table, with your protracting pin or Compasse point, assigne any point at pleasure upon the Table, and to that point apply the edge of the Index, turning the Index about upon that point, till through the sights thereof you espie a mark set up at E, or parallel to the line E K, and then, with your protracting pin, or Compasse point, or Black-lead, draw a line by the side of the Index to the assigned point upon the Table. Then (the Table remaining immoveable) turn the Index about upon the same point, and direct the sights to a mark set up at G, or parallel thereto, that is, so far distant from G, as your Instrument is placed from K, and then, by the side of the Index, draw another line to the assigned point, so shall you have drawn upon your Table two lines, which shall represent the two hedges E K and K G, and those lines shall include an angle equal to the angle, E K G, and although you know not the quantity of this angle yet you may (by the 1 or 2 *Chapters* of this *Book*) finde the quantity thereof if there were any need, for in working by this Instrument, it is sufficient only to give the symetry or proportion of angles and not their quantities, as in working by the Theodolite or Circumferentor it is. Also, in working by the Plain Table, there needeth no protraction at all, for you shall have upon your Table the true figure of any angle or angles which you observe in the field, in their true positions, without any farther trouble.

2 *How to find the quantity of an angle in the field by the* Theodolite.

Let it be required to find the quantity of the angle E K G by the



the Theodolite: place your Instrument at K, laying the Index on the diameter thereof, then turn the whole Instrument about (the Index still resting on the Diameter) till through the sights you espie the mark at E, then screwing the Instrument fast there, turn the Index about upon the center, till through the sights you espie the mark at G, then note what degrees (on the frame of the Table) are cut by the Index, which you will finde to be 114 degrees, and that is the quantity of the angle E K G.

3 *How find the quantity of any angle in the field by the* Circumferentor.

If it were required to finde the quantity of the former angle E K G, by the Circumferentor; First, place your Instrument (as before) at K, with the Flower-de-luce, in the Card, towards you; then direct your sights to E, and observe what degrees in the Card are cut by the South end of the Needle, which let be 296, then turning the Instrument about the staff (the Flower-de-luce always towards you) direct the sights to G, noting then also what degrees are cut by the South end of the Needle, which suppose 182, this done (alwayes) substract the lesser number of degrees out of the greater, as in this Example 182 from 296, and the remainder is 114 degrees, which is the true quantity of the angle E K G.

Again, the Instrument standing at K, and the sights being directed to E, as before, suppose that the South end of the Needle had cut 79 degrees; and then directing the sights to G, the same end of the Needle had cut 325 degrees, now, if from 325, you substract 79, the remainder is 246, but because this remainder 246 is greater then 180, you must therefore substract 246 the remainder, from 360, and there will remain 114, the true quantity of the inquired angle, and thus you must alwayes do, when the remainder exceedeth 180 degrees.

¶ This adding and substracting for the finding of angles, may seem tedious to some, but here the Reader is desired to take no-

notice, that for quick dispatch the Circumferentor is as good an Instrument as the best, for in going round a field, or in Surveying of a whole Mannor, you are not to take notice of the quantity of any angle, but only to observe what degrees the Needle cutteth, which in those cases is sufficient, as will appear hereafter, bnt in taking of Distances by the Circumferentor it is altogether necessary, as may appear by the 7 *Chapter* following, and for that reason I have here shewed how to find an angle by the Circumferentor, and also that you might thereby perceive what congruity and harmony there is in all the three Instruments: but the Circumferentor is not a fitting Instrument for the taking of Distrnces.

4 *How to set the Index and Labal Horizontal upon the Staff.*

When you have screwed the Index and sights to the Staff as a Circumferentor, before you put the Label upon the brass pin or wier, you must hang a line and plummet upon that pin, and then put on the Label, then move the Index up and down till the thrid and plummet hang directly upon a line which is gaged from under the pin all along the Sight, and then doth the Instrument stand horizontal or level, which it must always do when you take an altitude therewith.

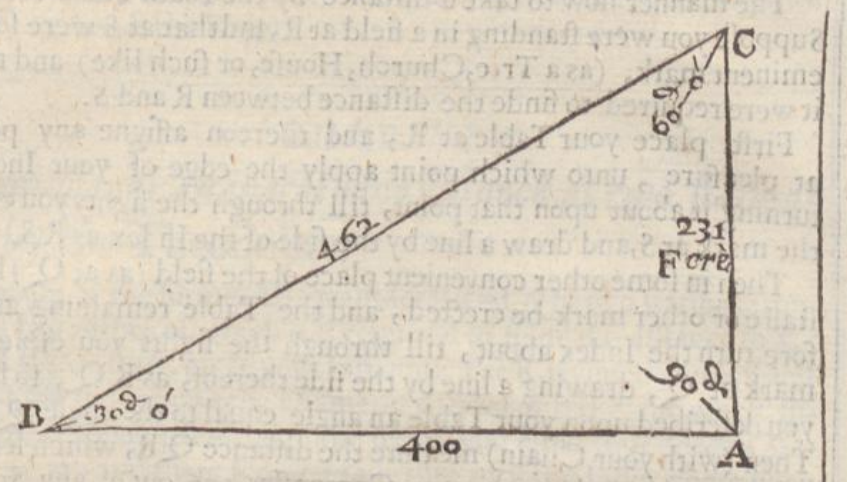
5 *How to observe an Angle of Altitude.*

The Label which is to be hanged on one of the Sights of the Circumferentor (as was intimated in the description thereof) and the Tangent line on the edge of the Index, is only for the finding of angles of altitude, and is therefore only useful in taking of heights, and in surveying of mountanous and un-even grounds.

The manner how to observe an angle of Altitude by this Label, and the Tangent line on the Index, is thus.

Suppose C A to be a Tree, Tower, or Hill, whose height were required. Your Instrument being placed at B, exactly level, direct the sights thereof towards C A, and there fix it, hanging the Label on the fartheſt sight, upon a pin for that purpose; then move the Label too and fro, along the side of the Index, till through the sight at the end of the Label, and by the Pin on which the Label hangeth, you espy the very top of the object to be measured at C, then note what degree of the Tangent line is cut by the Label, which suppose 30, and that is the quantity of the Angle of Altitude, it being equal to the angle C B A.

Thus



Thus by the Rules in this Chapter delivered, may the true quantity of any angle be eaſily taken, and this is the moſt convenient uſe to be firſt placed, I will now ſhew how by your ſeveral Inſtruments you may take all manner of heights and diſtances, whether acceſſible or inacceſſible, ſeveral wayes, with divers other neceſſary concluſions iucident thereunto.

CHAP. V.

How to take an inacceſſible Diſtance at two ſtations by the three fore-mentioned Inſtruments, and firſt by the Plain Table.

YOu are taught in the laſt Chapter how to make obſervation of any angle in the field by the ſeveral Inſtruments before mentioned, as the Plain Table, Theodolite, and Circumferentor, and alſo an angle of Altitude by the Index, and the Label thereunto annexed. I conceive it now convenient to ſhew how all manner of heights and diſtances may be readily and exactly meaſured, ſeveral wayes, whether they be acceſſible or inacceſſible: and firſt of diſtances.

¶ You may remember that I formerly intimated, that the meaſuring of a Height or Diſtance is only to reſolve a Triangle, ſo that when you make any obſervation either of Height or Diſtance, the obſervation of angles which you make are the angles of ſome Triaugle, aud the lines which you meaſure on the ground, are the ſides of the ſame Triangle, and theſe are the given parts of the Triangle.

The manner how to take a distance by the Plain Table is thus, Suppose you were standing in a field at R, and that at S were some eminent mark, (as a Tree, Church, House, or such like) and that it were required to finde the distance between R and S.

First, place your Table at R, and thereon assigne any point at pleasure, unto which point apply the edge of your Index, turning it about upon that point, till through the sights you espie the mark at S, and draw a line by the side of the Index, as R S.

Then in some other convenient place of the field (as at Q) let a staffe or other mark be erected, and the Table remaining as before, turn the Index about, till through the sights you espie the mark at Q, drawing a line by the side thereof, as R Q, so have you described upon your Table an angle equal to the angle Q R S, Then (with your Chain) measure the distance Q R, which let be 176 foot, then take with your Compasses 176 out of any Scale, and set it upon your Table from C to Q, so shall this point Q upon your Table, represent the mark at Q in the field.

This done, set up a staff at R, and remove your Table to Q, laying the Index upon the line Q R, and holding it fast there, turn the whole Table about till through the sights you espie the mark set up at your former place of standing at R: then screw the Table fast, and lay the Index on the point Q, turning it about, till through the sights you espie your mark at S, then draw a line by the side of the Index, which will cut the line R S (first draw) in the point S.

By this means shall you have upon your Table a Triangle equal to the Triangle Q R S, the correspondent sides and angles thereof being proportionally equal with those in the field: therefore if with your Compasses you take the length of the side R S, & apply that distance to the same Scale from whēce you took the side Q R, you shall find it to contain 400 foot, and that is the distance between R and S. Likewise, if you take with your Compasses the length of the line Q S, and apply it to the same Scale, you shall find it to contain almost 303, and so many foot is the distance Q S.

¶ In this manner shall the distance between any two places be measured, although they be so situated, that by reason of water or other impediments you cannot approach neer unto. And here note, that when you take your second station, that you take it as large as the ground will permit, so shall your

your work be so much the truer, by how much the distance taken is the larger.

CHAP. VI.

How to take an inaccessible distance at two stations by the Theodolite.

IN the former Diagram, let R and ♀ be two stations, from either of which it is required to finde the distance to S.

First, place your Instrument at R, laying the Index and sights upon the Diameter thereof turning the whole Instrument about, till through the sights you espie your second station at ♀, and there screw it fast, then turn the Index about upon the center, till through the sights you espy the mark at S, noting the degrees cut by the Index, which suppose 45 degrees 10 minutes Then remove your Instrument to ♀, laying the Index on the Diameter thereof, and holding it there turn the whole Instrument about, till through the sights you espie your mark at S, and fixing the Instrument there, turn the Index about till through the sights you see the mark set up at your former station at R, noting the degrees there cut, which let be 110 degrees 30 minutes. This done, measure the distance of your two stations ♀R, which let be 176 feet, so in the Oblique angled Triangle ♀S R, you have given, (1) the angle S R ♀, 45 degrees 10 minutes, the angle observed at your first station. (2) the angle R ♀S, 110 degrees 30 minutes, which was the angle observed at your second station. And (3) you have given the side R ♀S 176 foot, which is the distance of your two stations: and you are to find the two other sides R S, and ♀S which you may find by the 7 *Case* of the 4th Chapter of the 3 *Book*, in this manner: for,

Having the two angles R ♀S and R ♀S given you have also the third angle R S ♀ given, 24 degrees 20 minutes, it being the complement of the other two to 180 degrees (by the 17th *Chap.* of the 3d, *Lib.* 3.) Then to find the other two sides, the proportion is;

I. For the side ♀S.

As the sine of the angle R S ♀, 24 degrees 20 minutes,
Is to the Logarithm of the side R ♀ 176 foot,
So is the sine of the angle ♀R S 45 degrees, 10 minutes,
To the Logarithm of the side ♀S, 303 foot *ferè*.

II. For the side R S.

As the sine of the angle ♀R S, 45 degrees 10 minutes,
Is to the Logarithm of the side ♀S, 303 foot,
So is the sine of the angle R ♀S 110 d. 30 min. (or 69 d. 30. m.)
To the Logarithm of the side R S, 400 foot.
Which is the distance required.

¶ I have been larger upon this particular then I intended, having sufficiently insisted thereon before in the dimension of plain Triangles) but that the Reader may fully understand these necessary conclusions, I have in this example used all the perspicuity I could imagine, so that in the subsequent Chapters I may be the briefer, for this being well understood, he may easily apprehend any of the other at the first view.

CHAP. VII.

How to take an in-accessible distance at two stations by the Circumferentor.

LEt it be required to find the distance from R and Q to S. First, place your Instrument at R, and direct the sights to S, observing what degrees the South end of the Needle cutteth, which let be 315 degrees 30 min. then turning the Instrument about, direct the sights to Q observing what degrees the Needle there cutteth, which let be 270 degrees 20 minutes, therfore from 315 degrees 30 minutes, substract 270 degrees 20 minutes, and there will remain 45 degrees 10 minutes, which is the quantity of the angle S R Q.

Then remove the Instrument to Q, and direct the sights to R, the Needle cutting 91 degrees 00 minutes, also, direct the sights to S, the Needle cutting 340 degrees 30 minutes, now if you substract 91 degrees 00 minutes, from 340 degrees 30 minutes, the remainder is 249 degrees 30 minutes, which because it exceedeth 180 degrees) substract from 360 degrees, and there remains 110 degrees 30 min. the true quantity of the angle R Q S.

Having thus obtained the two angles R Q S and S R Q, you must measure the stationary distance Q R 176 foot, so have you given in the Tringle Q R S, (1) the angle R Q S 110 degrees 30 minutes, (2) the angle Q R S, 45 degrees 10 minutes, (3) the angle Q S R, 20 degrees 10 minutes, (the complement of the other) two to 180 degrees, and (4) the stationary distance Q R 176 foot, whereby you may find the other sides Q S and R S, according to the doctrine delivered in the foregoing Chapter.

	deg.	*min.*
First station at R, degrees cut	315	30
	270	20
The quantity of the angle Q R S	45	10

Second

	deg.	*min.*
Second station at Q, degrees our	340	30
	91	00
	249	30
	460	00
The quantity of the angle R Q S	100	30

The stationary distance 176 foot.

Having these things given, if you resolve the Triangle Q R S, you shall find the side R S to contain 400 foot, and the side Q S 393 foot *ferè*, as in the last Chapter.

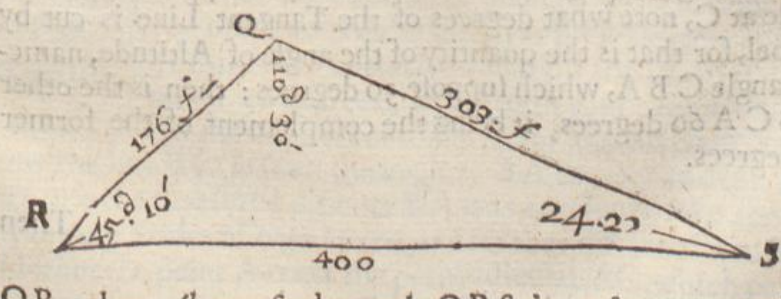
CHAP. VIII.

How to protract or lay down a Distance taken, according to the directions of the two last Chapters, upon paper, by help of your Protractor or line of Chords.

WHen you make any observations in the field, by the Theodolite or Circumferentor, you are to note down the quantities of the several lines and angles observed in the field, in a Book or paper, so that they may be ready at hand when you come to protraction, and this is the usual way.

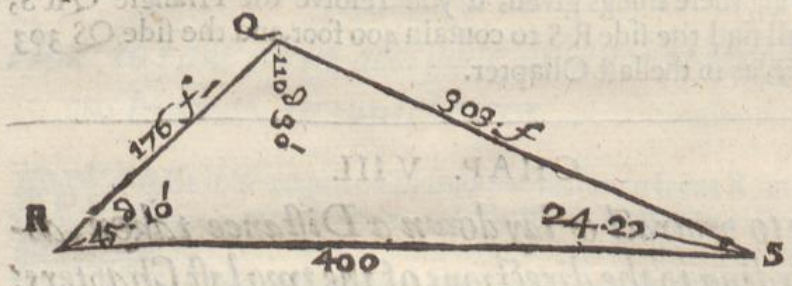
Suppose it were required to draw upon paper or pastbord the true symetry or proportion of the distance taken in the last Chapter.

First, upon your paper draw a line at length as R Q, then, upon one end thereof, as at R, place the center of your Protractor, and lay the Meridian line E F of the Protractor, directly upon the line



Q R: then, (because the angle Q R S is 45 degrees 10 minutes, therfore, against 45 degrees 10 minutes of your Protractor, make a mark upon your paper with your protracting pin (as is before taught *Chap.* 2.) and draw the line R S. This done, from any Scale, take

take your ſtationary diſtance R Q 176 foot, and ſet it from R to Q. Then upon the point Q (becauſe the angle R Q S contains 110 degrees 30 minutes) place the center of the Protractor, and turn it about till the line R Q lie directly under 110 degrees, then (at the point E of the Protractor) make a mark with your protracting pin, and through that point draw the line Q S, which will cut the line R S in the point S: then if you meaſure the length of the lines Q S and R S, by the ſame Scale from whence you took 176 for the line Q R, you ſhall find the line Q S to contain 303, and the line R S to contain 400, exactly agreeing with the numbers found in the laſt Chapter.



CHAP. IX.

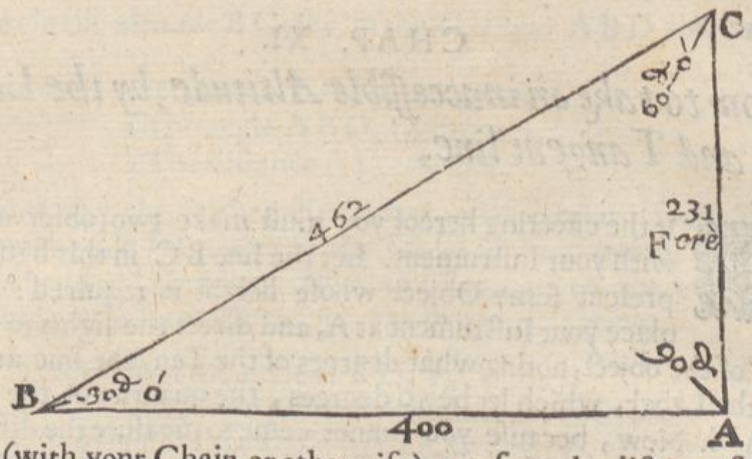
How to take the altitude of any Tower, Tree, Steeple, or the like (being acceſſible) by the Label and Tangent Line.

HAving in the fifth *Section* of the fourth Chapter of this *Book*, ſhewn how to obſerve an angle of Altitude by the Label and Tangent Line, we now come to the further uſe thereof.

Suppoſe therefore that the line C A were a Tree, Towre, Steeple, or other thing, whoſe height were required.

Firſt, place your Inſtrument at any convenient diſtance from the Baſe or foot of the object to be meaſured, as at B, and there looking through the ſights of the Label, till you eſpy the top of the Altitude at C, note what degrees of the Tangent Line is cut by the Label, for that is the quantity of the angle of Altitude, namely, the angle C B A, which ſuppoſe 30 degrees: then is the other angle B C A 60 degrees, it being the complement of the former to 90 degrees.

Then



Then (with your Chain or otherwise) measure the distance from B (the place of your standing) to A, the foot of the thing to be measured,) which suppose 400 foot: Then in the Triangle A B C, there is given (1) the angle C B A 30 degrees, (2) the angle B C A, 60 degrees, and (3) the distance B A 400 foot, and it is required to finde the side C A, by the 1 *Case* of right angled plain Triangles: For,

As the sine of the angle B C A, 60 degrees,
Is to the Logarithm of the side B A 400 foot;
So is the sine of the augle C B A 30 degrees,
To the Logarithm of the side C A.

This proportion being wrought according to the former directions, the side C A will be found to contain almost 231 foot, and that is the height of C A required.

CHAP. X.

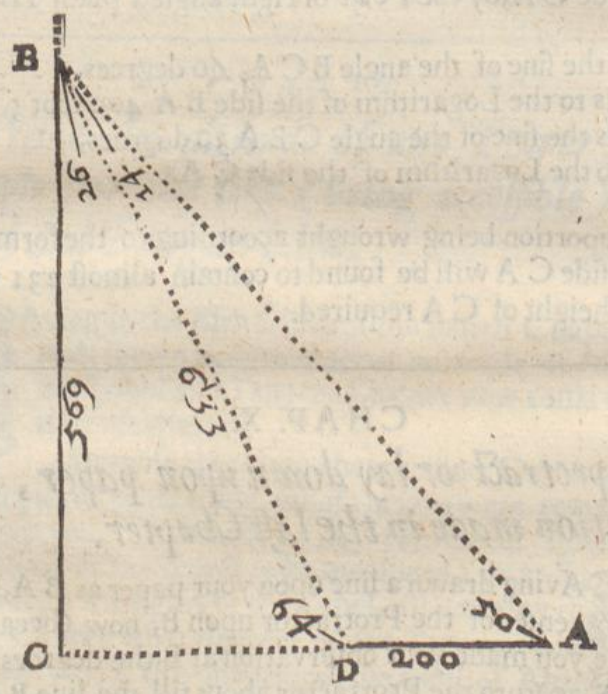
How to protract or lay down upon paper, the observation made in the last Chapter.

HAving drawn a line upon your paper as B A, place the center of the Protractor upon B, now (because when you made your observation at B, the degrees cut were 30) turn the Protractor about till the line B A lie just under 30 degrees, then (with your protracting pin) make a mark by the edge of your Protractor against 00 degrees, & draw the line B C, so shall the angle C B A contein 30 degr. Then (because the measured distance B A was 400 foot,) take 400 from any of your Scales of equal parts, and set that distance from B to A and from the point A, erect the perpendicular AC, which perpendicular being taken in your Compasses, and measured upon the same Scale from whence the 400 foot was taken, you shall find it to contein almost 231 foot, and so much is the altitude C A as before.

CHAP. XI.

How to take an inaccessible Altitude, by the Label and Tangent line,

FOr the effecting hereof you must make two observations with your Instrument. Let the line B C in this figure represent some Object whose height is required: First, place your Instrument at A, and direct the sights to B, the top of the object, noting what degrees of the Tangent line are cut by the Label, which let be 50 degrees, the quantity of the angle B A C. Now, because you cannot come to measure the distance from A to C, by reason of some River or other impediment lying between A and C, therefore, with your Chain, measure out from A towards C, any number of feet, according as the ground will permit, as from A to D, which suppose to be 200 foot, and at D, place



your Instrument again, and there observe the quantity of the angle B D C, which suppose to be 64 degrees, these two angles being known, the two opposite angles are also known, for the angle BAC being 50 degrees, the whole angle A B C must be 40 degrees, the complement of the former to 90 degrees: again, the angle B D C being 64 degrees, the angle DBC must be the complement thereof, namely 26 degrees, then if you substract the angle DBC 26 degrees, from the whole angle A B C 40 degrees, there will remain 14 degrees for the angle A B D, by the knowledge whereof you ma

may attein the altitude B C; for, in the Triangle A B D you have given,

1 The angle B A D, 50 degrees,
2 The angle A B D, 14 degrees,
3 The distance A D 200 foot.

Which (by the former directions) will help you to finde the length of the side DB, either by the Tables in the 5 *Book*, or by the Lines of artificial Numbers, Sines and Tangents on the Index of your Table, as is formerly taught, the proportion being,

As the sine of the angle A B D, 14 degrees,
Is to the Logarithm of the side A D, 200 foot;
So is the sine of the angle B A D, 50 degrees,
To the Logarithm of the side D B.

Which by working according to the former direction, will be found to be 633 foot.

Then must you make a second work in the Triangle B C D, in which you have given,

1 The angle B D C, 64 degrees,
2 The angle D B C 26 degrees,
3 The side D B, 633 foot,

And you are to find the side of B C, the altitude required, wherefore say again,

As the sine of the angle B C D, 90 degrees,
Is to the Logarithm of the side D B 633 foot;
So is the sine of the angle B D C 64 degrees,
To the Logarithm of the Altitude B C:

Which according to the former Doctrine will be found to be 569 foot.

CHAP. XII.

How to Protract the observation taken in the last Chapter.

When you have made your observation as in the last Chapter, and noted down in a Book or otherwise, that the degrees cut your first station at A were 50, and the degrees cut at the second station at D were 64, and that your stationarie distance A D was 200 foot, you may immediately find the Altitude B C by protraction, thus,

First, draw a line as A C, in which line let A represent your first station, whereon lay the center of your Protractor, and make the angle B A C to contein 50 deg. (as hath been several times be-

fore shewn:) and draw the line AB. Then upon the line A C set off the distance of your two stations 200 foot from A to D, then bring your Protractor to D (which represents your second station) and placing the center of your Protractor thereupon, set off an angle of 64 degrees, as B D C, and draw the line D B then where these two lines A B and D B intersect or meet, which is in the point B, from that point let fall the perpendicular B C, the lenght whereof being measured upon the same Scale from whence you tooke the distance A D, will give you 569 foot, and that is the altitude of A B, which was required.

CHAP. XIII.

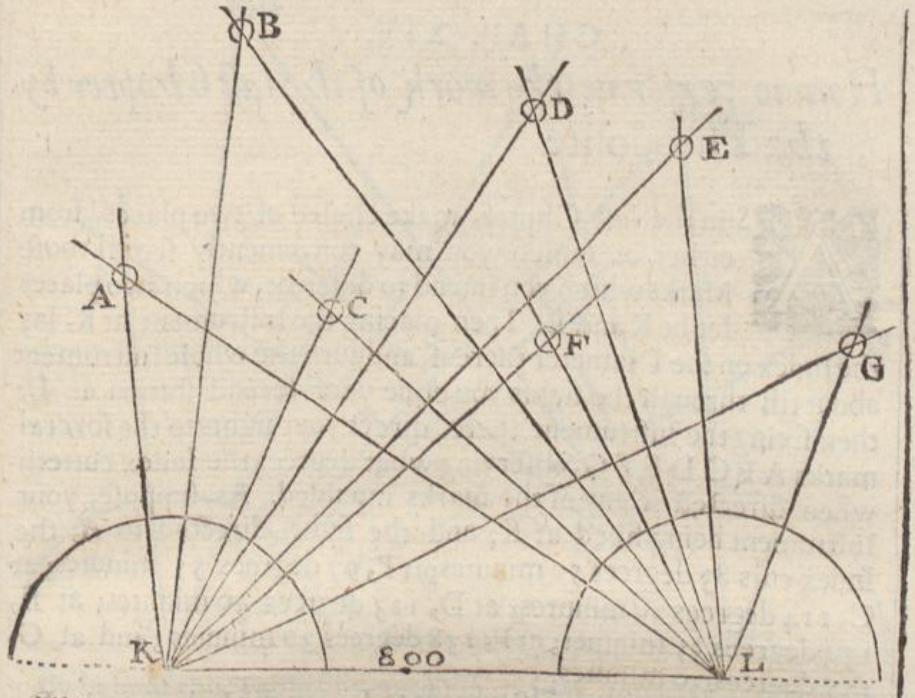
How to take the distance of divers places one from another, according to their true scituation, in Plano, *and to make (as it were) a Map thereof, by the* Plain Table.

THis Proposition is of good use to describe in *plano* the most eminent places in a Town or City, and to make (as it were) a Map thereof. Let A B C D E F G. be certain eminent places scituate in some Town or City, and let it be required to describe all those places upon paper, by which distance of any of them one from another, may be readily found.

At some convenient distance from the City, Town, or Field, make choice of two other convenient places as K and L, from either of which you may plainly discern all the marks which you intend to describe in your Map. Then, at one of these places, (as at K) place your Table and neere one of the sides thereof draw a line parallel to the edge of the Table; In this line assigne any point as K for your first station, and laying the Index upon this line, turn the Table about, till through the sights you espie the other place which you intend for your second station, which found, screw the Table fast there.

Then laying the Index to the point K, turn it about, till through the sights you espie your first mark at A, and by the side of the Index draw the line A K. Secondly, turn the Index to the second mark at B, and draw the line B K. Thirdly, direct your sights to C, and draw the line C K. Fourthly, direct your sights to D, and draw the line D K. Fifthly, direct the sights to E, and draw the line E K. Sixthly, direct the sights to F, and draw the line K F. Lastly, direct the sights to G, and draw the line K G, so have you finished your work at your first station.

This



This done, with your Chain, measure the distance of your two stations K and L, which suppose to contain 800 foot, and removing your Table to L, lay the Index upon the line K L, turning the Table about till through the sight you see your first station at K, and there screw it fast so that it alter not so long as your work continueth.

Then laying the Index to the point L, direct your sights to the several marks as before, namely, to A C B F D E G, and from each of those marks draw lines by the side of the Index, as A L, C L, B L. F L, D L, E L, and G L, so is your work finished at your second station also.

Having thus done, first observe where the line K A crosseth the line L A, which is at A, at which point you may draw the figure or write the name of the thing which it representeth. Secondly, observe where the line K B crosseth the line L B, which is at B, at which point write the name of the place as before. Thirdly, observe where the lines K C and L C intersect, which is at C, at which point also note the place, Fourthly, at the intersection of K D and L D which is at D, write the name of the place as before.

Do thus with all the rest of the places be they never so many, so shall the several points of intersection A B C D E F G upon your Table, represent the respective places in the Town or City.

Now to know the distance of any of these places one from another, you must take the distance required in your Compasses, and apply it to the same Scale by which the stationarie distance K L was laid down, and it will there shew you the distance required.

CHAP.

CHAP. XIV.

How to performe the work of the last Chapter by the Theodolite.

AS in the last Chpter, make choice of two places, from either of which you may conveniently see all those Marks which you intend to describe, which two places let be K and L. Then placing the Instrument at K, lay the Index on the Diameter thereof, and turn the whole Instrument about till through the sights you espie your second station at L: then fixing the Instrument there, direct your sights to the several marks A B C D E F G, observing what degrees the Index cutteth when directed to any of the marks intended. As, suppose, your Instrument being fixed at K, and the sights directed to A, the Index cuts 83 degrees 50 minutes; at F, 97 degrees 55 minutes; at C, 114 degrees 10 minures; at D, 123 degrees 40 minntes; at E, 134 degrees 35 minutes; at F, 138 degrees 30 minutes; and at G, 155 degrees, 20 minutes.

Then removing your Instrument to L, lay the Index on the Diameter thereof, and turn it about till through the sights you espie your former station at K, as is before taught: Then directing the sights to your first mark A, the Index cuts 33 degrees 50 minutes; at C, 43 degrees 40 minutes; at B, 54 degrees 10 minutes; at F, 64 degrees; at D, 73 degrees 20 minutes; at E 87 degrees 15 minutes; and at G, 113 degrees 40 minutes.

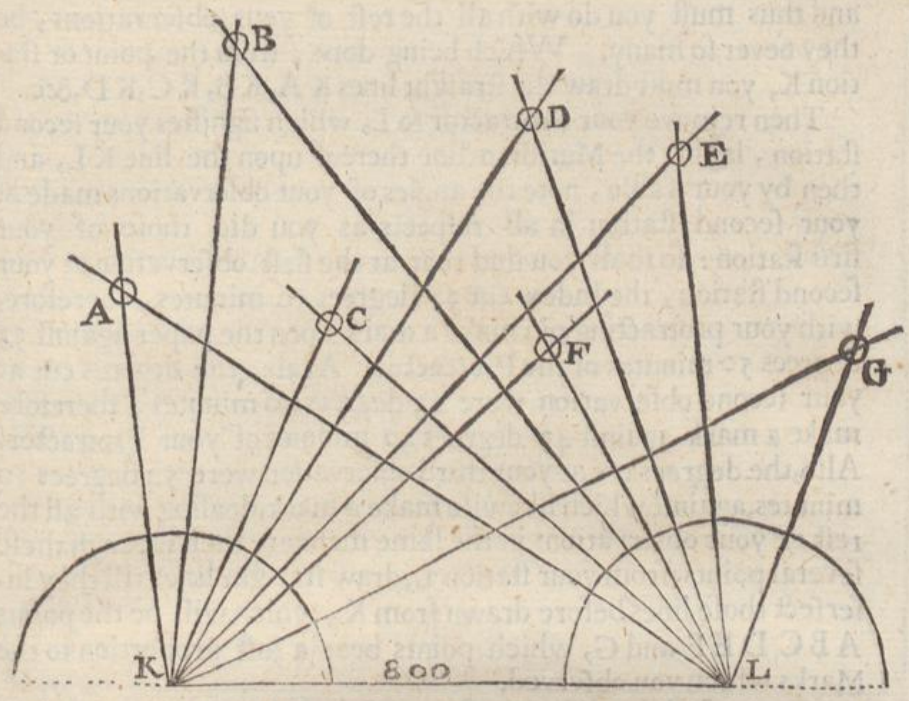
These several observations of the degrees cut by the Index at both stations, ought to be noted in a Book or paper, together with the stationarie distance, as in this example.

		deg:	*min.*
First station	A	83	50
	B	97	55
	C	114	10
	D	123	40
	E	134	35
	F	138	30
	G	155	20

The Stationarie distance 800 Foot.

Second station	A	33	50
	B	43	40
	C	54	10
	D	64	00
	E	73	20
	F	87	15
	G	113	40

By



By help of this Table of your obſervations, you may at any time protract the ſame upon paper, and making a Scale of equal parts anſwerable to the parts of your ſtationary diſtance, you may with your Compaſſes meaſure the diſtance of any of theſe marks or places one from another, or from either of your ſtations.

CHAP. XV.

How to protract the former Obſervations upon Paper, and to make a Scale to meaſure any of the Diſtances.

YOur paper or parchmẽt being provided, draw thereupon a line at length, and therein aſſigne two points as K and L, repreſenting your two ſtations, then upon your firſt ſtation at K, lay the Center of your Protractor, with the Meridian line therof (which is noted with E F) directly upon the line K L. Then lay the Table of your obſervations before you, and ſeeing that at your firſt obſervation the Index cut 83 degrees 50 minutes, you muſt therefore with your protracting pin make a mark againſt 83 degrees 50 minutes of your Protractor. Again, ſeeing that at your ſecond obſervation the Index cut 97 degrees 55 minutes, therefore, with your protracting pin, make a mark upon your paper, againſt 97 degrees 55 minutes of your Protractor. And thirdly, ſeeing that at your third obſervation your Index cut 114 degrees 10 minutes, you muſt likewiſe make a mark againſt 114 degrees 10 minutes,

and

and thus must you do with all the rest of your observations, be they never so many. Which being done, from the point or station K, you must draw the straight lines K A, K B, K C, K D, &c.

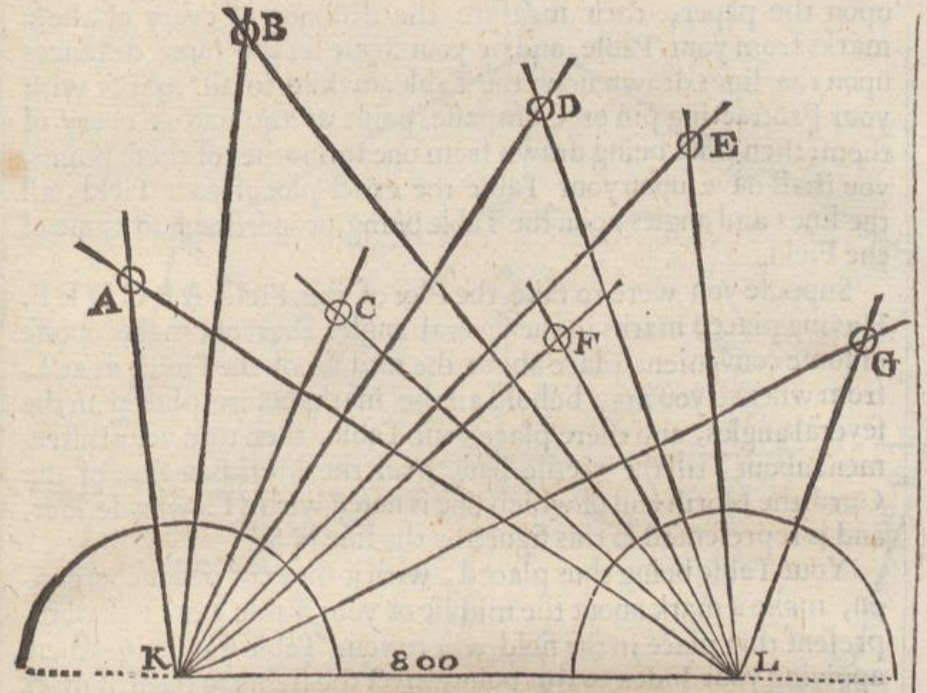
Then remove your Protractor to L, which signifies your second station, laying the Meridian line thereof upon the line K L, and then by your Table, note the angles of your observations made at your second station in all respects as you did those of your first station: so shall you find that at the first observation at your second station, the Index cut 33 degrees 50 minutes, therefore, with your protracting pin make a mark upon the paper against 33 degrees 50 minutes of the Protractor. Again, the degrees cut at your second observation were 43 degrees 40 minutes, therefore make a mark against 43 degrees 40 minutes of your Protractor. Also, the degrees cut at your third observation were 54 degrees 10 minutes, against which likewise make a mark, dealing with all the rest of your observations in the same manner: then through these several points, from your station L, draw straight lines till they interfect those lines before drawn from K, which will be the points A B C D E F and G, which points bear a just proportion to the Marks which you observed.

Now to find the distance of any of these marks one from another, you must divide a line into such equal parts, so that your stationarie distance K L may contain 800 of them. Your Scale being thus made, take in your Compasses the distance between any two marks or places here described, and apply it to your Scale so shall it exactly shew you the true distance between the two places so taken, in the same parts as the line K L was divided.

In this manner may you with speed and exactnesse attein the true distance and situation of any Mark or Marks far remote, without approaching neer any of them: and thus in over-grown land, where you can neither go about it, nor measure within it, this Chapter will be of excellent use.

¶ I might here insert divers other Cases concerning the taking of Heights and Distances; as, divers places lying in the same right line to find their distance; or, part of a Distance or Altitude being given, to find the whole, with infinite other of that nature, but seeing that these are but parts or branches of what is here delivered, and are rather Problemes of curiosity then use, I will therefore passe them over, and the rather, because these being rightly understood, the performance of any other will be very easie. But remember alwayes in taking of inaccessible Heights and Distances, as also in the plotting of un-passeable grounds, that you take this your stationarie distance as as may be. And if at any time you be required to the altitude of a Castle, Church or Tree, standing on a Hill, you you must perform it at two operations, first, by taking the altitude of the Castle and Hill together as one altitude, and secondly, by taking the height of the Hill alone; then

by



by ſubſtracting the height of the Hill from the whole height, the remainder ſhall be the height of the Caſtle. And here note alſo, that in the taking of all manner of Altitudes, whether acceſſible or inacceſſible, you muſt alwayes adde the height found, the height of your Inſtrument from the ground.

CHAP. XVI.

How to take the true plot of a field at one ſtation taken within the ſame field, ſo that from thence you may ſee all the angles of the ſame field by the Plain Table.

WHen you enter any field to ſurvey, your firſt work muſt be to ſet up ſome viſible mark at each angle thereof, or let one go continually before you to every angle, holding up a white cloth, or the like, to direct you: which being done, make choice of ſome convenient place about the middle of the field, from whence you may behold all your Marks, and there place your Table covered with a ſheet of paper, the needle hanging directly over the Meridian line of the Card (which you muſt alwayes have regard unto, eſpecially when you are to ſurvey many fields together). Then make a marke about the middle of your paper, which ſhall repreſent that part of the field where your Table ſtandeth, and laying the Index unto this point, direct your ſights to the ſeverall angles where you before placed your marks, and draw lines by the ſide of the Index

upon the paper; then measure the distance of every of these marks from your Table, and by your Scale set the same distances upon the lines drawn upon the Table, making small marks with your Protracting pin or Compasse point at the end of every of them; then lines being drawn from one to another of these points, you shall have upon your Table the exact plot of your Field, all the lines and angles upon the Table being proportional to those of the Field.

Suppose you were to take the Plot of the Field A B C D E F. Having placed marks in the several angles thereof, make choise of some convenient place about the middle of the Field, as at L, from whence you may behold all the marks before placed in the several angles, and there place your Table, then turn your Instrument about, till the needle hang over the Meridian line of the Card, the North end of which line is noted with a Flower-de-luce, and is represented in this figure by the line N S.

Your Table being thus placed, with a sheet of paper thereupon, make a mark about the middle of your Table which shall represent that place in the field where your Table standeth: then, applying your Index to this point, direct the sights to the first mark at A, and the Index resting there, draw a line by the side thereof to the point L, then with your Chain measure the distance from L, the place where your Table standeth, to A your first mark, which suppose to be 8 Chains 10 Links, then take 8 Chains 10 Links from any Scale, and set that distance upon your Table from L to A, and at A make a mark.

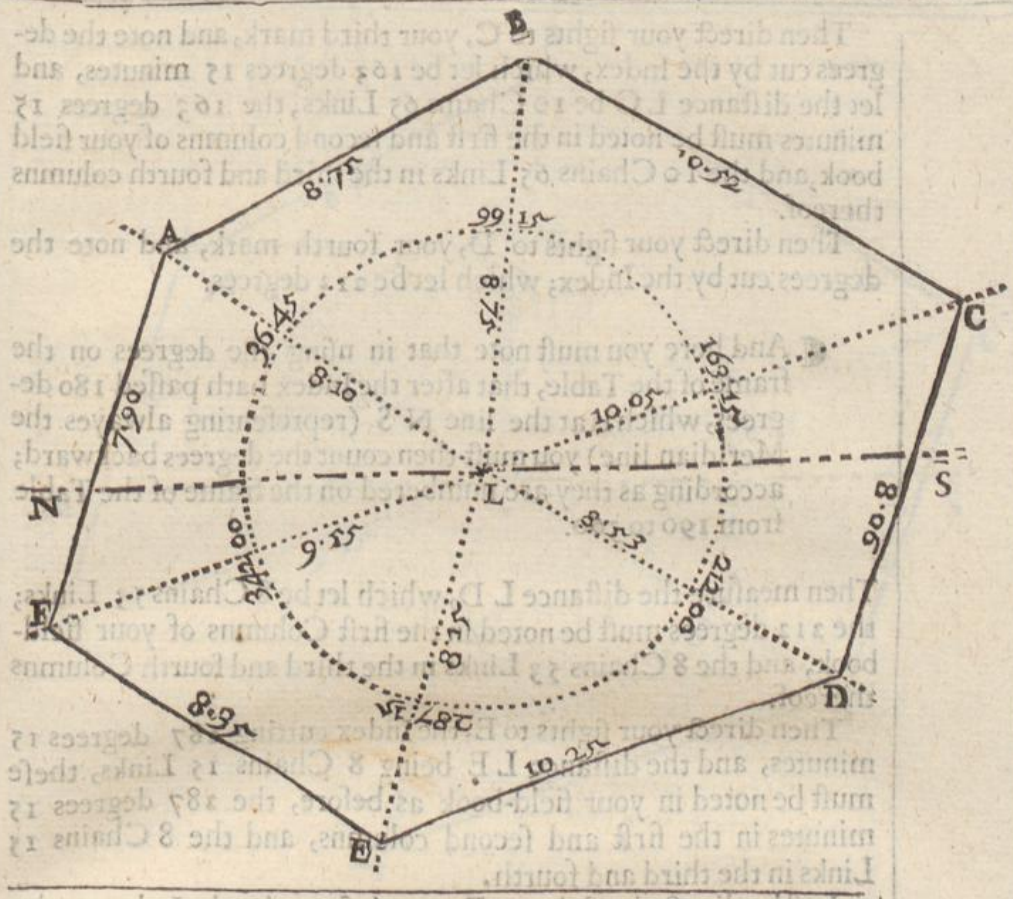
Then directing the sights to B the second mark, draw a line by the side of your Index as before, and measure the distance from your Table at L, to your mark at B, which suppose 8 Chains 75 links, this distance must be taken from your Scale, and set upon your Table from L to B, and at B make another mark.

Then direct the sights to the third mark C, and draw a line by the side of the Index, measuring the distance from L to C, which suppose 10 Chains 65 links; this distance being taken from your Scale and applyed to your Table from L to C, shall give you the point C, representing your third mark.

In this manner you must deale with the rest of the marks at D E and F, and more, if the field had consisted of more angles.

Lastly, when you have made observation of all the marks round the Field, and found the points A B C D E and F upon your Table, you must draw lines from one point to another till you conclude where you first began: as draw a line from A to B, from B to C, from C to D, from D to E, from E to F, and from F to A, where you began: then will A B C D E F be the exact figure of your field, the sides and angles of the said figure bearing an exact proportion to those in the Field, and the line N S, in this and the following figures, alwayes representeth the Meridian line.

CHAP.



CHAP. XVII.

How to take the plot of a field at one ſtation taken in the middle thereof by the Theodolite.

PLace marks at the ſeveral angles of the field as before and make choice of ſome convenient place about the middle thereof, as L, from whence you may ſee all the marks, and there place your Inſtrument, the Needle hanging directly over the Meridian line in the Card.

This done, direct your ſights to the firſt mark at A, noting what degrees the Index cutteth, which let be 36 degrees 45 minutes, theſe 36 degrees 45 minutes muſt be noted down in your field-book in the firſt and ſecond Columns thereof. Then meaſure the diſtance from L the place of your Inſtrument, to A your firſt mark, which let contain 8 Chains 10 Links, theſe 8 Chains 10 Links muſt be placed in the third and fourth Column of your field-book, as hath been directed in the deſcription thereof.

Then direct the ſights to B your ſecond mark, and note the degrees cut by the Index, which let be 99 degrees 15 minutes, and the diſtance L B 8 chains 75 links, the 99 degrees 15 minutes muſt be noted in the firſt and ſecond Columns of your field-book, and the 8 Chains 75 Links in the third and fourth Columns.

Then direct your sights to C, your third mark, and note the degrees cut by the Index, which let be 163 degrees 15 minutes, and let the distance L C be 10 Chains 65 Links; the 163 degrees 15 minutes must be noted in the first and second columns of your field book, and the 10 Chains 65 Links in the third and fourth columns thereof.

Then direct your sights to D, your fourth mark, and note the degrees cut by the Index; which let be 212 degrees:

¶ And here you must note that in using the degrees on the frame of the Table, that after the Index hath passed 180 degrees, which is at the line N S (representing alwayes the Meridian line) you must then count the degrees backward; according as they are numbered on the frame of the Table from 190 to 360.

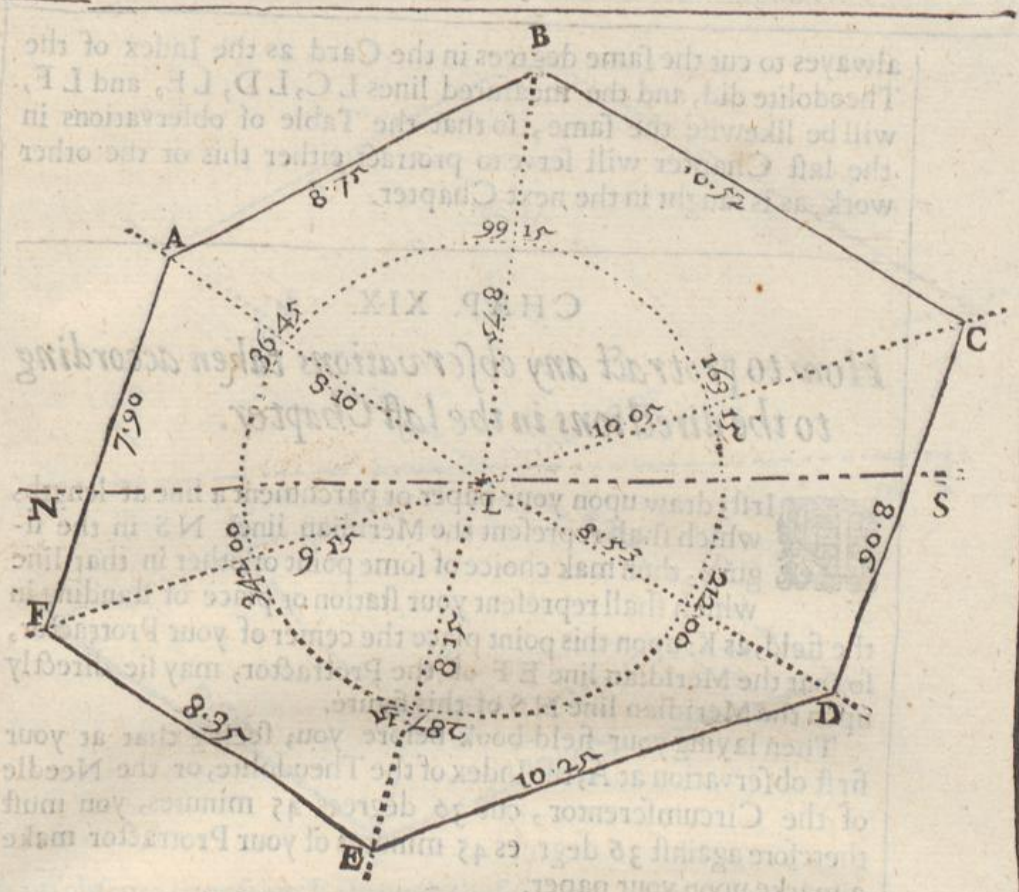
Then measure the distance L D, which let be 8 Chains 53 Links; the 212 degrees must be noted in the first Columns of your field-book, and the 8 Chains 53 Links in the third and fourth Columns thereof.

Then direct your sights to E, the Index cutting 287 degrees 15 minutes, and the distance L E being 8 Chains 15 Links, these must be noted in your field-book as before, the 287 degrees 15 minutes in the first and second columns, and the 8 Chains 15 Links in the third and fourth.

Lastly, direct the sights to F, your last mark, the Index cutting 342 degrees, and the distance L F being 9 Chains 55 Links, these must be noted down in your field-book in all respects as the former, *viz.* the 342 degrees in the first column, and the 6 Chains 55 Links in the third and fourth: then will your observations noted in your field-book stand as in this Table following.

	Degrees	*Minutes*	*Chains.*	*Links*
A	36	45	8	10
B	99	15	8	75
C	163	15	10	65
D	212	00	8	53
E	287	15	8	15
F	342	00	9	55

CHAP.



CHAP. XVIII.

How to take the plot of a Field at one ſtation taken in the middle thereof by the Circumferentor.

THere is little difference between the work of this and the laſt Chapter: for, the marks being placed in the ſeveral angles of the field, and the ſtation appointed at L, place there the Inſtrument, and turning it about, direct the ſights to A (the Flower-de-luce of the Card being alwayes towards you) the South end of the Needle cutting 36 degrees 45 minutes the ſame which the Index of the Theodolite did in the laſt Chapter, then meaſuring the diſtance from L to A, you will finde it to contain, as before, 8 Chains 10 Links, which you muſt note down in your field-book as in the laſt Chapter.

Then turning the whole Inſtrument about (as before) direct the ſights to B, the South end of the Needle cuttng 99 degrees 15 minutes, and the diſtance L B will contain 8 Chains 75 Links, which note down in your Book alſo.

In this manner muſt you direct the ſights to all the other angles C D E and F, and you ſhall finds the South end of the Needle al-

alwayes to cut the same degrees in the Card as the Index of the Theodolite did, and the measured lines L C, L D, L E, and L F, will be likewise the same, so that the Table of observations in the last Chapter will serve to protract either this or the other work, as is taught in the next Chapter.

CHAP. XIX.

How to protract any observations taken according to the directions in the last Chapter.

FIrst, draw upon your paper or parchment a line at length, which shall represent the Meridian lines N S in the figure, then mak choice of some point or other in that line which shall represent your station or place of standing in the field, as K: upon this point place the center of your Protractor, so that the Meridian line E F of the Protractor, may lie directly upon the Meridian line N S of this figure.

Then laying your field-book before you; seeing that at your first observation at A, the Index of the Theodolite, or the Needle of the Circumferentor, cut 36 degrees 45 minutes, you must therefore against 36 degrees 45 minutes of your Protractor make a marke upon your paper.

2 Seeing the degrees cut at your second observation were 99 degrees 15 minutes, you must mark upon your paper against 99 degrees 15 minutes of your Protractor.

3 The degrees cut at your third observation were 165 degrees 15 minutes, therefore against 163 degrees 15 minutes make a mark upon your paper.

4 The degrees cut by the Index or Needle at your fourth observation being 212 degrees ===

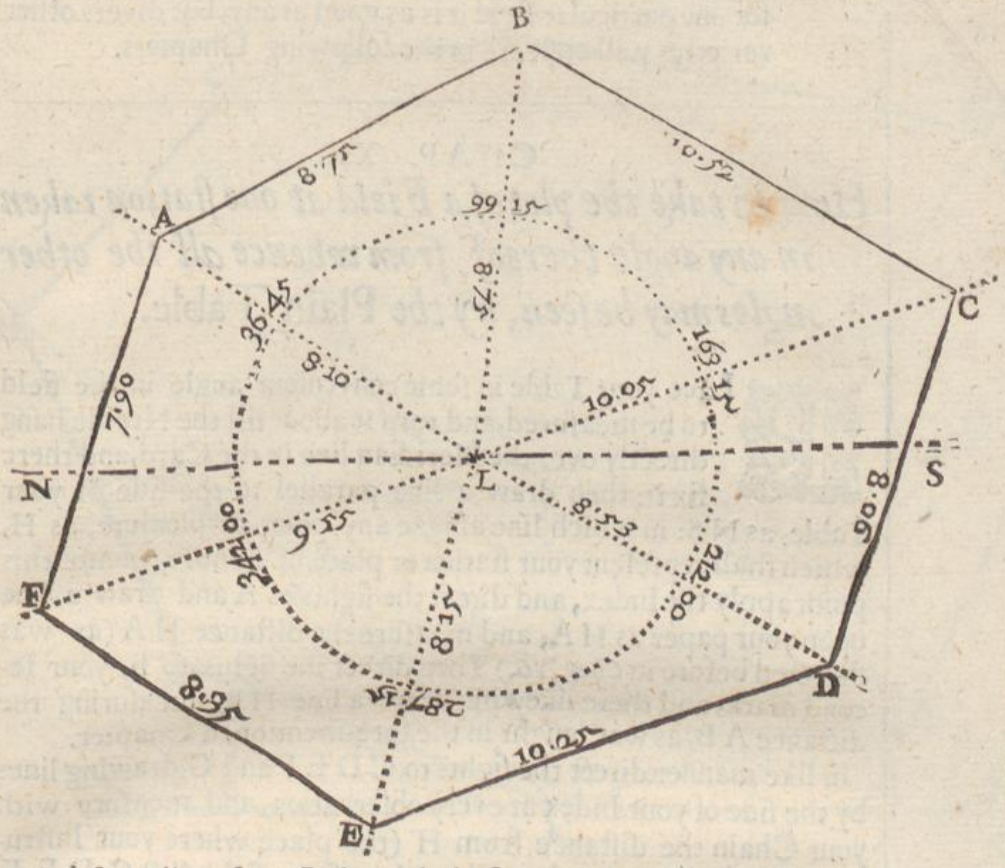
¶ Now because 212 degrees is greater then 180 degrees you must therefore turn the Semicircle of the Protractor downwards, yet the line E F thereof must lie directly upon the Meridian line N S, as before.

===you must against 212 degrees of the Protractor make a mark upon your paper.

5 Seeing the degrees cut at your fifth observation were 287 deg. 15 minutes: therefore make a mark against 287 degrees 15 minutes of the Protractor.

Lastly, the degrees cut at your last observation were 342, therefore against 342 degrees of your Protractor make a mark with your Protracting pin, as before.

Having thus protracted all the degreees of your several observations, take away your Protractor, and laying a ruler to the point L, draw



draw obſcure lines from L through thoſe points, which lines will be L A, L B, L C, L D, L E, and L F.

This done, you muſt obſerve by your field-book the length of every line

As the line L A at your firſt obſervation was 8 Chains 10 Links, therefore, 8 Chains 10 Links being taken from your Scale and ſet upon your paper from L to A, it ſhall give you the point A upon your paper.

2 The length of your ſecond line being 8 Chains 75 Links, you muſt take 8 Chains 75 Links from your Scale, and ſet it upon your paper from L to B.

3 The line L C being 10 Chains 65 Links, you muſt therefore take 10 Chains 65 Links from your Scale, and ſet it upon your paper from L to C.

And thus muſt you deale with all the reſt of the lines, as L D, L E, and L F.

Laſtly, draw the lines A B, B C, C D, D E, E F, and F A, ſo ſhall you have the exact figure of the field upon your paper.

¶ In theſe four laſt Chapters you are taught how to take the plot of any field at one ſtation taken in the midſt thereof, both by the Plain Table, Theodolite, and Circumferentor, and alſo how to protract the ſame. This way of plotting of a field is ſeldome, or never, uſed in ſurveying of divers parcels, but for

for one particular field it is as good as any, but divers other varieties will appeare in the following Chapters.

CHAP. XX.

How to take the plot of a Field at one station taken in any angle thereof, from whence all the other angles may be seen, by the Plain Table.

PLace your Table in some convenient angle in the field to be measured, and turn it about till the Needle hang directly over the Meridian line in the Card, and there fix it: then draw a line parallel to the side of your Table, as N S: in which line assigne any point at pleasure, as H, which shall represent your station or place of standing, unto this point apply the Index, and direct the sights to A and draw a line upon your paper as H A; and measure the distance H A (as was directed before in *Chap.* 16.) Then direct the sights to B, your second mark, and there likewise draw a line H B, measuring the distance A B, as was taught in the fore-mentioned Chapter.

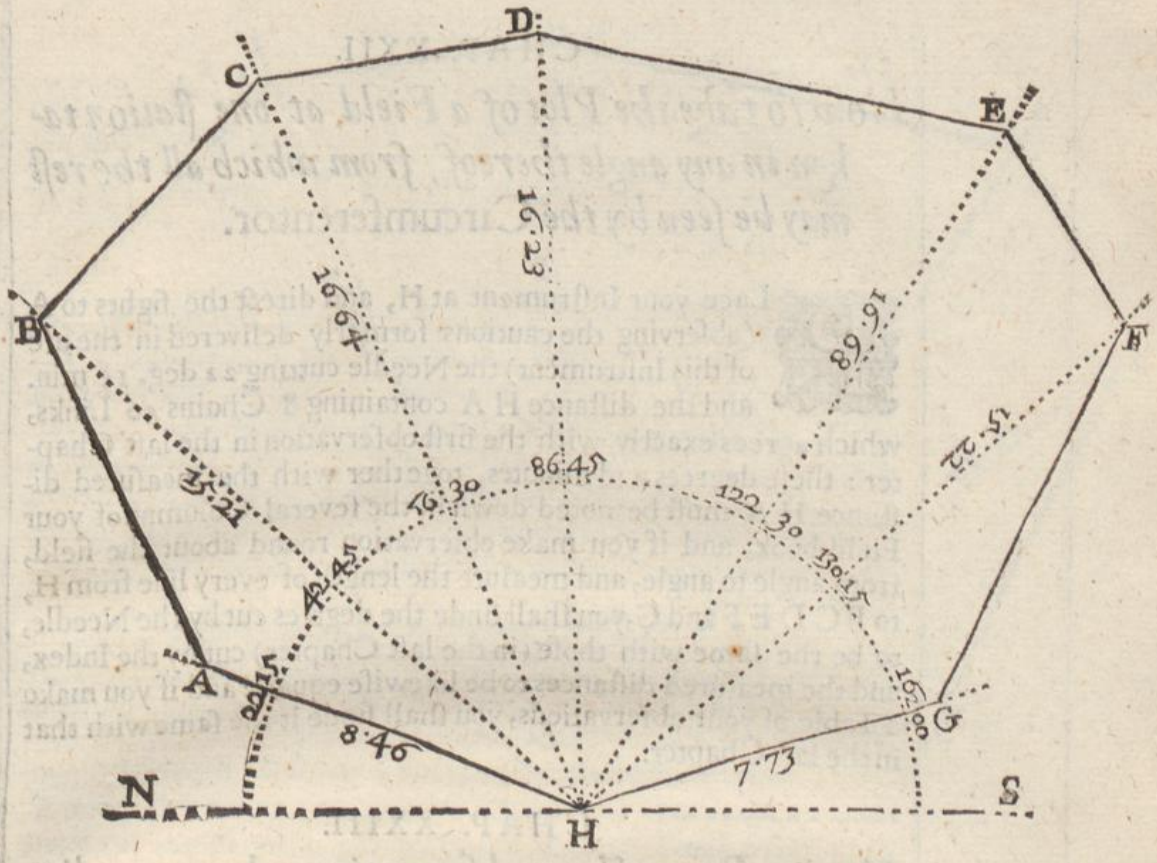
In like manner direct the sights to C D E F and G, drawing lines by the side of your Index at every observation, and measure with your Chain the distance from H (the place where your Instrument standeth) to the severall angles of the field A, B, C, D, E, F, and G; which distances being taken in your Compasses, from any Scale, and set upon your Table from H upon the severall lines H A H B, H C, H D, H E, H F, and H G, so shall you have upon your Table the points A, B, C, D, E, F, and G, by which marks draw the lines H A, A B, B C, C D, D E, E F, F G, and G H, which lines will include the exact figure of the field upon your Table.

CHAP. XXI.

How to take the plot of a Field at one station taken in any angle thereof by the Theodolite.

IN the same figure following, having placed your Instrument at H, as is taught in the fore-going Chapter direct the sights to A, your first mark, noting the degrees cut by the Index, which suppose 22 degrees 15 minutes, these degrees and minutes must be noted in the first and second columns of your field-book (as hath been before sufficiently taught.) Then with your Chain measure the distance from your station at H to the angle A, which let be 8 Chains 46 Links, which you must place in the third and fourth columns of your field-book, according to the former directions.

2. Direct



2 Direct your sights to B noting the degrees there cut, which suppose 42 degrees, 45 minutes, these degrees and minutes place in the first and second Columns of your field-book, and measure the distance H B, 15 Chains 21 Links, and note them down in the third and fourth Columns thereof.

3 Direct your sights to C, the degrees cut being 68 degrees 30 minutes, and the distance H C 16 Chains 64 Links, note these also in your field-book as before.

And in this manner must you deale with the other marks D, E, F, and G, so having noted them all in your field-book they will stand as followeth.

	Degrees	*Minutes*	*Chains*	*Links*
A	22	15	8	46
B	42	45	15	21
C	66	30	16	64
D	86	45	16	23
E	122	30	16	68
F	130	15	15	22
G	162	00	7	73

CHAP. XXII.

How to take the Plot of a Field at one station taken in any angle thereof, from which all the rest may be seen by the Circumferentor.

PLace your Instrument at H, and direct the sights to A (observing the cautions formerly delivered in the use of this Instrument) the Needle cutting 22 deg. 15 min. and the distance H A containing 8 Chains 46 Links, which agrees exactly with the first observation in the last Chapter: these degrees and minutes, together with the measured distance H A must be noted down in the several Columns of your Field-book, and if you make observation round about the field, from angle to angle, and measure the length of every line from H, to B C D E F and G, you shall finde the degrees cut by the Needle, to be the same with those (in the last Chapter) cut by the Index, and the measured distances to be likewise equall: and if you make a Table of your observations, you shall finde it the same with that in the last Chapter.

CHAP. XXIII.

How to Protract any observation taken according to the Doctrine of the two last Chapters.

FIrst, draw the meridian line N S, and make choice of a point therein representing your stationarie angle, as at H, to which point apply the center of your Protractor, the Semicircle upwards. Then laying your Field-book before you, you may perceive that at your first observation (which was at A) the Index of the Theodolite, or the Needle of the Circumferentor cut 22 deg. 15 minutes, therefore make a mark against 22 degrees 15 minutes, & draw the line H A.

2 The degrees cut at your second observation at B, being 42 deg. 45 minutes, make a mark likewise against 42 degrees 45 minutes of your Protractor, and draw the line H B.

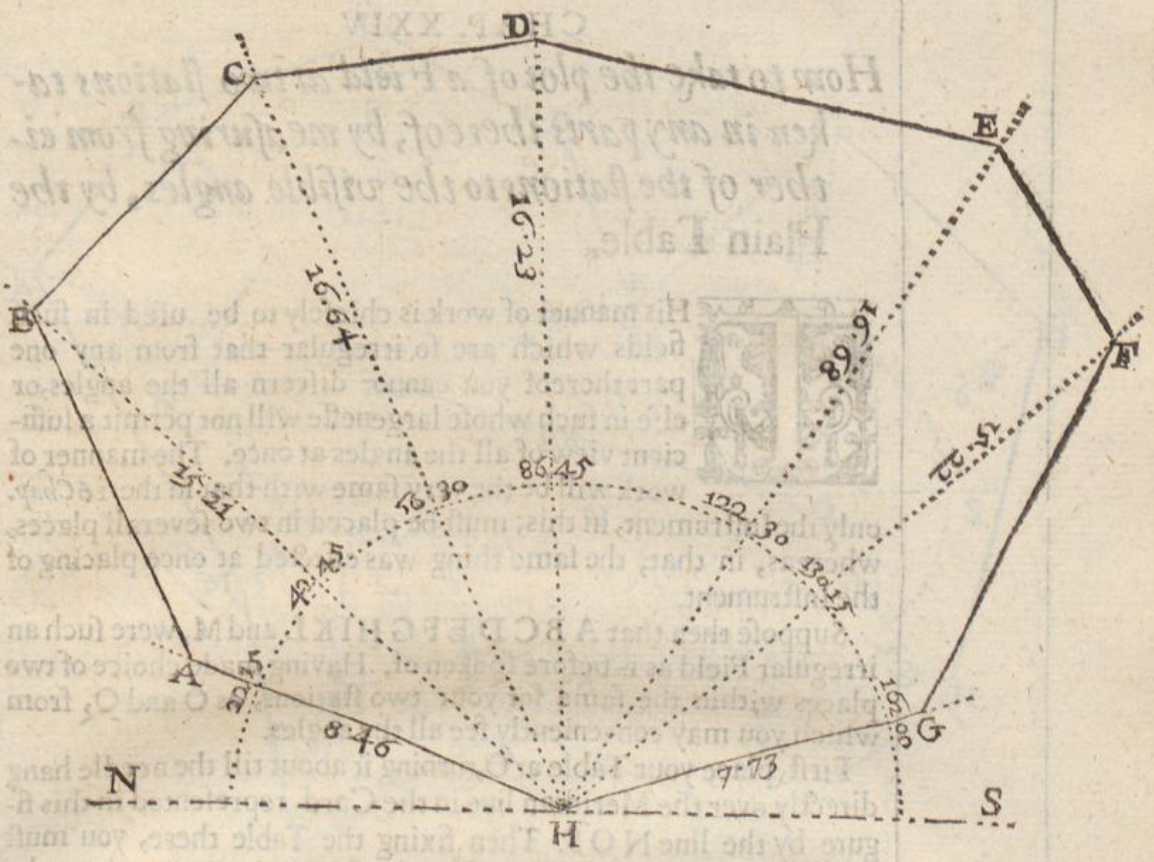
3 The degrees cut at your third observation being 66 deg. 30 mi. make a marke against 66 deg. 30 min. and draw the line H C.

And in this manner must you proceed with the rest of your observations, D, E, F, and G.

Having thus protracted your angular observations, proceed now to your lineall, namely, to the length of your lines, noted in the third and fourth Columns of your Field-book.

1 Seeing that the lenght of your first line H A was 8 Chains 46 Links, you must take 8 Chains 46 Links from your Scale, and apply it to your paper from H unto A.

2 The



2 The length of your ſecond line H B, being 15 Chains 21 Links take 15 Chains 21 Links from your Scale, and apply that diſtance to your paper from H unto B.

3 The diſtance of your third mark H C being 16 Chains 64 Links, take that diſtance from your Scale, and apply it to your paper from the point H unto C.

In all reſpects as before, you muſt proceed with the meaſuring of all the other lines about the field, were they never ſo many.

Laſtly, if from theſe point A B C D E F G, and H, you draw the line A B, B C, C D, D E, E F, F G, and G H, you ſhall have upon your paper the exact figure of your field.

¶ And herein you may receive abundant ſatisfaction, to ſee your ſeveral Inſtrumental operations, and your Geometricall protraction ſo exactly to agree: and if at any time you make ſeverall obſervations of any one piece of ground, according to the directions of the foregoing Chapters, or the like, if you finde them not exactly to agree, you may be ſure you have failed in one or other of your obſervations, and therefore, before you proceed further, it is beſt to reform your firſt errour.

CHAP. XXIV

How to take the plot of a Field at two stations taken in any parts thereof, by measuring from either of the stations to the visible angles, by the Plain Table.

THis manner of work is chiefely to be used in such fields which are so irregular that from any one part thereof you cannot discern all the angles, or else in such whose largeness will not permit a sufficient view of all the angles at once. The manner of work will be the very same with that in the 16 *Chap.* only the Instrument, in this, must be placed in two severall places, whereas, in that, the same thing was effected at once placing of the Instrument.

Suppose then that A B C D E F G H I K L and M, were such an irregular Field as is before spoken of. Having made choice of two places within the same for your two stations, as O and Q, from which you may conveniently see all the angles.

First, place your Table at O, turning it about till the needle hang directly over the Meridian line in the Card, represented in this figure by the line N O S. Then fixing the Table there, you must

(1) direct the sights to A, and by the side of the Index draw the line A O, containing 7 Chains 46 links.

(2) direct the sights to B, and draw the line B O, containing 7 Chains 18 Links.

(3) direct the sights to C, and draw the line O C, containing 7 Chains 21 links.

(4) direct the sights to D, and draw the line O D, containing 6 Chains 33 Links.

(5) direct the sights to E, and draw the line O E, containing 5 Chains 57 Links.

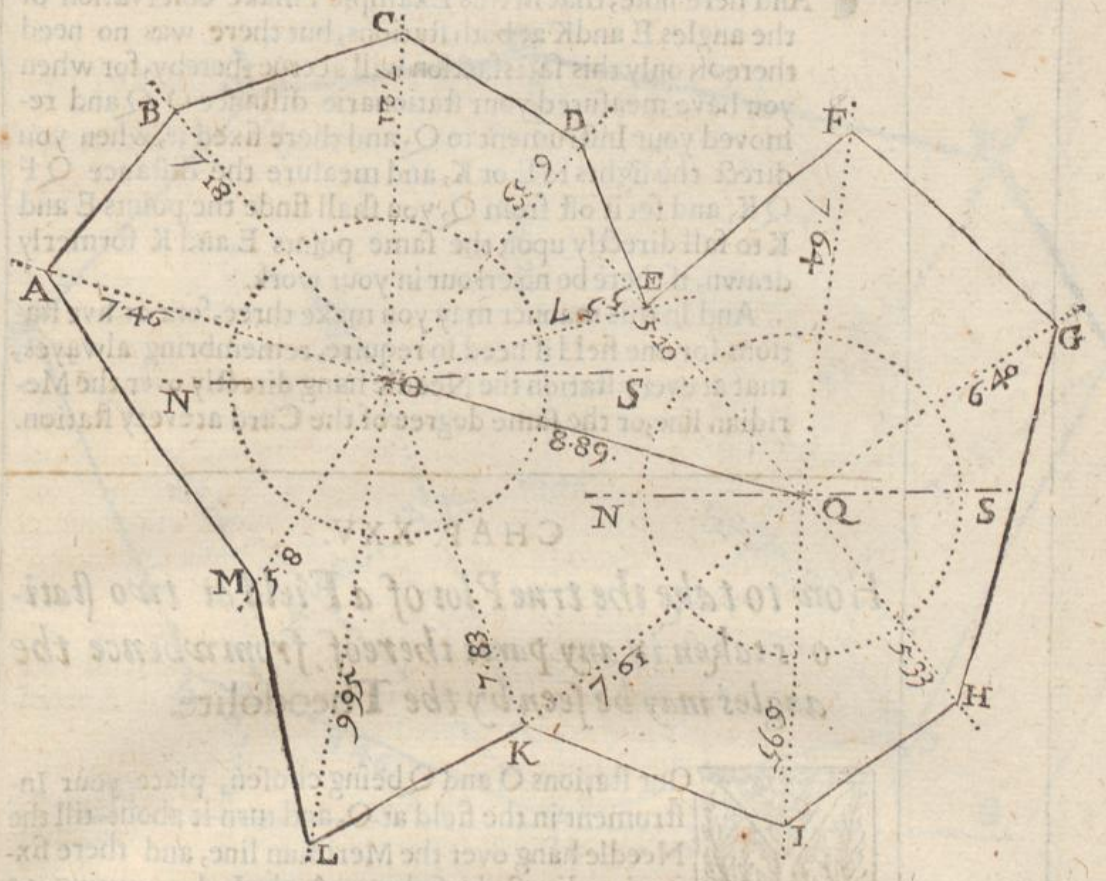
(6) direct the sights to K, and draw the line O K, containing 7 Chains 83 Links.

(7) direct the sights to L, and draw the line O L, containing 9 Chains 95 Links.

(8) direct the sights to M, and draw the line O M, containing 5 Chains 8 Links.

Having thus made observation of these angles which are all that can conveniently be seen from your first station at O, and draw the several lines O A, O B, O C, O D, O E, O F, O K, O L, and O M, and upon them set the severall lengths as you found them by measuring, as from O to A, 7 Chains 46 Links, from O to B, 7 Chains 18 Links &c. You must then lay the Index again to the point O, and direct the sights to your second station at Q, drawing the line O Q, then measure the distance from O to Q, which let contain 8 Chains 89 Links.

Then



Then remove your Instrument to Q, and lay the Index upon the line O Q, turning the table about till through the sights you espie your first station at O then will the Needle hang directly over the Meridian line in the Card as before, and your Instrument is truly scituated in the same position as before, so that you may now deale with the angles F, G, H, and I, (which before you could not conveniently see) as you did with those on the other side of the field, by laying the Index to the point Q, and directing the sights,

(1) to E, and drawing the line Q E, containing 5 Chains 10 Links.
(2) to F and drawing the line Q F, containing 7 Chains 64 Links.
(3) to G and drawing the line Q G, containing 6 Chains 40 Links.
(4) to H, and drdwing the line Q H, containing 5 Chains 33 Links.
(5) to I, and drawing the line Q I, containing 6 Cnains 95 Links.
(6) to K, and drawing the line Q K, containing 7 Chains 61 Links.

These angles being observed and the lines measured as the former were, you shall finde the severall points E, F, G, H, I, and K, on this side of the Field also, so that you may draw the lines A B, B C, C D, D E, E F, F G, G H, H I, I K, K L, L M, and M A, which shall represent upon your Table the exact figure of the field to be measured.

And

¶ And here note, that in this Example I make observation of the angles E and K at both stations, but there was no need thereof, only this satisfaction will accrue thereby, for when you have measured your stationarie distance O Q and removed your Instrument to Q, and there fixed it, when you direct the sights to E or K, and measure the distance Q F Q K, and set it off from Q, you shall finde the points E and K to fall directly upon the same points E and K formerly drawn, if there be no errour in your work.

And in this manner may you make three, four or five stations for one field if need so require, remembring alwayes, that at every station the Needle hang directly over the Meridian line, or the same degree of the Card at every station.

CHAP. XXV.

How to take the true Plot of a Field at two stations taken in any parts thereof, from whence the angles may be seen by the Theodolite.

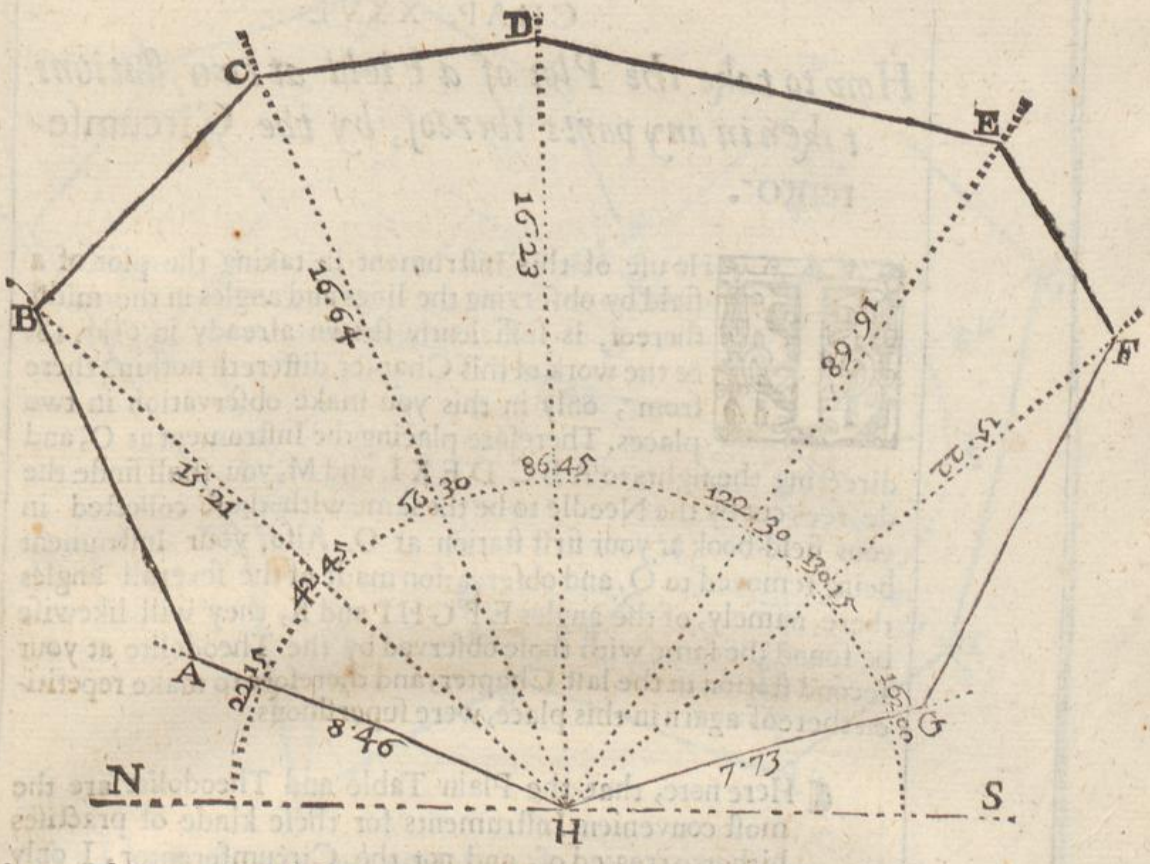
YOur stations O and Q being chosen, place your Instrument in the field at O, and turn it about till the Needle hang over the Meridian line, and there fixing it, direct the sights to A, the Index cutting 19 degrees 10 minutes, and the line O A containing 7 Chains 46 Links, the 19 degrees 10 minutes must be placed in the first and second columns of your field-book, and the 7 Chains 46 Links in the third and fourth columns thereof.

Then direct the sights to B, the Index cutting 53 degrees 30 minutes, and the line O B containing 7 Chains 18 Links, which note down in your field-book as before.

In this manner proceed with the rest of the lines and angles namely, so many as you intend to observe at your first station *viz.* A, B, C, D, K, L, and M: which done, direct the signes to your second station at Q, the Index cutting 18 degrees 15 minutes, which note down in your field-book by it selfe: Also measure the stationarie distance O Q, 8 Chains 89 Links, as before, this also must be noted in your field-book.

Having thus finished one part of the field, remove your Instrument to Q, and laying the Index upon 18 degrees 15 minutes, (which is the inclination or difference of Meridians between your two stations) turn it about till through the signes you espie your first station at O, then will the Needle hang over the Meridian line, and the Instrument will be truly scituate.

Then direct the sights to E, the Index cutting 52 degrees 15 minutes, and the line Q E containing 5 Chains 10 Links, which must be



be noted in your Field-book in all respects as formerly. In this manner make observation of all the other lines angles, as E F G H I and K, which being collected into your Field-book will stand as followeth.

	deg.	*Min.*	*Chai.*	*Link.*	
A	19	10	7	46	
B	53	30	7	18	
C	95	15	7	21	
D	132	00	6	33	The first station
E	166	30	5	57	at O.
K	251	30	7	83	
L	282	00	9	95	
M	304	30	8	05	

The stationary distance O Q is 8 Chains 89 Links, and the angle O Q N 18 degrees 15 minutes, the inclination or difference of Meridians.

E	52	15	5	10	
F	99	30	7	64	
G	148	30	6	40	The second sta-
H	232	30	5	33	tion at Q.
I	275	00	6	95	
K	321	30	7	61	

CHAP.

CHAP. XXVI.

How to take the Plot of a Field at two stations taken in any parts thereof, by the Circumferento^r.

THe use of this Instrument in taking the plot of a field by observing the lines and angles in the midst thereof, is sufficiently shewn already in *Chap.* 18. & the work of this Chapter differeth nothing there from, only in this you make observation in two places. Therefore placing the Instrument at O, and directing the sights to A B C D E K L and M, you shall finde the degrees cut by the Needle to be the same with those collected in your field-book at your first station at O. Also, your Instrument being removed to Q, and observation made of the severall angles there, namely, of the angles E F G H I and K, they will likewise be found the same with those observed by the Theodolite at your second station in the last Chapter, and therefore to make repetition thereof again in this place, were superfluous.

¶ Here note, that the Plain Table and Theodolite are the most convenient Instruments for these kinde of practises hitherto treated of, and not the Circumferentor, I only have hinted the use thereof, that the agreement of the severall Instruments might be taken notice of, the Cicumferentor serving chiefly for large Champion plains and Wood-lands aswill appear hereafter.

CHAP. XXVII.

How to protract any observations taken according to the directions of the two last Chapters.

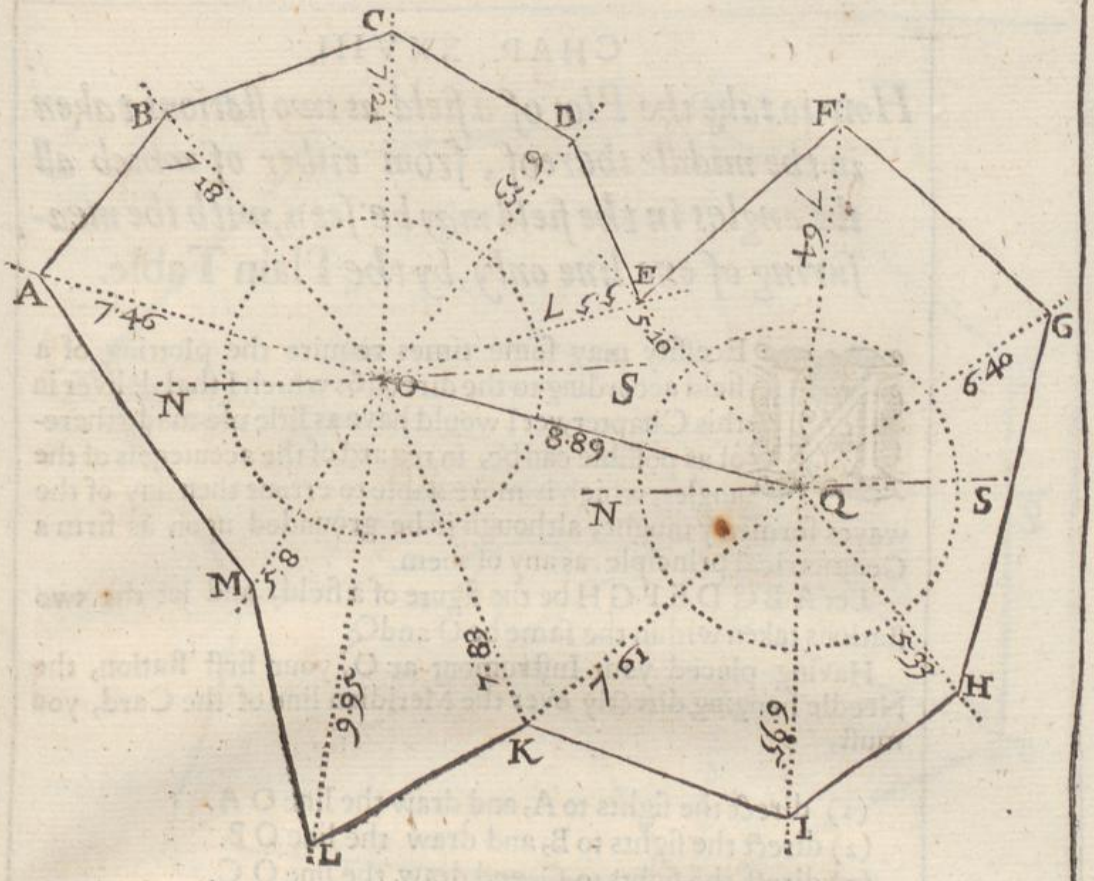
DRaw upon your paper the Meridian line M O S, the point O representing your first station: upon this point O place the center of your Protractor, laying the line E F thereof, directly upon the Meridian line N S Then taking your field-book before you observe the degrees there noted, namely,

(1) at A, 19 degrees 10 minutes the line O A containing 7 Chains 46 Links.

(2) at B, 53 degrees 30 minutes, the line O B containing 7 Chains 18 Links.

(3) at C, 95 degrees 15 minutes, the line O C containing 7 Chains 21 Links.

And



And so of the rest, against which degrees and minutes make marks by the edge of your Protractor, and draw lines from O through those marks, as O A, O B, O C, O D, O E, O K, O L, O M, and upon those lines set off the length from O, as you finde them collected in your field-book.

Having thus protracted the observations of your first station (before you move your Protractor) make a marke against 18 degrees 15 minutes which is the inclination or difference of Meridians, and draw the line O 2, setting of 8 Chains 89 Links the length thereof from O to 2. Then upon the point 2, place the center of the Protractor, as before, moving it up and down till the line O 2 lies just under 18 degrees 15 minutes, and holding it there, lay your field-book before you, and prick down by the side thereof the severall degrees and minutes as byy our Instrument you observed them, together with the lengths of the lines as they were measured, drawing lines through those points also as the lines 2 E, 2 F, 2 G, 2 H, 2 I, and 2 K.

Lastly, draw the lines A B, B C, C D, D E, E F, &c. so shall you have upon your paper the exact plot of your field, in which (if there be no errour in your work) the line M A being drawn will close exactly with the line B A in the point A.

CHAP. XXVIII.

How to take the Plot of a field at two stations taken in the middle thereof, from either of which all the angles in the field may be seen, with the measuring of one line only, by the Plain Table.

NEcessity may some times require the plotting of a field according to the directiõs which I shal deliver in this Chapter, yet I would have as litle use made thereof as possible can be, in regard of the accuteness of the angles, which is more liable to errour then any of the wayes formerly taught, although it be grounded upon as firm a Geometrical principle, as any of them.

Let A B C D E F G H be the figure of a field, and let the two stations taken within the same be O and Q.

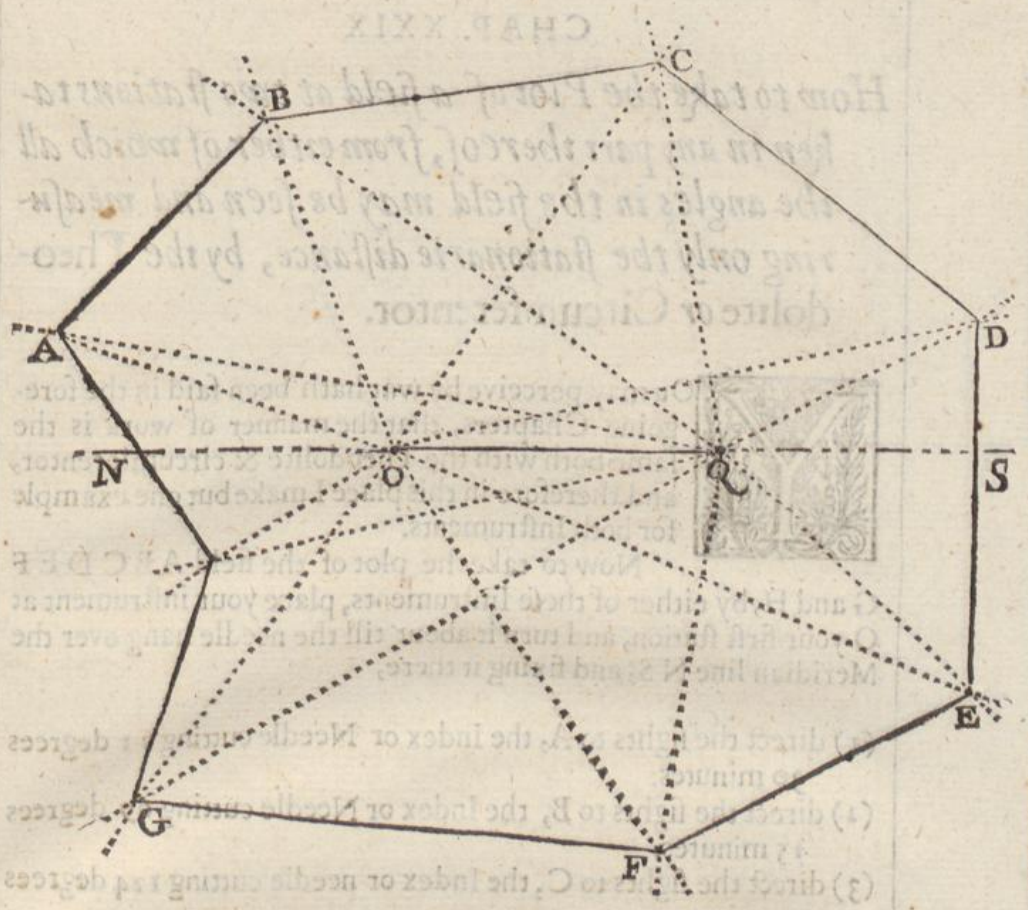
Having placed your Instrument at O, your first station, the Needle hanging directly over the Meridian line of the Card, you must,

(1) direct the sights to A, and draw the line O A.
(2) direct the sights to B, and draw the line O B.
(3) direct the sights to C, and draw the line O C.
(4) direct the sights to D, and draw the line O D.
(5) direct the sights to E, and draw the line O E.
(6) direct the sights to F, and draw the line O F.
(7) direct the sights to G, and draw the line O G.
(8) direct the sights to H, and draw the line O C.

This done, direct the sights to your second station at Q, and draw the line O Q upon your Table: then (with your Chain) measure out your stationarie distance O Q, which is 7 Chains, and removing your Instrument to Q (the needle hanging over the Meridian line of the Card as before) make observation as you did at O; As,

(1) direct the sights to A, and draw the line Q A.
(2) direct the sights to B, and draw the line Q B.
(3) direct the sights to C, and draw the line Q C.
(4) direct the sights to D, and draw the line Q D.
(5) direct the sights to E, and draw the line Q E.
(6) direct the sights to F, and draw the line Q F.
(7) direct the sights to G, and draw the line Q G,
(8) direct the sights to H, and draw the line Q H.

Now



Now you may plainly perceive by the figure where the correspondent lines at each ſtation interſect or croſſe each other; as,

(1) the lines O A and Q A interſect each other at A.
(2) the lines O B and Q B, interſect each other at B.
(3) the lines O C and Q C, interſect each other at C.
(4) the lines O D and Q D, interſect each other at D.
(5) the lines O E and Q E, interſect each other at E.
(6) the lines O F and Q F. interſect each other at F.
(7) the lines O G and Q G, interſect each other at G.
(8) the lines O H and Q H. interſect each other at H.

Therefore, if from one to another of theſe points ſucceſſively you draw lines, you ſhall have upon your paper the exact ſymetry or proportion of your field, as namely, the lines A B, B C, C D, D E, &c.

In this kinde of plotting you cannot but perceive a wonderfull quick diſpatch, you being to meaſure nothing but the diſtance between your ſtations, but by reaſon of the acuteneſſe of the angles (without exact and curious drawing of your lines, and obſerving the preciſe points of interſection) you may run into groſſe abſurdities and miſtakes.

CHAP. XXIX

How to take the Plot of a field at two stations taken in any part thereof, from either of which all the angles in the field may be seen and measuring only the stationarie distance, by the Theodolite *or* Circumferentor.

YOu may perceive by wat hath been said in the foregoing Chapters, that the manner of work is the same both with the Theodolite & circumferentor, and therefore in this place I make but one example for both Instruments.

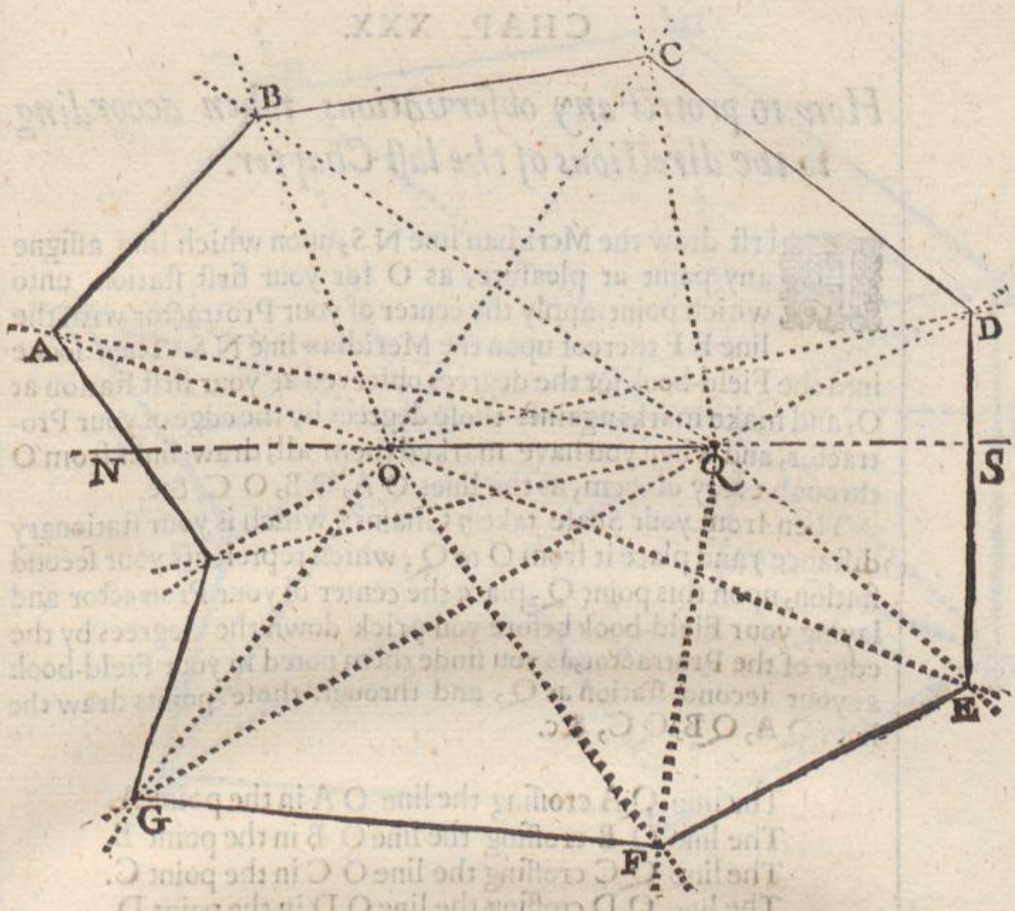
Now to take the plot of the field A B C D E F G and H, by either of these Instruments, place your instrument at O your first station, and turn it about till the needle hang over the Meridian line N S, and fixing it there,

(1) direct the sights to A, the Index or Needle cutting 21 degrees 30 minutes.
(2) direct the sights to B, the Index or Needle cutting 69 degrees 15 minutes.
(3) direct the sights to C, the Index or needle cutting 124 degrees 45 minutes.
(4) direct the sights to D, the Index or Needle cutting 168 degrees 10 minutes.
(5) direct the sights to E, the Index or Needle cutting 202 degrees 30 minutes.
(6) direct the sights to F, the Index or Needle cutting 237 degrees 30 minutes.
(7) direct the sights to G, the Index or Needle cutting 307 degrees 00 miuutes.
(8) direct the sights to H, the Index or Needle cutting 328 degrees 30 minutes.

This done, measure your stationarie distance O 2, which suppose to contain 7 Chains, and remove your Instrumenr to 2, turning it about till the Needle hang directly over the Meridian liue as before, and there fix it; then,

(1) direct the sights to A, the Index or Needle cutting 11 degrees 00 minutes.
(2) direct the sights to B, the Index or Needle cutting 35 degrees 30 minutes.
(8) direct the sights to C, the Index or Needle cutting 79 degrees 45 minntes.

(4) di-



(4) direct the sights to D, the Index or Needle cutting 153 degrees 1; minutes.

(5) direct the sights to E, the Index or Needle cutting 224 degrees 50 minutes.

(6) direct the sights to F, the Index or Needle cutting 279 degrees 30 minutes.

(7) direct the sights to G, the Index or Needle cutting 329 degrees 00 minutes.

(8) direct the sights to H, the Index or Needle cutting 347 degrees 30 minutes.

Having thus made observation of all the angles round about the field at both stations and noted the degrees cut by the Index of the Theodolite or the Needle of the Circumferentor, and noted them down in your field-book, together with the distance between your two stations, you may proceed to protract your work as is taught in the next Chapter.

CHAP.

CHAP. XXX.

How to protract any observations taken according to the directions of the last Chapter.

FIrst draw the Meridian line N S, upon which line assigne any point at pleasure, as O for your first station, unto which point apply the center of your Protractor with the line E F thereof upon the Meridian line N S. Then looke into the Field-book for the degrees observed at your first station at O, and make marks against those degrees by the edge of your Protractor, and when you have marked them all, draw links from O through every of them, as the lines O A, O B, O C, &c.

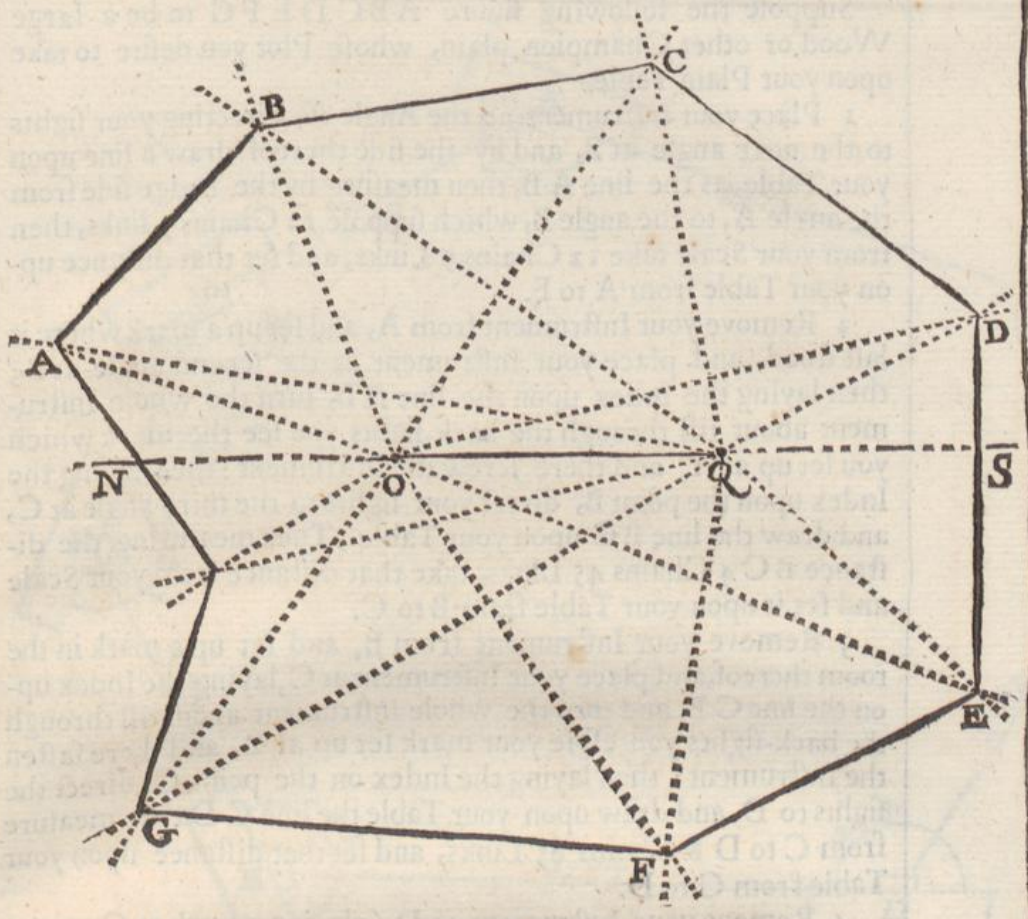
Then from your Scale take 7 Chains (which is your stationary distance) and place it from O to Q, which represents your second station, upon this point Q, place the center of your Protractor and laying your Field-book before you prick down the degrees by the edge of the Protractor, as you finde them noted in your Field-book at your second station at Q, and through those points draw the lines Q A, Q B, Q C, &c.

The line Q A crossing the line O A in the point A.
The line Q B crossing the line O B in the point B.
The line Q C crossing the line O C in the point C.
The line Q D crossing the line O D in the point D.
The line Q E crossing the line O E in the point E.
The line Q F crossing the line O F in the point F.
The line Q G crossing the line O G in the point G.
The line Q H crossing the line O H in the point H.

Therefore if you draw the lines A B, B C, C D, D E, E F, F G, G H, and H A, it shall be the exact plot or figure of the field required.

¶ I might now proceed to shew the manner of taking the plot of any field without approaching nigh the same; but in regard the performance thereof differeth nothing at all from that which is already taught in the 13, 14, and 15, Chapters of the fourth Book, I shall therefore in this place passe it over as superfluous.

CHAP.



CHAP. XXXI.

How to take the Plot of a Wood, Park, or other large Champion plain by the Plain Table, *by measuring round about the same, and making observation at every angle,*

HItherto we have shewed how the plot of any plain and even ground, or any small enclosure may be taken severall wayes, as being the easiest for a practioner to try experience upon, I now come to shew how the plot of any large Champion plain, or over-grown wood may be measured, for in such kinde of grounds the former directions will be of little validity, for the largenesse of the Plain, or the thicknes of the wood may many times hinder both your sights and measuring; therefore the best way to measure these kinde of Lands is to go about them, and make observation at every angle.

Sup-

Suppose the following figure A B C D E F G to be a large Wood or other Champion plain, whose Plot you desire to take upon your Plain Table.

1 Place your Instrument at the Angle A, directing your sights to the next angle at B, and by the side thereof draw a line upon your Table, as the line A B, then measure by the hedge side from the angle A, to the angle B, which suppose 12 Chains 5 links, then from your Scale take 12 Chains 5 Links, and set that distance upon your Table from A to F.

2 Remove your Instrument from A, and set up a mark where it last stood, and place your Instrument at the second angle at B; then laying the Index upon the line A B, turn the whole Instrument about till through the back-sights you see the mark which you set up at A, and there screw the Instrument: then laying the Index upon the point B, direct your sights to the third angle at C, and draw the line B C upon your Table, Then measuring the distance B C 4 Chains 45 Links, take that distance from your Scale and set it upon your Table from B to C.

3 Remove your Instrument from B, and set up a mark in the room thereof, and place your Instrument at C, laying the Index upon the line C B, and turn the whole Instrument about till through the back-sights you espie your mark set up at B, and there fasten the Instrument: then laying the Index on the point C, direct the sights to D, and draw upon your Table the line C D then measure from C to D 8 Chains 85 Links, and set that distance upon your Table from C to D.

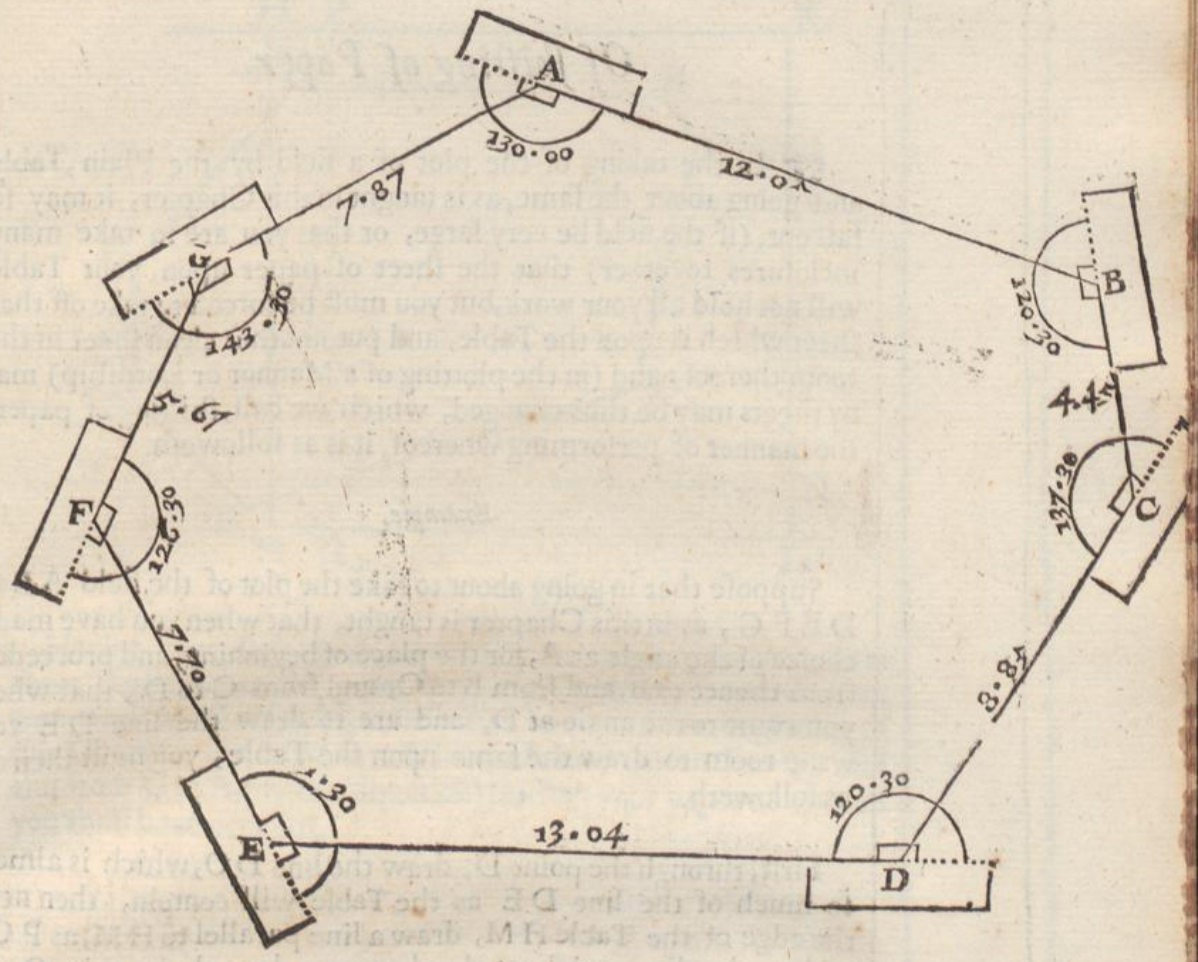
4 Remove your Instrument to D (placing a mark at C where it last stood) and lay the Index upon the line D C, turning the whole Instrument about till through the back-sights you espie the mark at C, and there fasten the Instrument: then lay the Index on the Point D, and direct the sights to E and draw the line D E then with your Chain measure the distanee D E 13 Chains 4 Links, and see that distance upon your Table from the point D unto E.

5 Remove your Instrument to E (placing a mark at D where it last stood) and laying the Index upon the line D E turn the whole Instrument about till through the back-sights you see your mark at D, and there fasten the Instrument: then lay the Index on the point E, and direct the sights to F, and draw the line E F, then measure the distance E F 7 Chains 70 Links, which take from your Scale, and set it on your Table from E to F.

6 Remove your Instrnment to F (placing a mark at E where it last stood) and lay the Index upon the line E F, turning the Instrument about, till through the back-sights you see your mark set up at E, and there fasten the Instrument: then laying the Index on the point F, direct the sights to G, and draw the line F G upon your Table, then measure the distance F G 5 Chains 67 Links, and set that off upon your Table from F to G.

7 Remove your Instrument to G (seting up a mark at F where it last stood) and lay the Index upon the line F G turning the whole

Instru-



Instrument about, till through the ſights you ſee the mark at F, and there faſten the Inſtrument, then laying the Index upon the point G direct the ſights to A (your firſt mark) and draw the line G A, which ſhall paſſe directly through the point A, where you firſt began, if you have truly wrought.

In this manner may you take the plot of any Champion plain be it never ſo large, and here note, that many times hedges are of ſuch a thickneſſe that you cannot come neere the ſides or angles of the field, either to place your Inſtrument or meaſure your lines; therefore, in ſuch caſes, you muſt place your Inſtrument, and meaſure your lines parallel to the ſide thereof, and then your work will be the ſame as if you meaſured the hedge it ſelfe.

Note alſo, that in thus going about a field, you may much help your ſelfe by the Needle, for looke what degree of the Card the needle cuts at one ſtation, if you remove your Inſtrument to the next ſtation, and with your back-ſights look to the mark where your Inſtrument laſt ſtood, you ſhall finde the Needle to cut the ſame degree again, which will give you no ſmall ſatisfaction in the proſecution of your work.

Of shifting of Paper.

☞ In the taking of the plot of a field by the Plain, Table and going about the same, as is taught in this Chapter, it may so fall out, (if the field be very large, or that you are to take many inclosures together) that the sheet of paper upon your Table will not hold all your work, but you must be forced to take off that sheet which is upon the Table, and put another clean sheet in the room thereof: and (in the plotting of a Mannor or Lordship) many sheets may be thus changed, which we call, shifting of paper, the manner of performing whereof, it is as followeth.

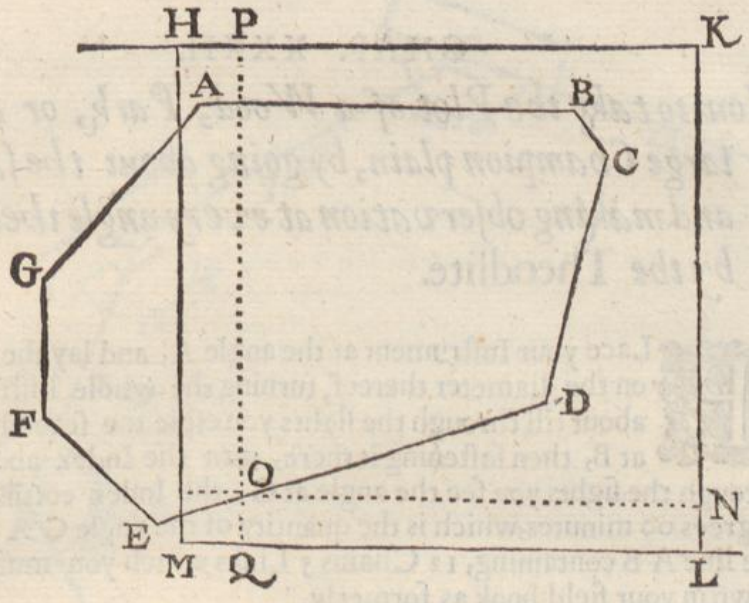
Example.

Suppose that in going about to take the plot of the field A B C D E F G, as in this Chapter is taught, that when you have made choice of the angle at A, for the place of beginning, and proceeded from thence to B, and from B to C, and from C to D, that when you come to the angle at D, and are to draw the line D E you want room to draw the same upon the Table, you must then do as followeth.

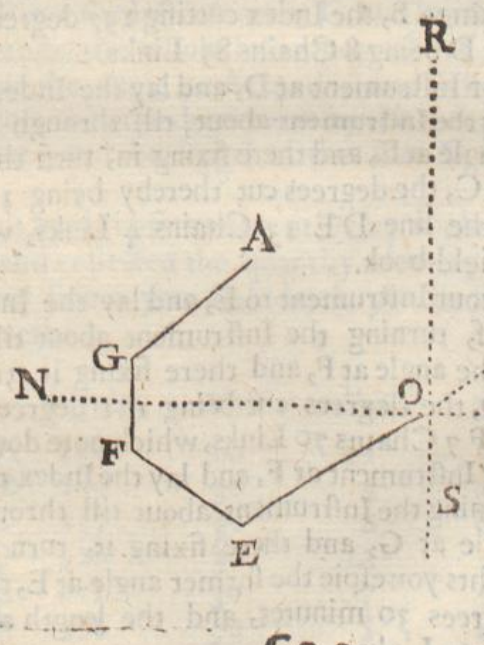
First, through the point D, draw the line D O, which is almost so much of the line D E as the Table will contein, then neer the edge of the Table H M, draw a line parallel to H M, as P Q, and another line at right angles thereunto through the point O, as O N, the point O being the farthest point that you can bring upon your Table.

This being done, marke this sheet of paper with the figure (1) about the middle thereof, for your first sheet, then taking this sheet off of your Table, put another clean sheet upon the Table, and draw thereupon a line parallel to the contrary edge of the Table, as the line R S in the other figure, then taking your first sheet of Paper, lay it upon the Table so that the line P Q may exactly lie upon the line R S to best advantage, as at the point O in the second figure, then with your Compass point draw so much of the line O D upon the clean sheet of Paper as the Table will bear.

Ha-



Having thus done proceed with your work upon your new sheet beginning at the point O, and so going forward with your work in all respects, as before is taught in the beginning of this Chapter, as from O to E, from E to F, from F to G, and and from G to A, (by this direction) shifting your paper as often as you shall have occasion.



CHAP. XXXII.

How to take the Plot of a Wood, Park, or other large Champion plain, by going about the same, and making observation at every angle thereof, by the Theodlite.

PLace your Instrument at the angle A, and lay the Index on the diameter thereof, turning the whole Instrument about till through the sights you espie the second angle at B, then fastening it there, turn the Index about till through the sights you see the angle at G, the Index cutting 130 degrees 00 minutes, which is the quantity of the angle G A B, and the line A B containing, 12 Chains 5 Links which you must note down in your field-book as formerly.

2 Remove your Instrument to B, laying the Index on the diameter, and turn it about till through the sights you see the third angle at C, and there fasten it, then turn the Index backward till through the sights you see the angle at A, the degrees cut by the Index being 120 degrees 30 minutes, the quantity of the angle A B C, and the line B C containing 4 Chains 45 Links, which you must note in your Book as before.

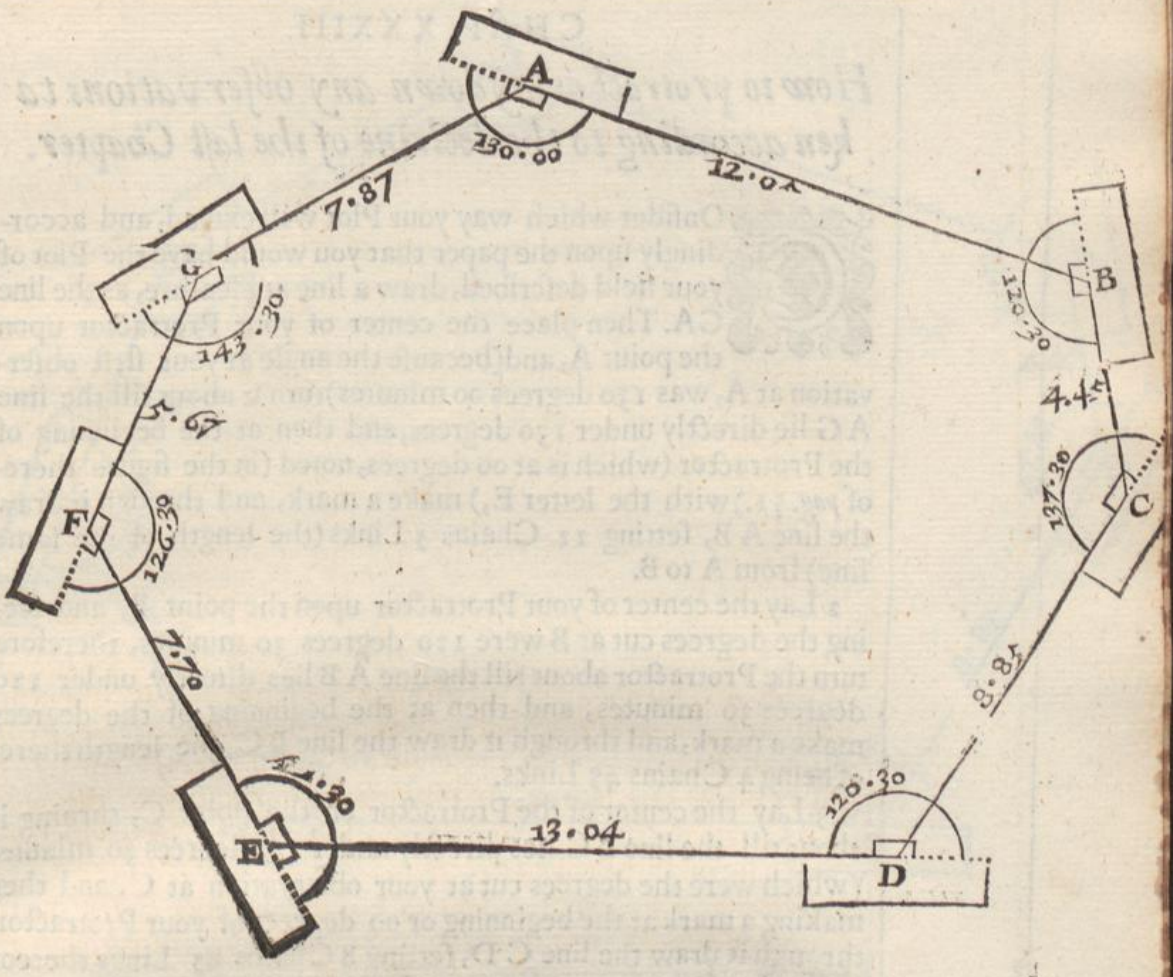
3 Remove your Instrument to C, and lay the Index on the diameter thereof, turning the Instrument about till through the sights you see the fourth angle at D, and there fixing it, direct the sights back again to B, the Index cutting 137 degrees 30 minutes, and the line C D being 8 Chains 85 Links.

4 Place your Instrument at D, and lay the Index on the Diameter, turning the Instrument about, till through the sights you espie the fift angle at E, and there fixing in, turn the Index backward towards C, the degrees cut thereby being 120 degrees 30 minutes, and the line D E 13 Chains 4 Links, which must be noted in your field-book.

5 Remove your Instrument to E, and lay the Index on the Diameter thereof, turning the Instrument about till through the sights you see the angle at F, and there fixing it, turn the Index backward to D, the degrees cut being 121 degrees 30 minutes, and the line E F 7 Chains 70 Links, which note down also.

6 Place your Instrument at F, and lay the Index on the Diameter thereof, turning the Instrument about till through the sights you see the angle at G, and there fixing it, turn the Index till through the sights you espie the former angle at E, the degrees cut being 126 degrees 30 minutes, and the length of the line F G being 5 Chains 67 Links.

7 Lastly,



7 Lastly, Place the Instrument at G, and lay the Index on the Diameter, turning the whole Instrument about till through the sights you espie the angle at A, and there fixing it, direct the sights back again to F, the degrees cut by the Index being 143 degrees 30 minutes, and the length of the line G A 7 Chains 87 Links

Having thus made observation at every angle of the field in this manner, and collected the quantity of every angle, and the length of every line in your field-book, you shall finde them to stand as followeth.

	Degrees	*Minutes*	*Chains*	*Links*
A	130	00	12	5
B	120	30	4	45
C	137	30	8	85
D	120	30	13	4
E	121	30	7	70
F	126	30	5	67
G	143	30	7	87

CHAP. XXXIII.

How to protract or lay down any observations taken according to the doctrine of the last Chapter.

CONsider which way your Plot will extend, and accordingly upon the paper that you would have the Plot of your field described, draw a line at pleasure, as the line GA. Then place the center of your Protractor upon the point A, and (because the angle at your first observation at A, was 130 degrees 00 minutes) turn it about till the line AG lie directly under 130 degrees, and then at the beginning of the Protractor (which is at 00 degrees, noted (in the figure thereof *pag.* 51.) with the letter E,) make a mark, and through it draw the line AB, setting 12 Chains 5 Links (the length of the same line) from A to B.

2 Lay the center of your Protractor upon the point B, and seeing the degrees cut at B were 120 degrees 30 minutes, therefore turn the Protractor about till the line AB lies directly under 120 degrees 30 minutes, and then at the beginning of the degrees make a mark, and through it draw the line BC, the length thereof being 4 Chains 45 Links.

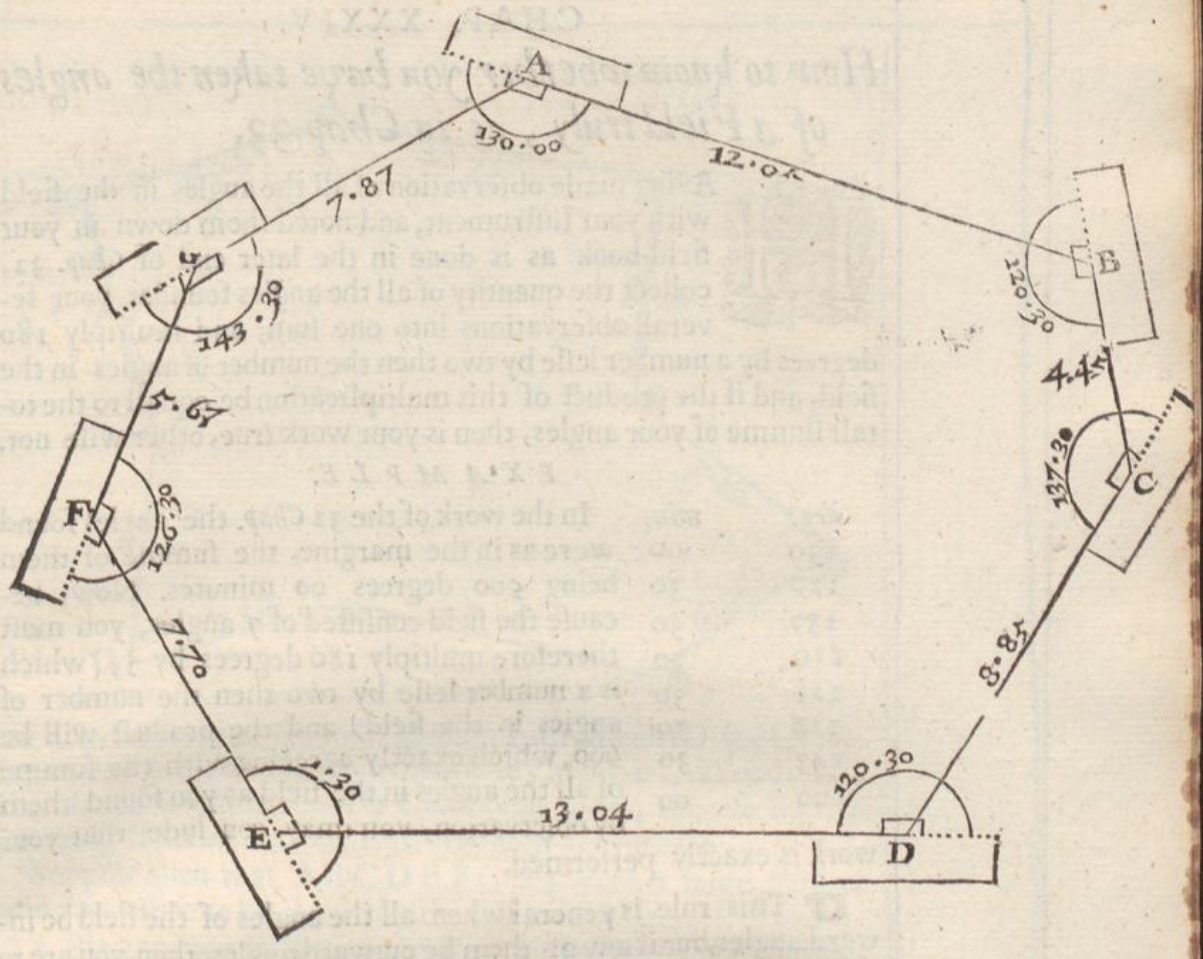
3 Lay the center of the Protractor on the point C, turning it about till the line BC lies directly under 137 degrees 30 minutes (which were the degrees cut at your observation at C,) and then making a mark at the beginning or 00 degrees of your Protractor, through it draw the line CD, setting 8 Chains 85 Links thereon from C to D.

4 Bring the center of your Protractor to the point D, turning it about till the line CD lies directly under 129 degrees 30 minutes, and then making a mark at the beginning of the Protractor, through it draw the line DE, and upon it set 13 Chains 4 Links from D to E.

In this manner must you deale with all the rest of the angles, and when you come to protract the angle at F, which is the last angle, and have drawn the line FG, you shall finde it to cut the line AG first drawn in the point G, leaving the line AG to contain 7 Chains 85 Links, and the line FG 5 Chains 67 Links; and in this, practise is better then many words, and the sight of the figure better then a whole Chapter of information, in which figure, you may see the Protractor lie at every angle in its true position.

This work may be performed other wise by protracting your last observation first so having drawn the line AG, lay the center of the Protractor on G, and the Meridian line thereof (namely EF) on the line GA, then (because the degrees cut at your observation at G, were 143 degrees 30 minutes) make a mark with your protracting pin against 143 degrees 30 minutes and through it draw the line GF, upon which line from G to F, set 5 Chains 67 Links.

Then



Then placing the center of your Protractor on the point F, and the Meridian line thereof upon the line F G, making a mark by the edge of the Protractor againſt 126 degrees 30 minutes (which were the degrees cut by the Index at your obſervation at F, and through that point draw the line F E, ſetting 7 Chains 70 Links thereupon from F to E.

And in this manner muſt you proceed with the reſt of the lines and angles, and at laſt you ſhall finde the plot of your field to cloſe at A, as before it did at G, and if the ſides and angles were never ſo many, the manner of the work would be the ſame.

¶ Here note that if in going about a field, and meaſuring the angles thereof with the Theodolite or degrees on the frame of the Table (as in *Chap.* 32.) that if you meet with any angle that bendeth inwards in the field, you muſt reckon that angle to be ſo much above 180 degrees as the bending is, and when you note the degrees of ſuch an angle in your field-book, you may make this > or the like mark againſt them for a remembrance when you come to protract, and in protracting you muſt turn the Semicircle of the Protractor the contrary way to what yon do in protracting of other angles.

CHAp

CHAP. XXXIV.

How to know whether you have taken the angles of a Field truly, as in Chap. 33.

HAving made observation of all the angles in the field with your Instrument, and noted them down in your field-book as is done in the later end of *Chap.* 32. collect the quantity of all the angles found at your severall observations into one sum, and multiply 180 degrees by a number lesse by two then the number of angles in the field, and if the product of this multiplication be equall to the totall summe of your angles, then is your work true, other wise not.

EXAMPLE.

deg.	*min.*
130	00
120	30
137	30
120	30
121	30
126	30
143	30
500	00

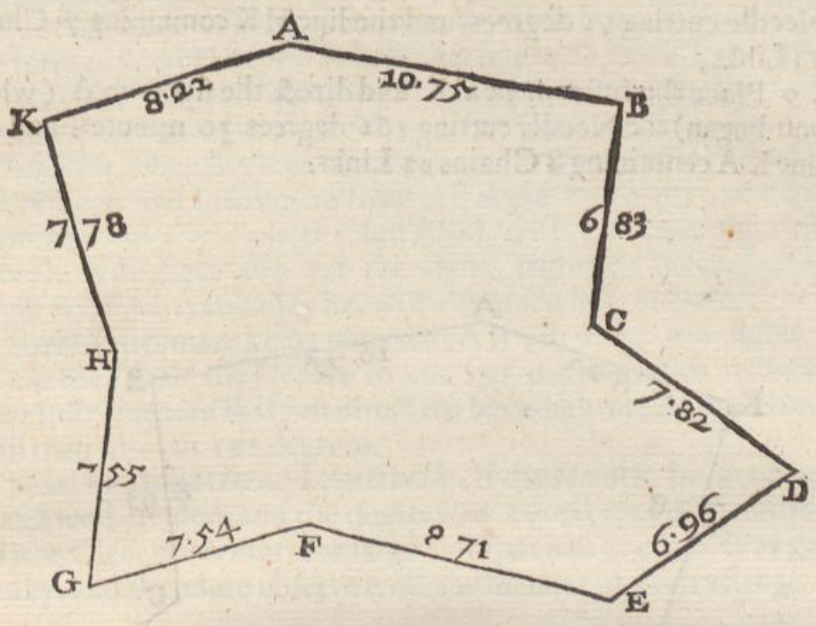
In the work of the 32 *Chap.* the angles found were as in the margine, the summe of them being 500 degrees 00 minutes. Now, because the field consisted of 7 angles, you must therefore multiply 180 degrees by 5, (which is a number lesse by two then the number of angles in the field) and the product will be 900, which exactly agreeing with the summe of all the angles in the field as you found them by observation, you may conclude that your work is exactly performed.

☞ This rule is general when all the angles of the field be inward angles, but if any of them be outward angles, then you are to take the complements of such angles to 180 degrees, which number of degrees is to be added to the rest of the angles, and their aggregate shall be equal to the product of the multiplication of 180, by a number less by two then the angles of the field, but these outward angles (be there never so many in one field) must not be accounted as angles, but wholly rejected.

CHAP. XXXV.

How to take the Plot of any Wood, Park, or other large Champion plain, by going about the same, and making observation at every angle thereof, by the Circumferentor.

WE have before shewn the use of the Circumferentor in taking the plot of any small incloſure several wayes, but for those kind of practises the Circumferentor is no convenient Instrument, the use thereof in those works was only intimated, that the agreement of the several Instruments in the performance of the same thing, might the better appear. Now the



the Circumferentor is a moſt abſolute Inſtrument for the ſurveying of any large and ſpacious buſineſſe, as a Park, Wood, or other large Common field or Champion plain, the uſe thereof differing from all that hath hitherto been delivered.

Suppoſe then that A B C D E F G H K were a large field or other incloſure to be plotted by the Circumferentor.

1 Placing your Inſtrument at A (the Flower-de-luce towards you) direct the ſights to B, the South end of the Needle cutting 191 degrees, and the ditch, wall or hedge A B containing 10 Chains 75 Links, the degrees cut, and the line meaſured, muſt be noted down in your field-book as in the foregoing examples.

2 Place your Inſtrument at B, and direct the ſights to C, the South end of the Needle cutting 279 degrees and the line B C containing 6 Chains 83 Links, which note down in your field-book as before.

3 Place the Inſtrument at C, and direct the ſights to D, the Needle cutting 216 degrees 30 minutes, and the line C D containing 7 Chains 82 Links.

4 Place the Inſtrument at D, and direct the ſights to E, the needle cutting 327 degrees, and the line DE containing 9 Chains 96 Links.

5 Place the Inſtrument at E and direct the ſights to F, the Needle cuting 12 degrees 30 minutes, and the line E F containing 9 Chains 71 Links.

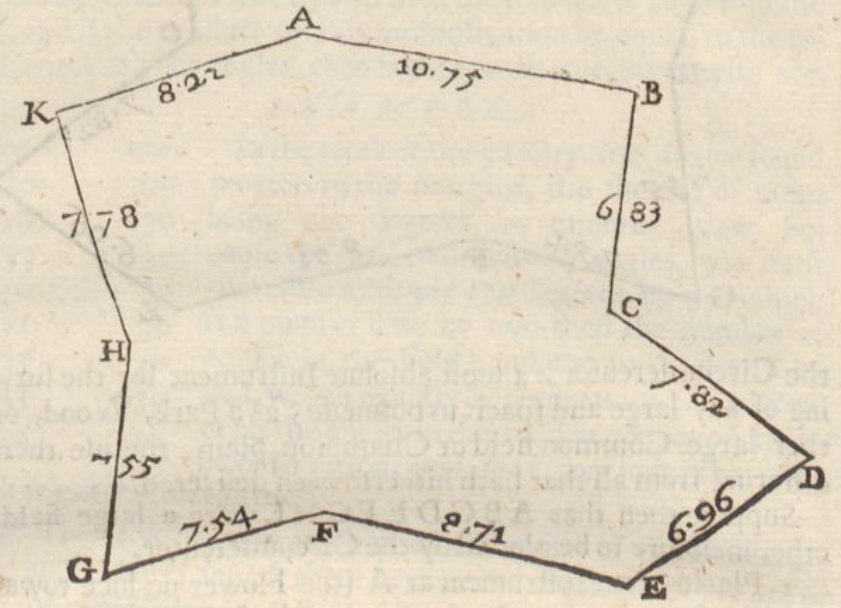
6 Place the Inſtrument at F, and direct the ſights to G, the Needle cutting 342 degrees 30 minutes, and the line F G, containing 7 Chains 54 Links.

7 Place the Inſtrument at G, and direct the ſights to H, the Needle cutting 98 degrees 30 minutes, and the line G H containing 7 Chains 52 Links.

8 Place

8 Place the Instrument at H, and direct the sights to K, the Needle cutting 71 degrees, and the line H K containing 7 Chains 78 Links,

9 Place the Iustrument at K, and direct the sights to A (where you began) the Needle cutting 161 degrees 30 minutes, and the line K A containing 8 Chains 22 Links.



Having gon round the field in this manner, and collected the degrees cut, and the lines measured in the severall columns of your field-book according to former directions, you shall finde them to stand as followeth, by which you may protract and draw the plot of your field as in the next Chapter.

	Degrees.	*Minutes.*	*Chains.*	*Links.*
A	191	00	10	75
B	279	00	6	83
C	216	30	7	82
D	325	00	6	96
E	12	30	9	71
F	342	30	7	54
G	98	30	7	54
H	71	00	7	78
K	161	30	8	22

In

In going about a field in this manner, you may perceive a wonderful quick dispatch, for you are only to take notice of the degres cut once at every angle, and not to use any back-sight as in the fore going work of the Theodolite: but to use back-sights with the Circumferentor is best for to confirm your work; for when you stand at any angle of a field, and direct your sights to the next, and observe what degrees the South end of the needle cutteth, if you remove your Instrument from this angle to the next, and look to the mark or angle where it last stood, with your back-sights the Needle will there also cut the same degree as before, which ought to be done, and may be, without much losse of time.

So the Instrument being placed at A if you direct the sights to B, you shall finde the Needle to cut 191 degrees, then removing your Instrument to B, if you direct the back-sights to A, the Needle will then also cut 191 degrees.

Now for dispatch and exactnesse (if the Needle be good, the Card well divided, and the degrees (by a good eye) truly estimated) the Circumferentor, for large and spacious grounds is as good as any, and therefore observe well the manner of protracting.

A Compendium.

☞ Notwithstanding the quick dispatch this Instrument maketh, there is one Compendium more which I will here insert, whereby (if one be taken) the one half of the work will be saved, for whereas (by the directions in this Chapter) you are to place the Instrument at every angle, it will be sufficient now to place it, but at every second angle, I will instance in the foregoing example.

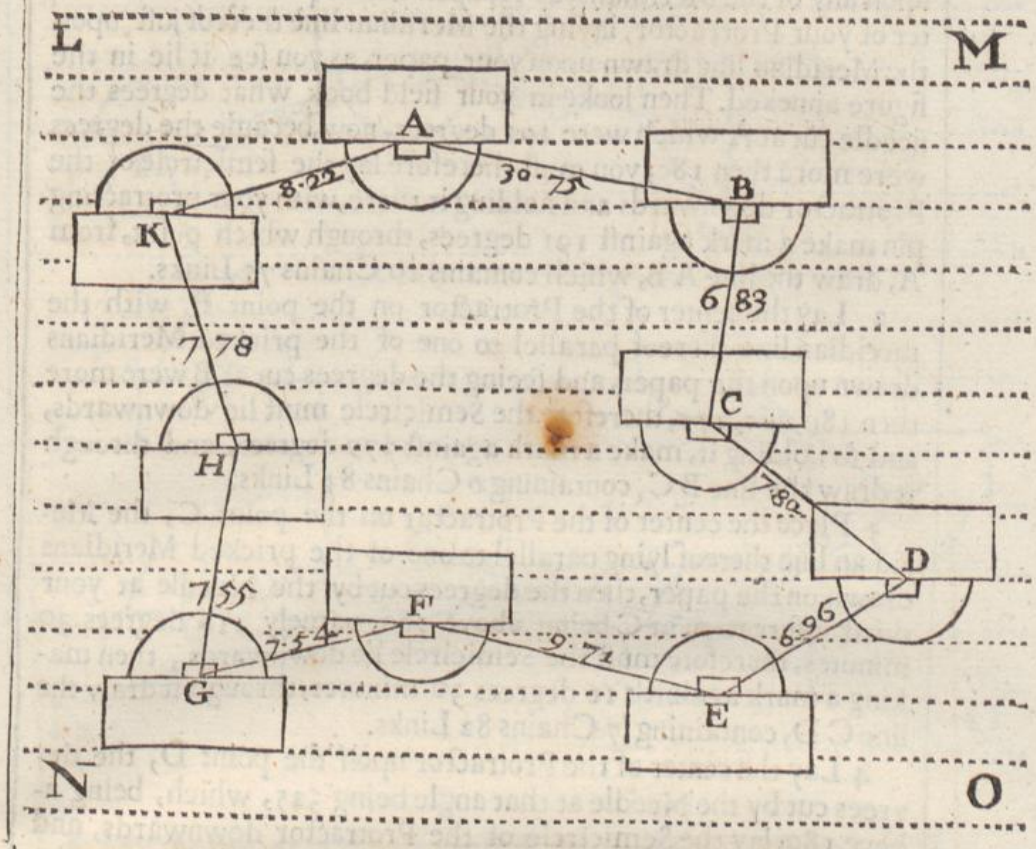
1 Placing your Instrument at A, and directing the sights to B, you find the Needle to cut 191 degrees; Then

2 Placing the Instrument at B, and directing the sights to C, you find the Needle to cut 279 degrees. And

3 Placiug the Instrument at C, and directing the fights to D, you find the Needle to cut 216 degrees.

Now, having placed your Instrument at A, and noted down the degrees cut by the Needle, which were 191, you need not go to the angle B at all, but go next to the angle G, and there place your Instrument, and directing your sights backwards to B, you shall find the Needle to cut 279 degrees, which was the same degrees

grees as were before cut when the Instrument was placed at B, so that the labour of placing the Instrument is wholly saved. Then (the Instrment still standing at C) direct the sights to D, and the Needle will cut 216 degrees, as before, which note in your field-book. This done remove your Instrument to E, and make observation according to this last direction, and you shall find your work to be the same as before, then remove the Instrument from E to G, and G to K, and so to every second angle, be there never so many, and here you see that half the labour is cleerly saved, and the work the same, as if the Instrument had been placed at either angle.



CHAP. XXXVI.

How to protract any obſervations taken by the Circumferentor, *according to the doctrine of the laſt Chapter.*

According to the largeneſſe of your Plot provide a ſheet of paper or skin of parchment, as L M N O, upon which draw the line L M, and parallel thereto, draw divers other lines, quite through the whole paper or parchment, as the pricked lines in the figure drawn between L M and NO, and let the diſtance of each of theſe parallels one from another be ſomewhat leſſe then the breadth of the Scale of your Protractor. Theſe parallel lines thus drawn do repreſent Meridians, and are hereafter ſo called, upon one or other of theſe lines (or parallel to one of them) the Meridian line of your Protractor noted in the figure thereof *pag.* 51, with E F) muſt alwayes be laid when you protract any obſervations taken by the Circumferentor as in the Chapter before going.

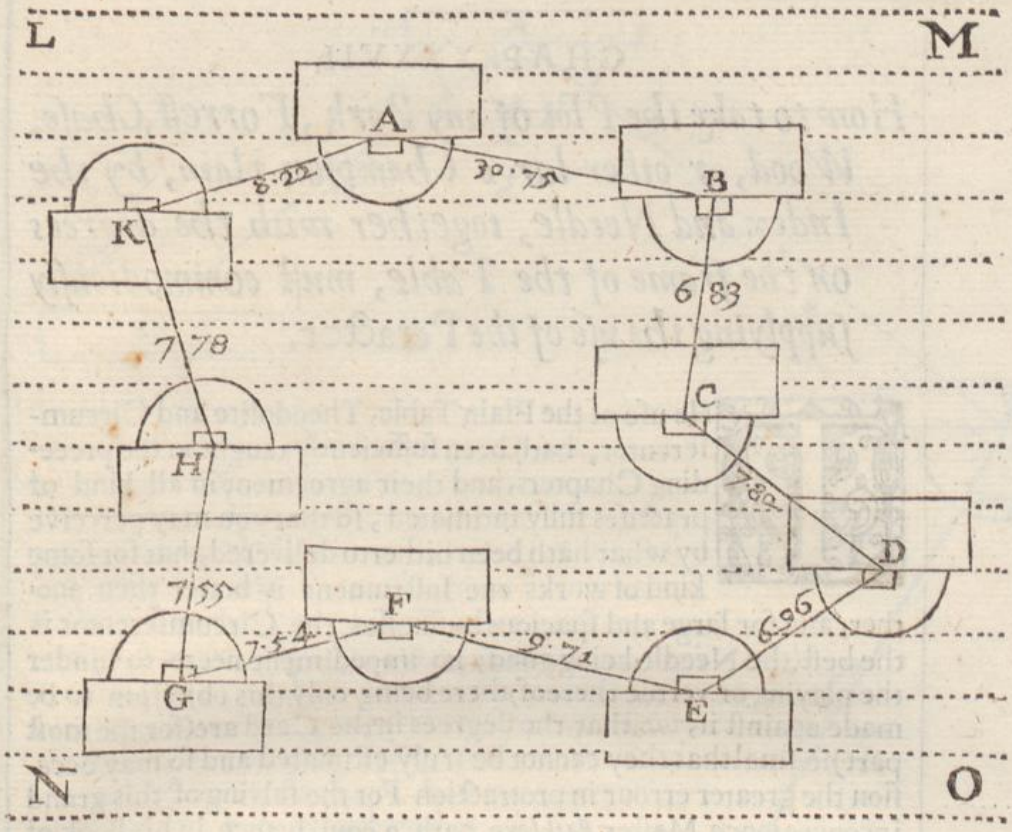
Your paper or parchment being thus pre pared, assigne any point upon any of the Meridians, as A, upon which point place the center of your Protractor, laying the Meridian line thereof just upon the Meridian line drawn upon your paper, as you see it lie in the figure annexed. Then looke in your field-book what degrees the needle cut at A which were 191 degrees, now, because the degrees were more then 180, you must therefore lay the semicircle of the Protractor downwards and holding it there, with your protracting pin make a mark against 191 degrees, through which point, from A, draw the line A B, which contains 10 Chains 75 Links.

2 Lay the center of the Protractor on the point B, with the meridian line thereof parallel to one of the pricked Meridians drawn upon the paper, and seeing the degrees cut at B were more then 180, *viz.* 279, therefore the Semicircle must lie downwards, and so holding it, make a mark against 279 degrees, and through it draw the line B C, containing 6 Chains 83 Links.

3 Place the center of the Protractor on the point C, the Meridian line thereof lying parallel to one of the pricked Meridians drawn on the paper, then the degrees cut by the Needle at your third observation at C being above 180, namely 216 degrees 30 minutes, therefore must the Semicircle lie downwards, then making a mark against 216 degrees 30 minutes, through it draw the line C D, containing 7 Chains 82 Links.

4 Lay the center of the Protractor upon the point D, the degrees cut by the Needle at that angle being 525, which, being above 180, lay the Semicircle of the Protractor downwards, and against 325 degrees make a mark with your protracting pin, through which point, and the angle D, draw the line D E, making it to contain 6 Chains 96 links.

5 Remove your Protractor to E, laying the Meridian line thereof upon (or parellel to) one of the Meridians drawn upon your paper, and because the degrees cut by the Needle at this angle were lesse then 180, namely, 12 degrees 30 minutes, therefore, lay the Semicircle of the Protractor upwards, and make a mark against 12 degrees 30 minutes, through which draw the line E F, containing 9 Chains 71 Links.



6 Lay the center of the Protractor upon the point F, and becauſe the degrees to be protracted are above 180, *viz.* 342 degrees 30 minutes, lay the Semicircle of the Protractor downwards, and make a mark againſt 342 degrees 30 minutes, drawing the line F G which conteins 7 Chains 54 Links.

And in this manner muſt you protract all the other angles G, H, and K, and more, if the field had conſiſted of more angles, alwayes obſerving this for a generall rule, to lay the meridian line of the Protractor upon (or parallel to) one of the Meridians drawn upon your paper (which the ſmall diviſions at each end of the Scale of the Protractor will help you to do,) and if the degrees you are to protract be leſſe then 180 (as thoſe at G H and K are) to lay the Semicircle of the Protractor upwards, or from you; and if they be above 180 degrees (as thoſe at A B C and D are) to lay the Semicircle downwards, as you ſee done in the figure.

☞ Notwithſtanding the Compendium in the laſt Chapter, where the Inſtrument was placed but at every ſecond angle, yet the manner of protracting is the ſame as in this Chapter without any alteration.

CHAP. XXXVII.

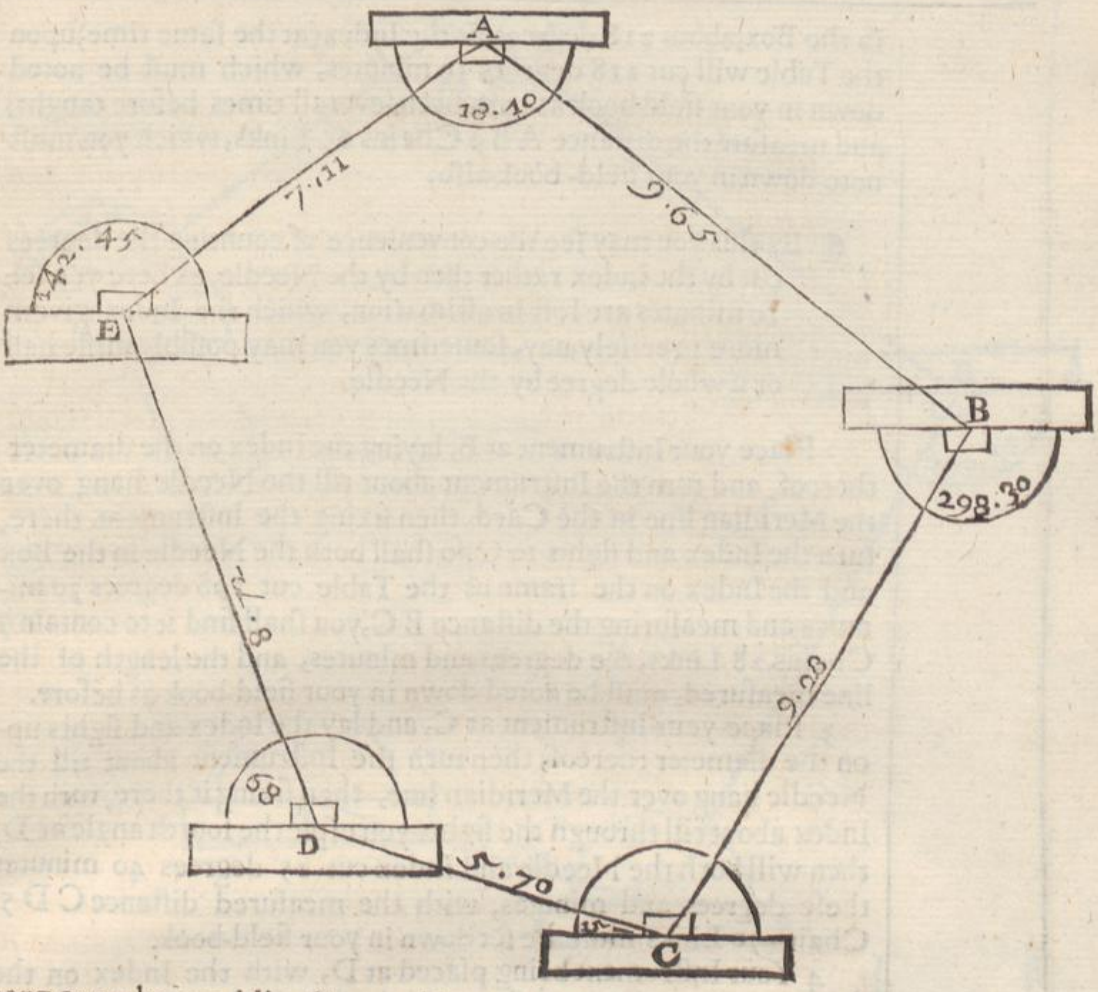
How to take the Plot of any Park, Forrest, Chase, Wood, or other large Champion plain, by the Index and Needle, together with the degrees on the frame of the Table, must commodiously supplying the use of the Peractor.

THe use of the Plain Table, Theodolite and Circumferentor, hath been sufficiently taught in the preceding Chapters, and their agreement in all kind of practises fully intimated, so that you may perceive by what hath been hitherto delivered, that for some kind of works one Instrument is better then another, and for large and spacious businesses, the Circumferentor is the best (the Needle being good, no impediment neere to hinder the playing or vertue thereof) there being only this objection to be made against it, *viz.* that the degrees in the Card are (for the most part) so small that they cannot be truly estimated and so may occasion the greater errour in protraction For the salving of this grand inconvenience Master *Rathborn* hath a contrivance in his Book of Surveying) by an Instrument which he calleth a Peractor which is no other then a Theodolite, only the Box and Needle is so fitted to the center of the Instrument that when the Instrument is fixed in any position whatsoever, the Index may be turned about, and yet the Box and Needle remain immoveable The benefit of this contrivance is, that wheras in the Circumferentor the degrees are cut by the Needle, here the same degrees are cut by the Index, and therefore are larger, the use whereof is thus.

Place the Peractor at any angle of a field, and turn it about till the Needle hang directly over the Meridian line in the Card then fix the Instrument there, and turn the Index about till through the sights you espie the mark or angle you would looke at, then shall the Index cut the same degrees and minutes upon the Limbe of the Peractor, as the Needle would have cut upon the Card of the Circumferentor, if used as is before taught: yet notwithstanding this contrivance you see you must be beholding to the Needle, the convenience only being, that the degrees which you are to note in your field-book, are larger upon the limb of the Instrument then in the Card, which (I confesse) is somthing considerable.

Now if any man have a desire to make use of this Instrument, thinking none better, he is much deceived, for the Box and Needle being screwed to the index of the Plain Table, and fastened to the center of the degrees upon the same frame of the Table, performeth the work of the Peractor much better then the Peractor it self; for, whereas in the use of Peractor, you always let the needle

hang



hang over the meridian line, and let the Index cut the deg, in this you ſhall ſee that in going round a field, the Needle in the Card, and the Index on the frame of the Table will cut like degrees, ſo that you have a double teſtimonie for every obſervation with the ſame facility, which is no ſmall ſatisfaction. Now becauſe (I know) there are ſome which are wedded to the uſe of this Inſtrument, and induce all men whom they can perſwade to the uſe thereof, thinking none ſo good, or at leaſt better, I will here in one example briefely ſhew the uſe thereof, as it is to be performed by the degrees projected on the frame of the Plain-Table, and thereby make the Plain Table more generall.

Let A B C D E be a field to be meaſured by the Index and Needle on the Plain Table, ſupplying the uſe of the Peractor.

1 Place your Inſtrument at A, laying the Index and ſights with the Box and Needle ſcrewed thereto upon the Diameter of the Table, then the Index ſo lying; turn the whole Inſtrument about til the Needle hang directly over the Meridian line in the Card, then ſcrew the Inſtrument faſt, and turn the Index about upon the center, til through the ſights you eſpie your ſecond angle at B, then you ſhall ſee that the South end of the Needle will cut upon the Card in

in the Box, about 218 degrees, & the Index (at the same time) upon the Table will cut 218 degrees 10 minntes, which must be noted down in your field book as hath been severall times before taught, and measure the distance A B 9 Chains 65 Links, which you must note down in your field-book also.

¶ By this you may see the convenience of counting the degrees cut by the Index rather then by the Needle, as here you see 10 minntes are lost in estimation, which the Index giveth more precisely, nay, sometimes you may possibly misse half or a whole degree by the Needle.

2 Place your Instrument at B, laying the Index on the diameter thereof, and turn the Instrument about till the Needle hang over the Meridian line in the Card, then fixing the Instrument there, turn the Index and sights to C, so shall both the Needle in the Box and the Index on the frame of the Table cut 298 degrees 30 minutes and measuring the distance B C, you shall find it to contain 7 Chains 28 Links, the degrees and minutes, and the length of the line measured, must be noted down in your field-book as before.

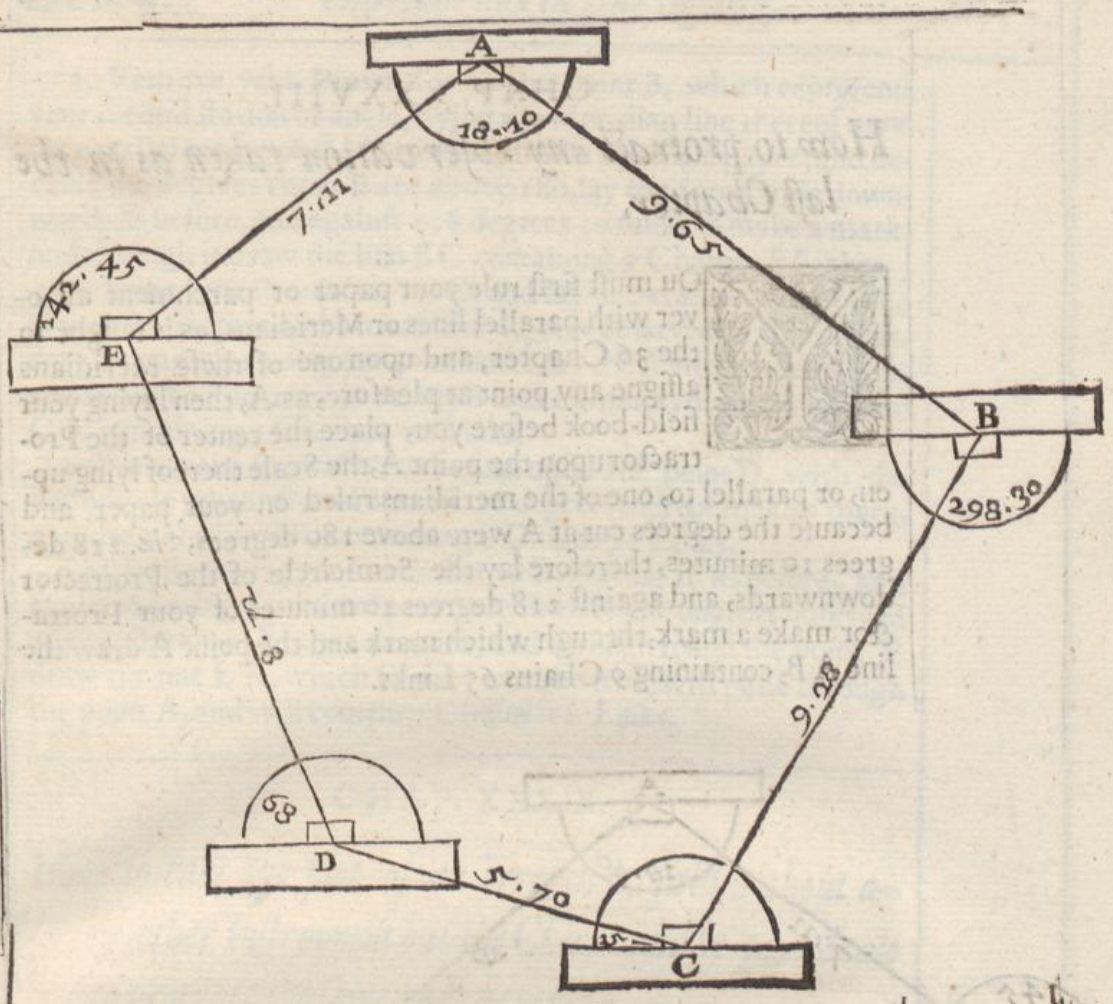
3 Place your Instrument at C, and lay the Index and sights upon the diameter thereof, then turn the Instrument about till the Needle hang over the Meridian line, then fixing it there, turn the Index about till through the sights you espie the fourth angle at D, then will both the Needle and Index cut 15 degrees 40 minutes these degrees and minutes, with the measured distance C D 5, Chains 70 Links, must be set down in your field-book.

4 Your Instrument being placed at D, with the Index on the diameter thereof, turn it about till the Needle hang over the Meridian line, and there fixing it, turn the Index about till through the sights you see the next angle at E, then will both the Needle and Index cut 68 degrees, and the distance G E will be 8 Chains 72 Links, which note in your field-book as before.

5 Lastly, place your Instrument at E, (observing all the former cautions) and direct the sights to A, where you shall finde both the Needle and Index to cut 142 degrees 45 minutes, and the measured distance E A to be 7 Chains 11 Links, which note down in your field-book.

And thus may you go about any field, let it consist of never so many sides and angles, observing alwayes this general rule to lay the Index with the Box and Needle, on the diameter of the Table, and to turn the Table about till the Needle hangs directly over the meridian line in the Card, and then fixing the Table, turn the Index about till through the sights you espie the mark you looke for: then will both the Index and the Needle cut the degrees which you must note in your field-book, so will the collected notes of this example stand as followeth.

Degrees



	Degrees	*Minutes*	*Chains*	*Links*
A	218	10	9	65
B	298	30	9	28
C	15	40	5	70
D	68	00	8	72
E	142	45	7	11

Having thus collected your ſeverall obſervations, you may proceed to protract your work as is taught in the next Chapter, which differeth nothing from that in the 36 *Chap.*

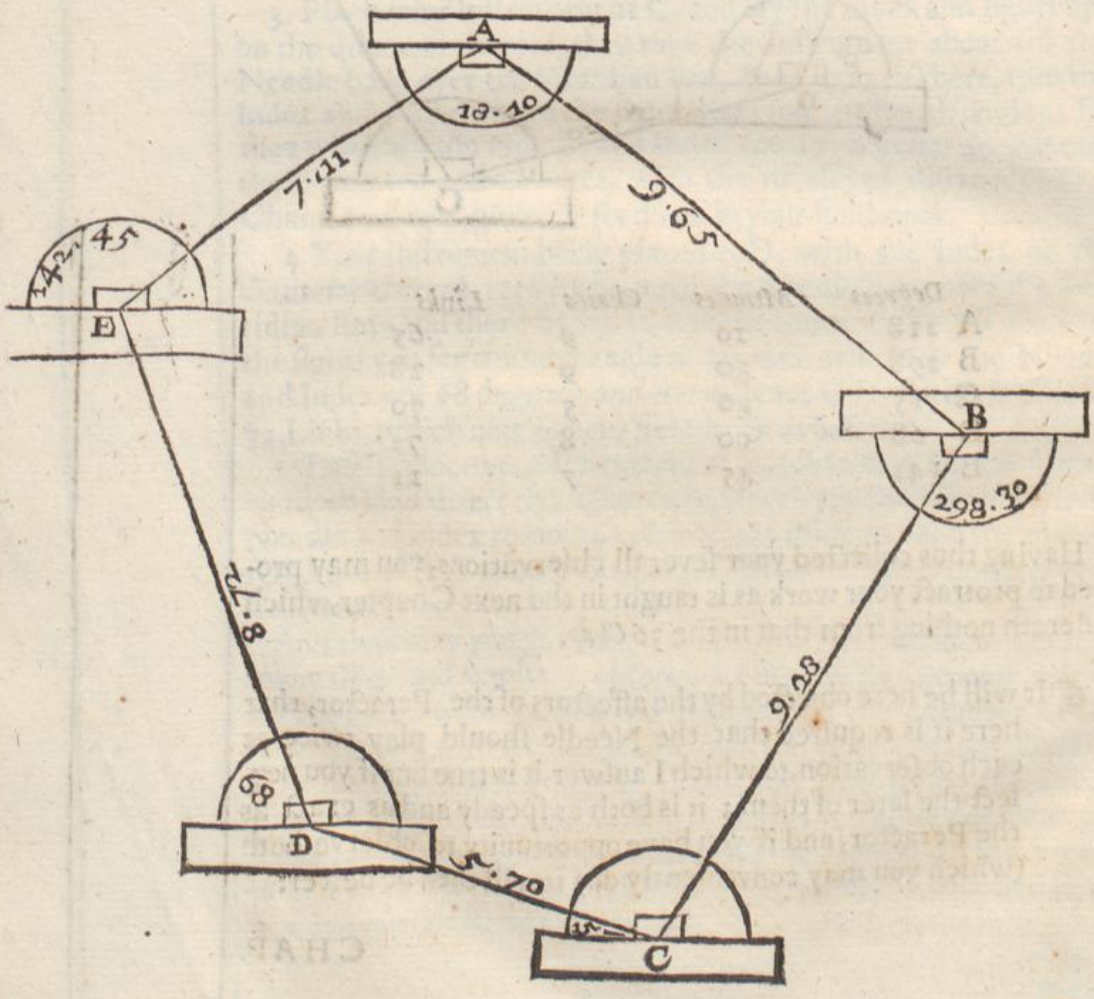
¶ It will be here objected by the affectors of the Peractor, that here it is required that the Needle ſhould play twice at each obſervation, to which I anſwer, it is true but if you neglect the later of them; it is both as ſpeedy and as exact as the Peractor, and if you have opportunity to obſerve both (which you may conveniently do) it will then be better.

CHAP.

CHAP. XXXVIII.

How to protract any observation taken as in the last Chapter.

YOu must first rule your paper or parchment all over with parallel lines or Meridians, as is taught in the 36 Chapter, and upon one of these Meridians assigne any point at pleasure, as A, then laying your field-book before you, place the center of the Protractor upon the point A, the Scale thereof lying upon, or parallel to, one of the meridians ruled on your paper, and becaufe the degrees cut at A were above 180 degrees, *viz.* 218 degrees 10 minutes, therefore lay the Semicircle of the Protractor downwards, and againſt 218 degrees 10 minutes of your Protractor make a mark, through which mark and the point A draw the line A B, containing 9 Chains 65 Links.



2 Re-

2. Remove your Protractor to the point B, which represents your second station or angle, laying the Meridian line thereof upon (or parallel to) one of the Meridians drawn upon the paper, and because the degrees cut at B are above 180, lay the Semicircle downwards as before, and against 298 degrees 30 minutes make a mark, and through it draw the line B C containing 9 Chains 28 Links.

3. Bring your Protractor to C, and lay it parallel to some one of your Meridians, and because the degrees observed at C were under 180, namely 15 degrees 40 minutes, lay the semicircle upwards, and against 15 degrees 40 minutes make a mark, drawing the line C D containing 5 Chaines 70 Links.

4. Place your Protractor as before upon the point D, with the Semicircle upwards, and against 68 degrees thereof make a mark, and draw the line DE containing 8 Chains 72 Links.

Lastly, Remove your Protractor to E, placing it as before, and against 142 degrees 45 minutes (which were the degrees observed at your station at E) make a mark, and through it and the point E draw the line E A, which (if your work be true) will passe through the point A, and will contain 7 Chains 11 Links.

☞ CHAP. XXXIX.

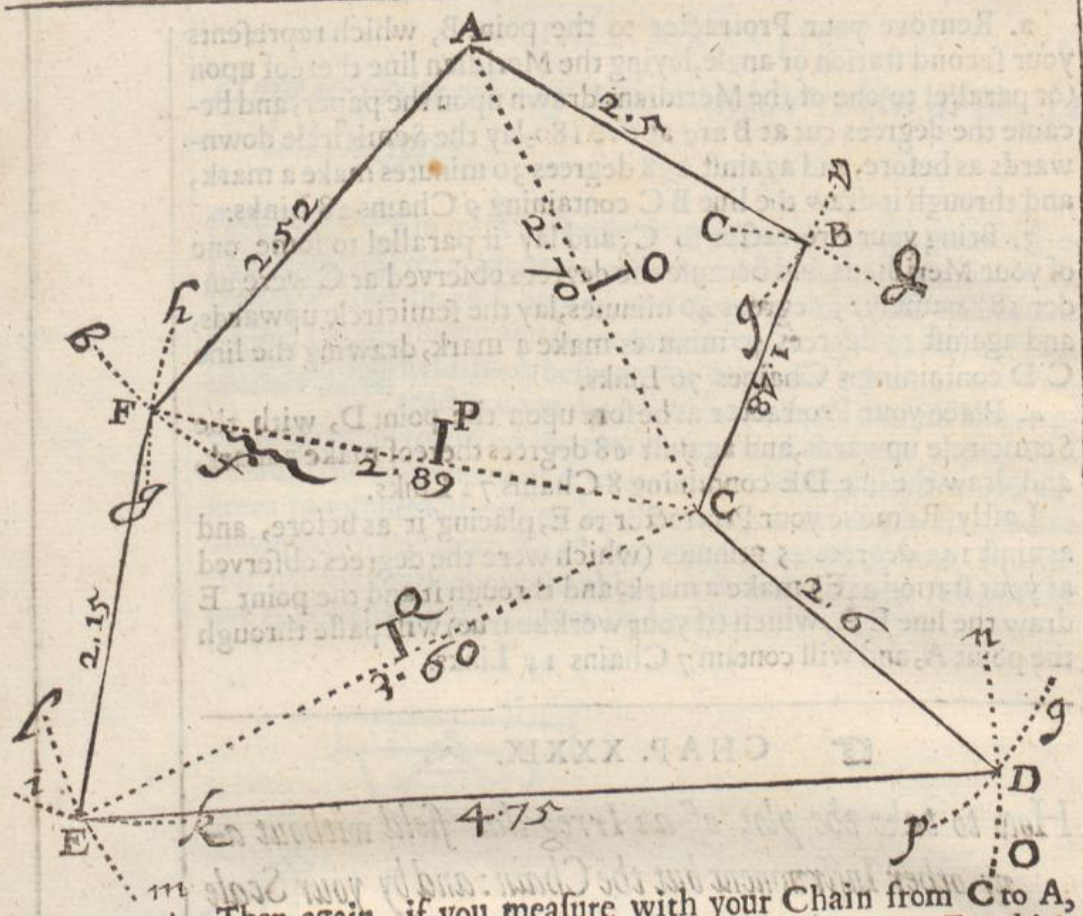
How to take the plot of an Irregular field without any other Instrument but the Chain: and by your Scale to protract the same upon paper.

THis way of taking the plot of a field (if it be carefully practised) is inferior to none of the ways formerly taught, though it be something tedious: Neither can it be practised upon Wood-lands, large Commons, Chases, Forrests, or Mountainous lands, but upon small inclosures only, the manner of effecting it is as followeth:

Let A B C D E F, be a field to be plotted, First, measure every side thereof beginning at the angle A, so shall you finde,

The side A B to Contain	2 Chains	5 Links
B C	1	48
C D	2	6
D E	4	75
E F	2	15
F A	2	52

Now because the field consisteth of six sides it may therefore be reduced into two Trapezias, and best (in this figure) by a line supposed to be drawn from the angle F to the angle C. by which supposed line which being measured will contain 2 Chains 89 Links, the whole field is divided into the two Trapezias A B C F, and F C E D.



Then again, if you measure with your Chain from C to A, which will conte in 2 Chains 70 Links, and from C to E, which conteins 3 Chains 60 Links, you shall divide those two Trapezias each into two Triangles, viz. the Trapezia A B C F into the Triangles A B C, and A C F: And the Tapezia F C E D into the Triangles F E C, and C D E. In every of which Triangles you have all the sides given, by help whereof you may upon paper or parchment, draw the exact figure of your field according to what Scale you please, in manner following.

First (taking into consideration the situation of your field) upon your paper draw the line A C conteining 2 Chains 70 Links of any Scale, Then, because the side A B conteins 2 Chains 5 links, take 2 Chains 5 Links from the same Scale, and placing one foot in A with the other describe the arch *a b*. Likewise, because the side B C conteins 1 Chain 48 Links take one Chain 48 Links from the Scale, and placing one foot of the Compasses in C, with the other describe the arch *c d*, crossing the former arch *a b* in the point B, then drawing two lines from C and A, to the point B, you have protracted the Triangle A B C.

Secondly, For the Triangle A F C, because the side A F conteins 2 C. 52 L. take 2 C. 52 L. out of your Scale, and placing one foot in A, with the other describe the arch *e f*. Likewise, because the side F C conteins 2 Chains 89 L. take 2 C. 89. L out of your Scale, and placing one foot of your Compasses in C, with the other

ther describe the arch *g h*, cutting the former arch *e f* in the point F, then drawing two lines from A and C to the point F, you shall enclose the Triangle A F C.

Thirdly. For the Triangle F E C, because the side F E conteins 2 Chains 15 Links, take 2 Chains 15 Links out of your Scale, and placing one foot in F, with the other describe the arch *i k*. Likewise, because the side C E conteins 3 Chains 60 Links, take 3 Chains 60 Lienks out of your Scale, and placing one foot in C, with the other describe the arch *l m* crossing the former arch *i k* in the point E, then drawing two lines from the points F and C, to the point E, you shall inclose, the Triangle F E C,

Lastly, For the Triangle C E D, because the side E D conteins 4 Chains 75 Links take 4 Chains 75 Links out of your Scale, and placing one foot in E, with the other describe the arch *n o*; likewise, because the side C D, conteins 2 Chains 6 Links, take 2 Chains 6 Links out of your Scale, and placing one foot in C, with the other describe the arch *p q* cutting the former arch *n o* in the point D, then drawing two lines from the points C and E to the point D, you shall inclose the Triangle C E D, and so is your worke finished.

Although this way be somewhat tedious, yet if it be but carefully performed it will effect the thing intended with much exactnesse, and the chiefe caution to be observed in the performance hereof is, that when you measure any of the diagonals, as C A, C F, or C E, you carry your Chain in a direct line, which you may easily do if you cause a marke to be set up at each opposite angle, and a stick or such like in the mid-way between the two angles, as (in this Example) if 3 sticks or marks were erected in the Diagonals at the letters O, P, and Q.

☞ CHAP. XL.

The use of the Instrument described in the fifth Chapter of the second Booke, as also of the Crosse mentioned in the sixth Chapter.

HAving in the 37th. Chapter of this Book shewed how to make the degrees on the frame of the Plain Table to supply the use of the Instrument which Master *Rathbourn* so highly commendeth, and calleth by the name of the Peractor, I thought good in this place to intimate that the Instrument mentioned in the fifth Chapter of the second Book will effect this Worke as well as the degrees on the frame of the Table, and for portability exceedeth any of the forementioned, The use of this Instrument is

so obvious, that I shall not need to give any particular example concerning the use thereof, it being the same that is already taught in the use of the Theodolite, and Circumferentor, only you have this advantage, that your needle is much longer, and the degrees much larger then can be in any ordinary Card.

In the sixth Chapter of the second Book there is mention made of an Instrument called a Crosse, which Instrument may be of good use in small inclosures, which consist of few sides and angles, the Instrument hath no graduations upon it, but is only to lay out right angles in the field it self without protracting, and so to cast up the content of any such field by right angled parallelograms, or long squares, and Triangles, the Instrument at the first reducing the field into the largest right angled parallelogram that may be.

☞ CHAP. XLI.

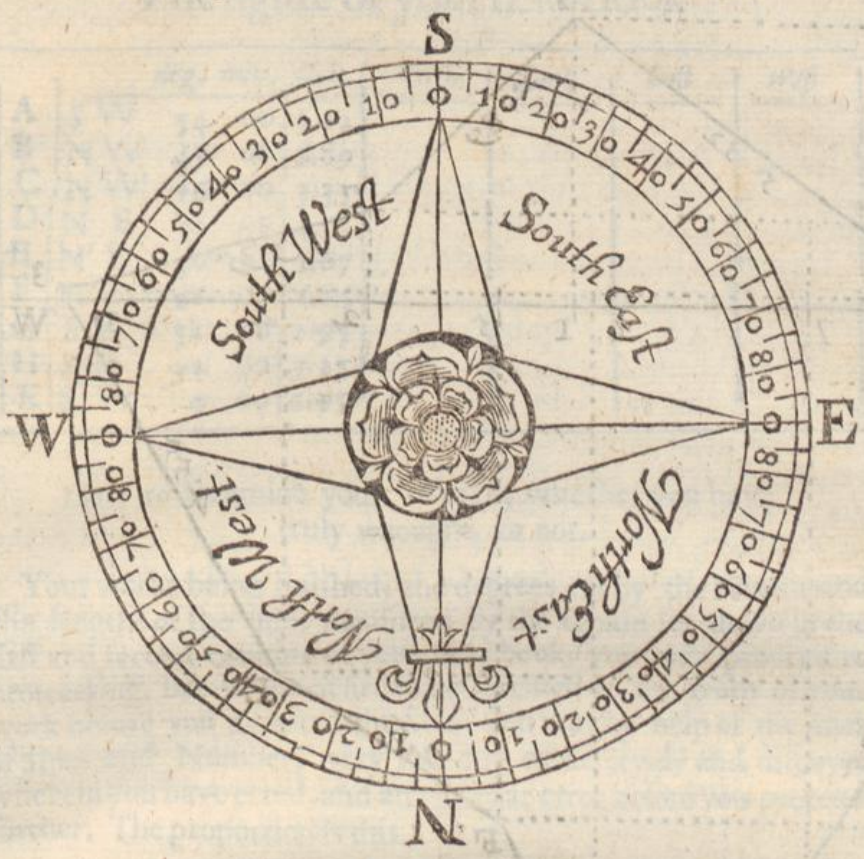
How to take the true plot of a Forrest, Chase, VVood, Park, or other large inclosure, by the Circumferentor, by a more exact way then the former, by which you may know before you begin to protract, whether your Plot will close or not, and also discover wherein you have erred, so that you may go over that part again, and examine the truth of your worke before you go out of the field.

FOr the performing of this Worke, the Card of the Circumferentor, (or the degrees on the frame of the plain Table) must be divided into four Quadrants or Quarters, each conteining 90 degrees, and numbred by 10, 20, 0, &c. to 90, beginning at the Meridian, and so reckoning to the East and West points, as in this figure.

Your Instrument being provided with such a Card as this figure representeth, you may proceed to take the plot of the ground you intend in manner following, but first provide your field-book which (in this case) must be ruled with red inke into six Columns, the first of which must be so broad, as to contein the number of degrees, and the quarter of the Compasse in which the degrees are cut by the South end of the Needle, the second Column is for the Chains and Links which every side of the field conteineth, the four other Columns which have written at the head thereof *North*, *South*, *East*, *West*, are to hold a certain number of Chains and Links, by the addition of which, you may examine your worke and discover whether it will close or not before you proceed to protraction.

THE

The figure of the Card of the Circumferentor.



The manner of working.

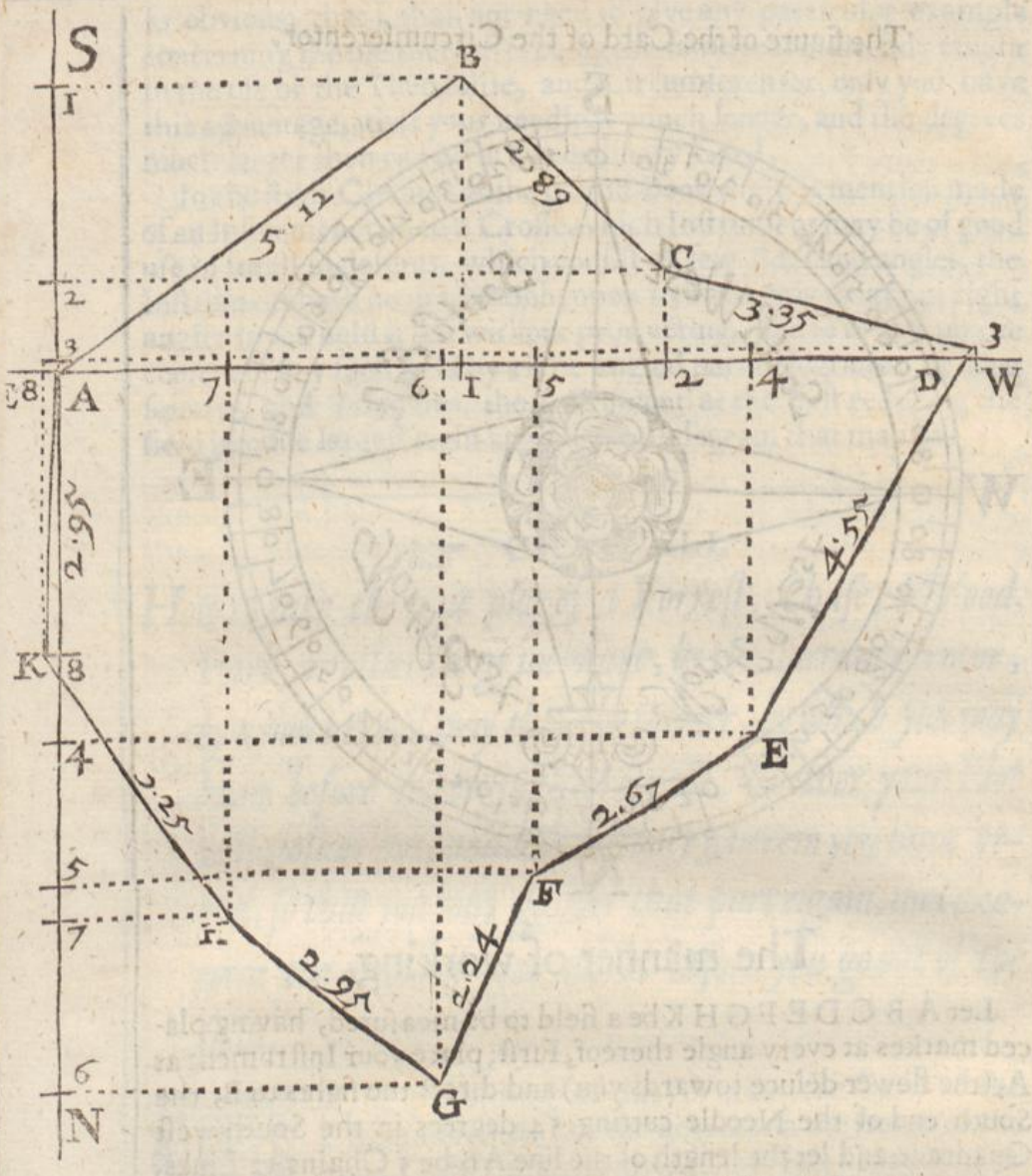
Let A B C D E F G H K be a field to be measured, having placed markes at every angle thereof, First, place your Instrument at A, (the flower deluce towards you) and direct the sights to B, the South end of the Needle cutting 54 degrees in the South-west Quadrant, and let the length of the line AB, be 5 Chains 12 Links, Now you must (in the first column of your field-book) set down S W 54 deg. 0 min. representing *South-West* 54 degrees 0 minutes, and in the second Column set down 5.12 representing 5 Chains 12 Links.

Secondly, place your Instrument at B, and direct the Sights to C, the needle cutting *North West* 45 degrees, and the line B C conteining 2 Chains 89 Links.

Thirdly, place your Instrument at C and direct the Sights to D the needle cutting North West 76 degrees, and the line C D conteining 3 Chains 35 Links.

Fourthly, place your Instrument at D & direct the sight to E, the needle cutting *North East* 31 degrees: and the line DE conteining 4 Chains 55 Links.

Fifthly, place your Instrument at E and direct your sights to F, the needle cutting *North East* 56 degrees, and the line E F conteining 2 Chains 67 Links.



Sixthly, place your Instrument at F, and direct the sights to G, the needle cutting *North East* 21 degrees and the line F G conteining 2 Chains 24 Links.

Seventhly, place your Instrument at G, and direct the sights to H, the needle cutting *South East* 51 degrees, and the line G H conteining 2 Chains 95 Links.

Eightly, place your Instrument at H, and direct the sights to K. the needle cutting *South East* 34 degrees, and the line H K conteining 3 Chains 25 Links.

Lastly, place your Instrument at K, and direct the sights to A, the Needle cutting *South West* 4 degrees, and the line K A conteining 2 Chains 95 Links.

Having thus made observation of all the angles and measured all the sides with your Chain and set them down in your field book, you shall finde them to stand as followeth.

The

The figure of your field Book

		deg.	*min.*	*C.L.*	*North*	*South*	*East*	*West*
A	S W	54	00	5.12				
B	N W	45	00	2.89				
C	N W	76	00	3.35				
D	N E	31	00	4.55				
E	N E	56	00	2.67				
F	N E	21	00	2.24				
G	S E	51	00	2.95				
H	S E	34	00	3.25				
K	S W	4	00	2.95				

How to Examine your Worke, whether you have truly wrought, or not.

Your worke being finiſhed, the degrees cut by the Needle and the lengths of the ſides meaſured by the Chain ſet down in the firſt and ſecond columns of your field book, you may proceed to protracting, but if you deſire to be ſatisfied of the truth of your work before you go out of the field, you may by help of the lines of Sines and Numbers very ſpeedily make tryal, and diſcover wherein you have erred, and amend that error before you proceed further. The proportion is this.

First,

As the Radius, or Sine of 90 degrees
is to the length of the ſide of the field in Chains and Links
So is the ſine of the degrees cut by the Needle
to the length in the *Parallel* in Chains and Links.

Wherefore, Extend the Compaſſes, from the Sine of 90, to the length of the ſide of the field, in the line of Numbers, the ſame extent will reach from the ſine of the degrees cut by the Needle, to the length in the parallel.

Secondly,

As the Radius, or ſigne of 90 degrees
is to the length of the ſide of the field in Chains and Links;
So is the ſine of the Complement of the degrees cut by the Needle
to the length in the *Meridian* in Chains and Links;

Wherefore, Extend the Compaſſes from the ſine of 90, to the length of the ſide of the field in the line of Numbers, the ſame extent will reach from the ſine of the complement of the degrees cut by the Needle, to the length in the *Meridian*.

¶ Note that the two columns in your field book which are noted with North and South, are the *Meridian* columns, and the two columns noted with Eaſt and Weſt are the *Parallel* columns, that

that is to say, the line of North and South, noted in the following figure with N S, is called the *Meridian*, and the line noted with E W in the same figure is called the *Parallel*.

EXAMPLE.

Let it be required to examine whether the degrees be rightly taken, and the sides truly measured in this figure, before you begin to protract.

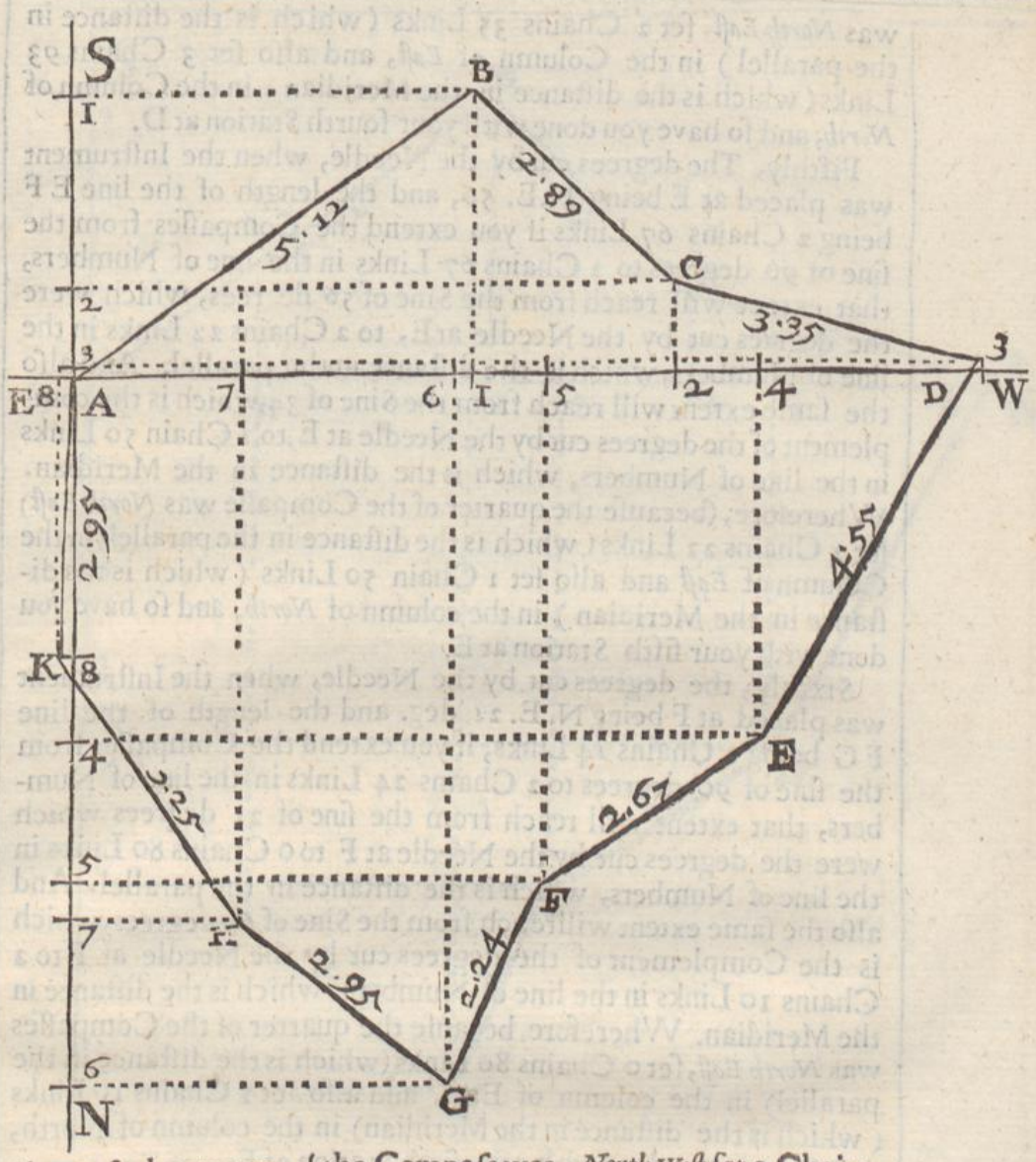
Your deg. being noted and your lengths of lines orderly placed in your field book, we proceed to examine the truth thereof thus.

First, The degrees cut by the Needle when the Instrument was placed at A being S. W. 54 degrees, and the length of the line A B, being 5 Chains 12 Links, if you extend the compasses from the sine of 90 degrees, to 5 Chains 12 Links in line of Numbers, that extent will reach from the Sine of 54 degrees (which were the degrees cut by the Needle at A) to 4 Chains 14 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the sine of 36 degrees (which is the complement of the degrees cut by the needle at A) to 2 Chains 97 Links, in the line of Numbers, which is the distance in the Meridian, wherefore (because the quarter of the Compasse was *South West*) set 4 Chains 14 Links (which is the distance in the parallel) in the Column of *West*, and also set 2 Chains 97 Links (which is the distance in the Meridian) in the Column of *South*, and so have you done with your first Station at A.

Secondly, The degrees cut by the Needle, when the Instrument was placed at B being N. W. 45, and the length of the line B C being 2 C. 89 L. if you extend the Compasses from the sine of 90 deg. to 2 Ch. 89 Lin. in the line of Numbers, that extent will reach from the Sine of 45 degrees, which were the degrees cut by the Needle at B, to 2 Chains 4 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 45, which is the complement of the degrees cut by the Needle at B, to 2 Chains 4 Links in the line of numbers, which is the distance in the Meridian. Wherefore, (because the quarter of the Compasse was *North West*) set 2 Chains 4 L. (which is the distance in the parallel) in the Column of *West*, and also set 2 Chains 4 Links (which is the distance in the Meridian) in the column of *North*, and so have you done with your second Station at B.

Thirdly, the degrees cut by the Needle, when the Instrument was placed at C being N. W. 76, and the length of the line C D, being 3 Chains 35 Links, if you extend the Compasses from the Sine of 90 deg. to 3 Chains 35 Links in the line of Numbers, that extent will reach from the sine of 76, which were the degrees cut by the Needle at C, to 3 Chains 25 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine 14, which is the complement of the degrees cut by the Needle at C, to 0 Chains 83 Links in the line of Numbers, which is the distance in the Meridian. Wherefore,

(because



(becauſe the quarter of the Compaſs was, *North Weſt* ſet 3 Chains 25 Links (which is the diſtance in the parallel) in the Column of *Weſt* and alſo ſet 0 Chains 83 Links, (which is the diſtance in the Meridian) in the column of *North*, and ſo have you done with your third Station at C.

Fourthly, The degrees cut by the Needle when the Inſtrument was placed at D, being N. E. 31 degrees, and the length of the line D E, being 4 Chains 55 Links, if you extend the compaſſes from the ſine of 90 degrees, to 4 Chains 55 Links in the line of Numbers, that extent will reach from the Sine of 31 degrees (which were the degrees cut by the Needle at D) to 2 Chains 35 Links in the line of Numbers, which is the diſtance in the parallel. And alſo the ſame extent will reach from the ſine of 59 degrees (which is the complement of the degrees cut by the Needle at D) to 3 Chains 93 Links, in the line of Numbers, which is the diſtance in the Meridian, wherefore (becauſe the quarter of the Compaſſe

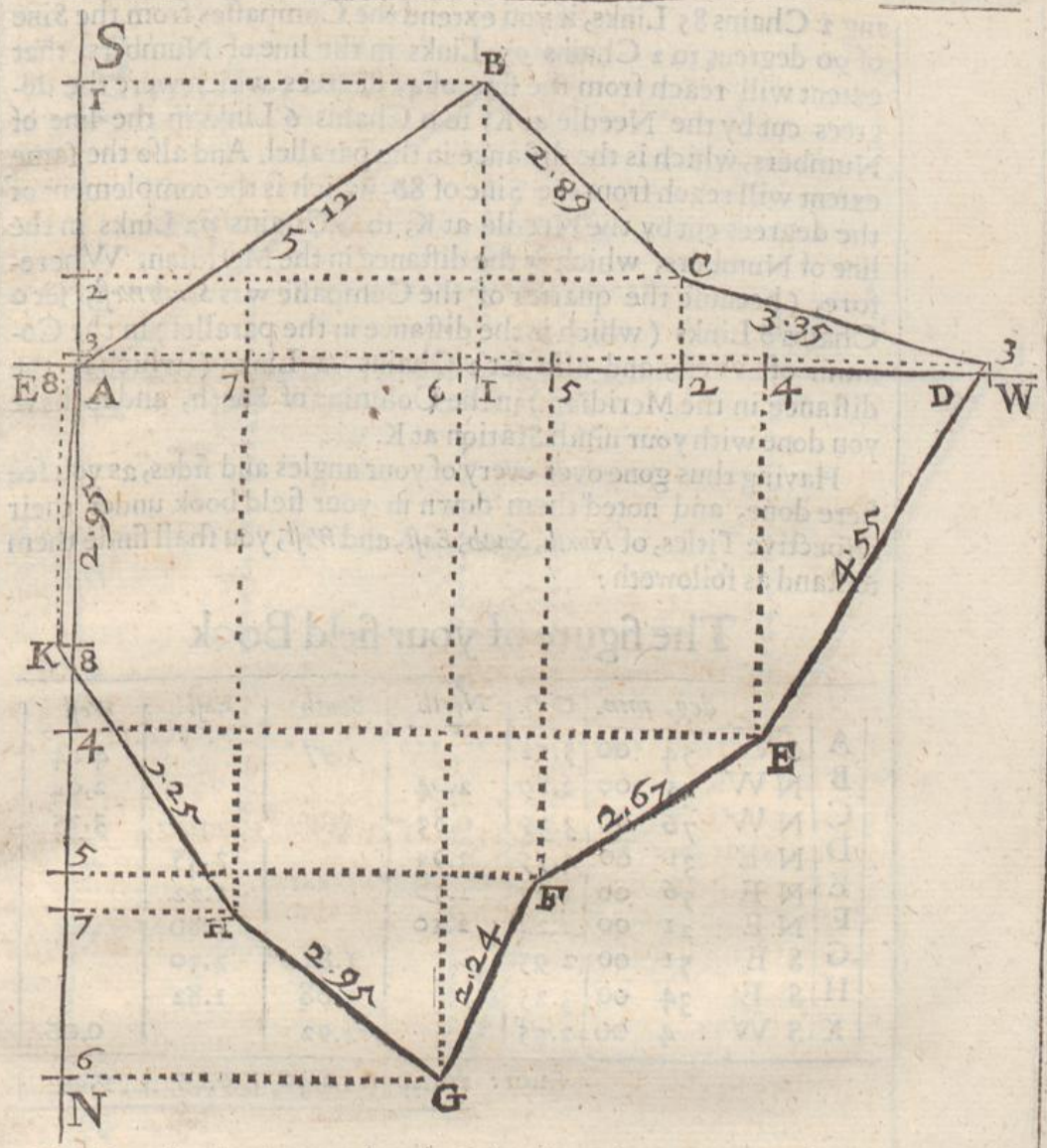
was *North East* set 2 Chains 35 Links (which is the distance in the parallel) in the Column of *East*, and also set 3 Chains 93 Links (which is the distance in the Meridian) in the Column of *North*, and so have you done with your fourth Station at D.

Fifthly, The degrees cut by the Needle, when the Instrument was placed at E being N.E. 56, and the length of the line E F being 2 Chains 67 Links if you extend the Compasses from the sine of 90 degrees to 2 Chains 67 Links in the line of Numbers, that extent will reach from the Sine of 56 degrees, which were the degrees cut by the Needle at E, to 2 Chains 22 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 34, which is the complement of the degrees cut by the Needle at E, to 1 Chain 50 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, (because the quarter of the Compasse was *North East*) set 2 Chains 22 Links (which is the distance in the parallel) in the Column of *East* and also set 1 Chain 50 Links (which is the distance in the Meridian) in the column of *North*, and so have you done with your fifth Station at E.

Sixthly, the degrees cut by the Needle, when the Instrument was placed at F being N. E. 21 deg. and the length of the line F G being 2 Chains 24 Links, if you extend the Compasses from the sine of 90 degrees to 2 Chains 24 Links in the line of Numbers, that extent will reach from the sine of 21 degrees which were the degrees cut by the Needle at F to 0 Chains 80 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 69 degrees, which is the Complement of the degrees cut by the Needle at F to 2 Chains 10 Links in the line of Numbers. which is the distance in the Meridian. Wherefore, because the quarter of the Compasses was *North East*, set 0 Chains 80 Links (which is the distance in the parallel) in the column of East, and also set 2 Chains 10 Links (which is the distance in the Meridian) in the column of North, and so have you done with your sixth Station at F.

Seventhly, the degrees cut by the Needle, when the Instrument was placed at G being S.E. 51 deg. and the length of the line G H being 2 Chains 95 Links, if you extend the Compasses from the Sine of 90 degrees to 2 Chains 95 Links in the line of Numbers, that extent will reach from the sine of 51 degrees, which were the degrees cut by the Needle at G, to 2 Chains 30 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 39, which is the complement of the degrees cut by the Needle at G, to 1 Chain 83 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, (because the quarter of the Compasse was *South East*, set 2 Chains 30 Links (which is the distance in the parallel) in the Column of East, and also set 1 Chain 83 Links (which is the distance in the Meridian) in the Columne of South, and so have you done with your seventh Station at G.

Eighthly,



Eightly, the degrees cut by the Needle, when the Instrument was placed at H being S. E. 34 deg. and the length of the line H K being 3 Chains 25 Links, if you extend the Compasses from the Sine of 90 degrees to 3 Chains 25 Links in the line of Numbers, that extent will reach from the sine of 34, degrees which were the degrees cut by the Needle at H, to 1 Chain 82 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 56, which is the complement of the degrees cut by the Needle at H, to 2 Chains 68 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, (because the quarter of the Compasse was *South East*, set 1 Chain 82 Links (which is the distance in the parallel) in the Column of East, and also set 2 Chains 68 Links (which is the distance in the Meridian) in the Columne of South, and so have you done with your eighth Station at H.

Ninthly, the degrees cut by the Needle, when the Instrument was placed at K being S. W. 4, and the length of the line K A, be-

ing 2 Chains 85 Links, if you extend the Compasses from the Sine of 90 degrees to 2 Chains 95 Links in the line of Numbers, that extent will reach from the sine of 4, degrees which were the degrees cut by the Needle at K, to 0 Chains 6 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 86, which is the complement of the degrees cut by the Needle at K, to 2 Chains 92 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, (becaus the quarter of the Compasse was *South West*, set 0 Chains 6 Links (which is the distance in the parallel) in the Column of West, and also set 2 Chains 92 Links (which is the distance in the Meridian) in the Columne of South, and so have you done with your ninth Station at K.

Having thus gone over every of your angles and sides, as you see here done, and noted them down in your field book under their respective Titles, of *North*, *South*, *East*, and *West*, you shall finde them to stand as followeth:

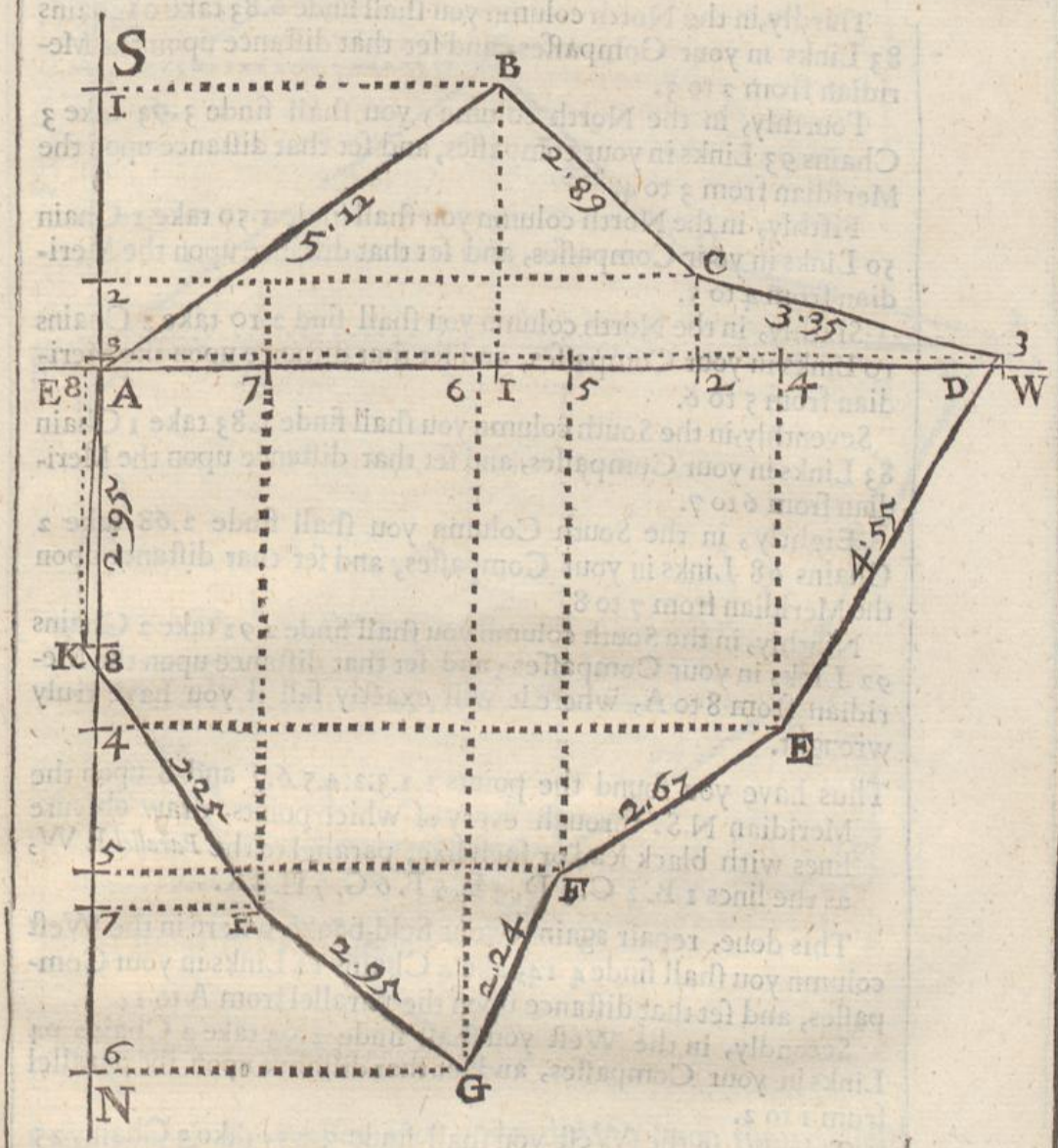
The figure of your field Book

		deg.	*min.*	*C.L.*	*North*	*South*	*East*	*West*
A	S W	54	00	5.12		2.97		4.14
B	N W	45	00	2.89	2.04			2.04
C	N W	76	00	3.35	0.83			3.25
D	N E	31	00	4.55	3.93		2.35	
E	N E	56	00	2.67	1.50		2.22	
F	N E	21	00	2.24	2.10		0.80	
G	S E	51	00	2.95		1.83	2.30	
H	S E	34	00	3.25		2.68	1.82	
K	S W	4	00	2.95		2.92		0.06
				Sum:	10.40	10.40	9.49	9.49

This done, adde all the figures in the North Column together, and you shall finde that they make 10 Chains 40 Links, and adde the South Column, and they make 10 Chains 40 Links also. Then adde the East Column, and they make 9 Chains 49 Links, Lastly, adde the West column and they also make 9 Chains 49 Links.

Now becaus the Sum of the North column, and the Sum of the South column are all one without any difference; and also the sum of the East column, and the sum of the West column also equal, you may be assured that your worke is true, but if the sums of the North and South columns, had differed your angles or sides had been falsly observed and also if the Sums of the East & West columns had differed, it had discovered an errour, but being they agree you may be assured your Worke is true, and therefore may with confidence proceed to protraction, according to the directions in the Chapter following.

CHAP.



CHAP. XLII.

How to protract any observations taken according to the direction of the last Chapter.

UPon a sheet of Paper or Parchment draw first a line as S N, representing the *Meridian*, and at right angles thereto another line E W representing the *Parallel*. Then laying your field book before you, you shall finde in the South column 2.97, wherefore take in your Compasses 2 Ch. 97 L. and place it upon the Meridian from A to 1, Secondly, in the North column you finde 2.04, take 2 Chains 4 Links in your Compasses and set that distance upon the Meridian from 1 to 2. Thirdly,

Thirdly, in the North column you shall finde 0.83 take 0 Chains 83 Links in your Compasses, and set that distance upon the Meridian from 2 to 3.

Fourthly, in the North column, you shall finde 3.93 take 3 Chains 93 Links in your compasses, and set that distance upon the Meridian from 3 to 4.

Fifthly, in the North column you shall finde 1.50 take 1 Chain 50 Links in your Compasses, and set that distance upon the Meridian from 4 to 5.

Sixthly, in the North column you shall find 2.10 take 2 Chains 10 Links in your Compasses, and set that distance upon the Meridian from 5 to 6.

Seventhly, in the South column you shall finde 1.83 take 1 Chain 83 Links in your Compasses, and set that distance upon the Meridian from 6 to 7.

Eightly, in the South Column you shall finde 2.68 take 2 Chains 68 Links in your Compasses, and set that distance upon the Meridian from 7 to 8.

Ninthly, in the South column you shall finde 2.92 take 2 Chains 92 Links in your Compasses; and set that distance upon the Meridian from 8 to A, where it will exactly fall if you have truly wronght.

Thus have you found the points 1.2.3.2.4.5.6.7 and 8 upon the Meridian N S. through every of which points, draw obscure lines with black lead or such like, parallel to the *Parallel* E W, as the lines 1 B. 2 C. 3 D. 4 E. 5 F. 6 G. 7 H. 8 K.

This done, repair again to your field-booke where in the West column you shall finde 4 14, take 4 Chains 14 Links in your Compasses, and set that distance upon the parallel from A to 1.

Secondly, in the West you shall finde 2.04 take 2 Chains 04 Links in your Compasses, and set that distance upon the parallel from 1 to 2.

Thirdly, in the West you shall finde 3.25, take 3 Chains 25 Links in your Compasses, and set that distance upon the parallel from 2 to 3.

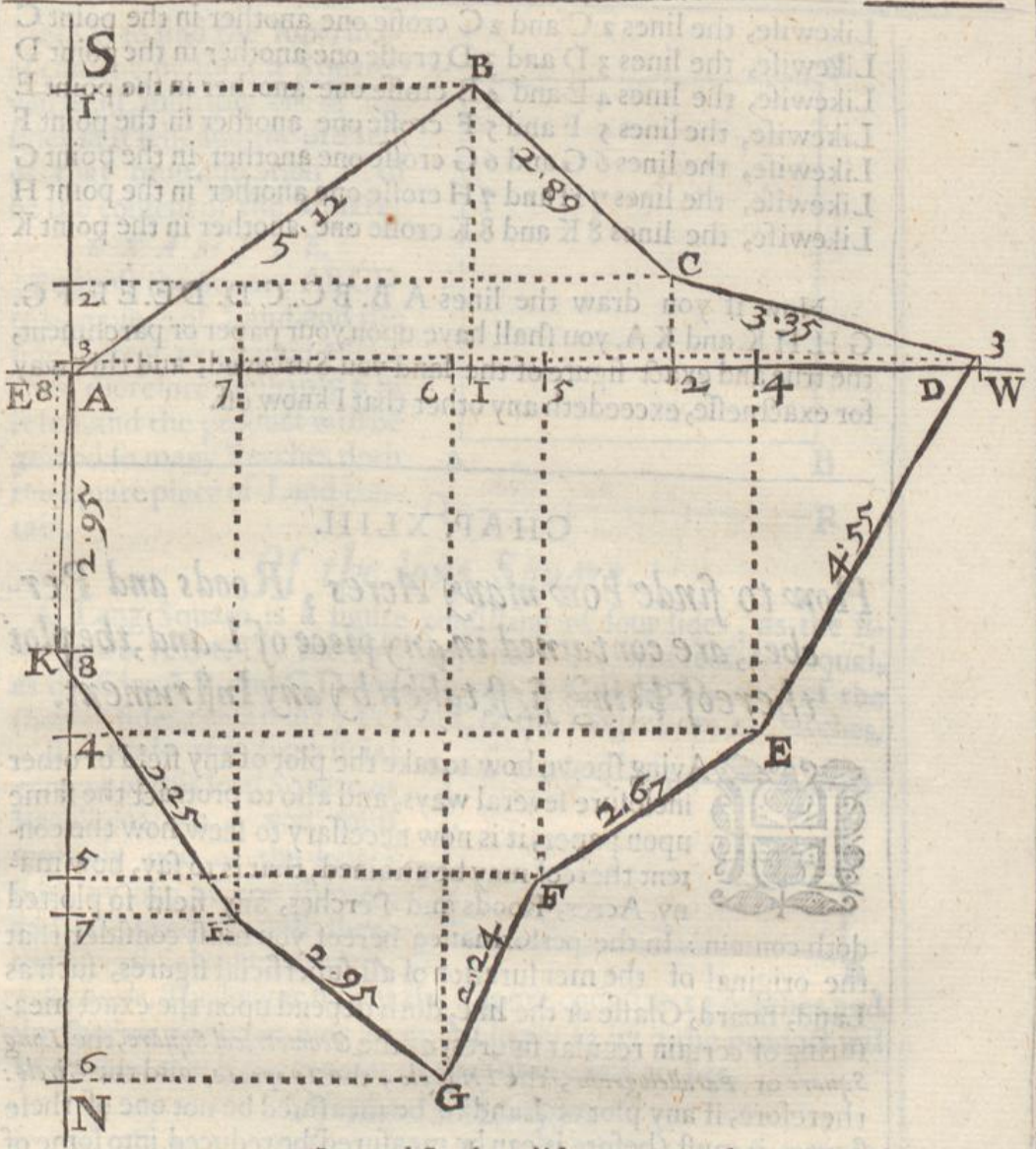
Fourthly, in the East you shall finde 2.35, take 2 Chains 35 Links in your Compasses, and set that distance upon the parallel from 3 to 4.

Fifthly, in the East you shall finde 2.22, take 2 Chains 22 Links in your Compasses, and set that distance upon the parallel from 4 to 5.

Sixthly, in the East you shall finde 0.80 take 0 Chains 80 Links in your Compasses and set that distance upon the parallel from 5 to 6.

Seventhly, in the East you shall finde 2.30, take 2 Chains 30 Links in your Compasses, and set that distance upon the parallel from 6 to 7.

Eightly, in the East you shall finde 1.82, take 1 Chain 82 Links



Links in your Compaſſes, and ſet that diſtance upon the parallel from 7 to 8.

Ninthly, in the Weſt you ſhall finde 0.06 take 0 Chains 06 Links in your Compaſſes, and ſet that diſtance upon the parallel from 8 to A. where it will alſo exactly fall if you have truly wrought.

Thus have you found the points 1.2.3.4.5.6.7.8. upon the Parallel E. W. through every of which points draw obſcure lines with black lead or ſuch like, parallel to the Meridian S N, as the lines, 1 B. 2 C. 3 D. 4 E. 5 F. 6 G. 7 H. 8 K.

This done, you ſhall finde that the line 1 B which is drawn parallel to the Parallel E. W. and the line 1 B which is drawn parallel to the Meridian S. N. will croſſe one another in the point B, wherefore a line drawn from A to B ſhall repreſent the ſide of the field A B, and if you have wrought truly you ſhall finde it to contein 5 Chains 12 Links.

Likewiſe

Likewiſe, the lines 2 C and 2 C croſſe one another in the point C
Likewiſe, the lines 3 D and 3 D croſſe one another in the point D
Likewiſe, the lines 4 E and 4 E croſſe one another in the point E
Likewiſe, the lines 5 F and 5 F croſſe one another in the point F
Likewiſe, the lines 6 G aud 6 G croſſe one another in the point G
Likewiſe, the lines 7 H and 7 H croſſe one another in the point H
Likewiſe, the lines 8 K and 8 K croſſe one another in the point K

Now if you draw the lines A B. B C. C D. D E. E F. F G. G H. H K. and K A. you ſhall have upon your paper or parchment, the true and exact figure of the land you Surveyed, and this way for exactneſſe, exceedeth any other that I know off.

CHAP. XLIII.

How to finde how many Acres, Roods and Perches, are contained in any piece of Land, the plot thereof being firſt taken by any Inſtrument.

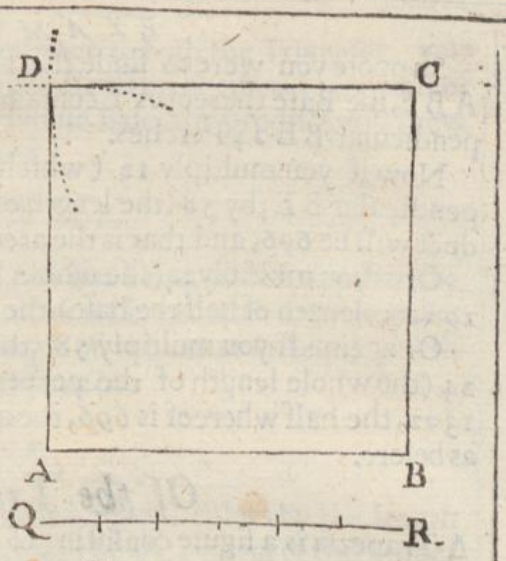
HAving ſhewn how to take the plot of any field or other incloſure ſeveral ways, and alſo to protract the ſame upon paper, it is now neceſſary to ſhew how the content thereof may be attained, that is to ſay, how many Acres, Roods and Perches, any field ſo plotted doth contein: In the performance hereof you muſt conſider that the original of the menſuration of all ſuperficial figures, ſuch as Land, Board, Glaſſe or the like, doth depend upon the exact meaſuring of certain regular figures, as the *Geometrical Square*, the *Long Square* or *Parallelogram*, the *Triangle*, the *Trapezia*, and the *Circle*: therefore, if any plot of Land to be meaſured be not one of theſe figures, it muſt (before it can be meaſured) be reduced into ſome of theſe forms: I will therefore in the firſt place ſhew how to meaſure any of theſe figures ſeverally by themſelves, and afterwards how to reduce any other irregular figure into ſome of theſe regular forms, and laſtly, to meaſure them by the ſame rules: and firſt,

Of the Geometrical Square.

A Geometrical Square is a figure conſiſting of four equal ſides and angles, as is the Square A B C D, whoſe ſides are all equal to the line Q R, which conteineth ſix equal parts, which may be attributed either to Inches, Feet, Yards, Perches, Chains, or any other meaſure whatſoever.

Now

Now, to find the superficial content of such a Square, you must multiply one of the sides in it self, and the product of that multiplication shall be the content of the Square.



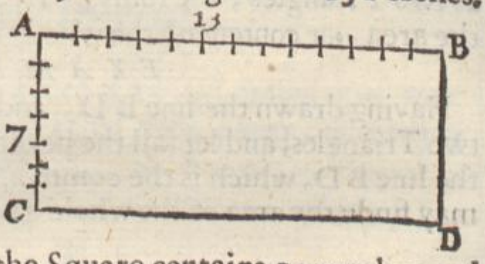
EXAMPLE.

Suppose the Square ABCD to be a piece of Land, and the side thereof to contain 6 Perches, therefore multiply 6 in it self, and the product will be 36, and so many Perches doth the square piece of Land contain.

Of the long Square.

A Long Square is a figure consisting of four sides, as the figure ABCD, the two opposite sides whereof are equal, as the sides A B, and C D, and likewise A C and B D, each of the shorter sides, containing 7 Perches, & the longer sides 13 Perches.

To finde the superficial content of this long Square or Parallelogram, you must multiply one of the longer sides by one of the shorter, and the product will shew the superficial content therof.

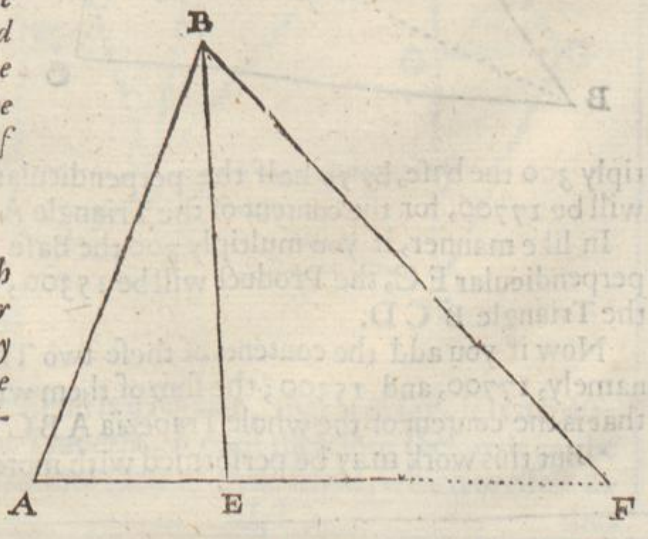


Example. The longer side of the Square contains 13 perches, and the shorter 7 perches, now if you multiply 13 by 7, the prodnct wil be 91, and that is the content of the Square in Perches.

Of the Triangle.

ALthough there be several kindes of Triangles, yet in respect they are all measured by one and the same rule, I will therefore add one example for all, which is general.

Half the length of the Base being multiplyed by the length of the perpendicular, shall be equal to the area of the Triangle.



Or, *Half the length of the Perpendicular being multiplyed by the whole Base, will be the content of the Triangle.*

EXAMPLE.

Suppose you were to finde the area or content of the triangle A B F, the Base thereof A F containing 58 Perches, and the perpendicular B E 24 Perches.

Now if you multiply 12 (which is half the length of the perpendicular B E) by 58 (the length of the whole base A F) the product will be *696*, and that is the area or content of the Triangle.

Or if you multiply 24 (the whole length of the perpendicular by 29 (the length of half the base) the product will be *696* as before.

Or again: If you multiply 58 (the whole length of the base) by 24 (the whole length of the perpendicular) the product will be 1392, the half whereof is *696*, the area or content of the Triangle, as before.

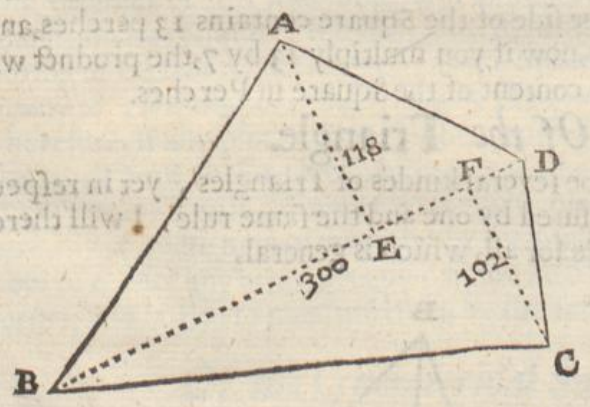
Of the Trapezia.

A Trapezia is a figure consisting of four unequal sides, and as many unequal angles, as is the figure A B C D.

To measure this Trapezia, you must first draw the diagonal line BD, for by this means the figure is reduced into two Triangles, as A D B, and C D B, then if you let fall the perpendiculars from the points A and C, you may measure them by the last examples, as two Triangles; the sums whereof being added together will be the area, or content of the whole Trapezia.

EXAMPLE.

Having drawn the line B D, and so reduced the Trapezia into two Triangles, and let fall the perpendiculars A E and C F, upon the line B D, which is the common base to both the Triangles you may finde the area of the whole Trapezia, thus



Suppose the perpendicular C F, were 102 perches the perpendicular A E 118 Perches, and the base B D (which is common to both Triangles) 300 Perches.

Now, if according to former directions, you multiply 300 the base, by 59 half the perpendicular A E, the product will be 17700, for the content of the Triangle A B D.

In like manner, if you multiply 300 the Base, by 51, half the perpendicular F C, the Product will be 15300, for the content of the Triangle B C D.

Now if you add the contents of these two Triangles together; namely, 17700, and 15300; the sum of them will be 33000, and that is the content of the whole Trapezia A B C D.

But this work may be performed with more brevity thus.

In

In respect the Base B D is common to both the Triangles, you may therefore add the two perpendiculars together, the half of which being multiplyed by the whole Base, the product will shew the content of the whole Trapezia.

EXAMPLE.

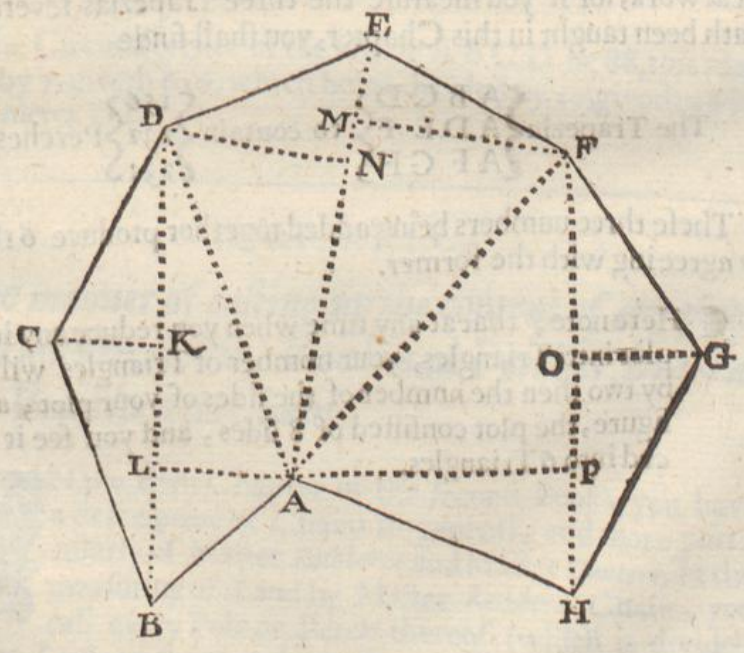
The two perpendiculars 118 and 102 being added together, the summe of them is 220, the half whereof is 110, this number being multiplied by 300 (the whole length of the common base) giveth 33000 the content of the whole *Trapezia*.

OR,

You may multiply the sum of the perpendiculars by the length of the Base, and half that product will be the content of the Trapezia also.

Of irregular Figures, how to reduce them into Triangles *or* Trapezias, *and to cast up the content thereof.*

LEt A B C D E F G H be the figure of a Field drawn upon your Plain Table, or otherwise protracted upon paper, according to any of the former directions.



In regard that the Field is irregular, that is to say, it is neither Sqnare, Triangle, or Trapezia, it must therefore (before it can be measured) be reduced into some of these forms, which to effect do

thus draw lines from one angle to other, as the lines A D, D B, A F, and F H, then will the whole figure be reduced into six Triangles, as

1 the Triangle B C D, } 4 the Triangle A E F,
2 the Triangle A D B, } 5 the Triangle A F H,
3 the Triangle A D E, } 6 the Triangle F G H.

These six Triangles being measured severally, according to the former directions, and the contents of them all added together into one sum, will shew the area or content of the whole field. As,

Suppose the Triangle { B C D, A D B, A D E, A E F, A F H, F G H } should contain { 72, 84, 110, 121, 165, 66 } Perches.

These six numbers being added together make 618 perches, and that is the area or content of the whole Field in Perches.

But for an abreviation of this work, you need not to finde the area of every Triangle, but of every Trapezia, as is before taught, for the figure is as well divided into Trapezias as Triangles, namely, into the Trapezias A B C D, A D E F, A F G H.

By this means you need but to finde the area or content of these three Trapezias, which will abbreviate nigh half of the Arithmetical work, for if you measure the three Trapezias severally, as hath been taught in this Chapter, you shall finde

The Trapezia { A B C D, A D E F, A F G H } to contain { 156, 231, 231 } Perches.

These three numbers being added together produce 618 exactly agreeing with the former.

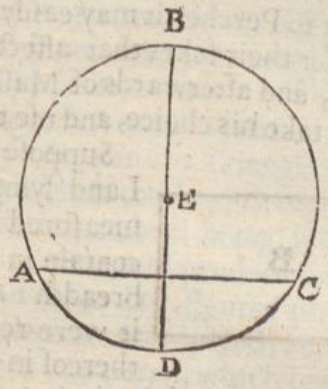
¶ Here note, that at any time when you reduce any irregular plot into Triangles, your number of Triangles will be less by two then the number of the sides of your plot; as in this figure, the plot consisted of 8 sides, and you see it is reduced into 6 Triangles.

Of

Of the Circle.

THe proportion of the Circumference of any Circle is to its diameter, as 7 to 22.

Now to finde the area or content of any Circle, you must multiply the diameter there of in it self, and multiply that sum by 11, which product being divided by 14, shall give you the area of the Circle.



EXAMPLE.

In this Circle A B C D, let the diameter thereof D B be 28, which multiplied in it self giveth 784, this number multiplyed by 11 giveth 8624, which being divided by 14, the quotient will be 616, and that is the area of the Circle

The Circumference of a Circle being given, to finde the Diameter.

MUltiply the Circumference by 7, and divide the product by 22, the Quotient shall be the length of the Diameter.

EXAMPLE.

Let the Circumference of the Circle A B C D be 88, this multiplyed by 7, giveth 616, which being divided by 22, giveth 28 for the Diameter D B.

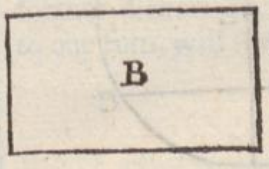
CHAP. XLIV.

Of the manner of casting up the content of any piece of Land in Acres, Roods and Perches, by Master Rathborns *Chain.*

IN the fifth Chapter of the second Book, you have a description of Chains in general, and more particularly of Master *Rathborns* and Master *Gunters*. In the measuring of Land by Master *Rathborns* Chain, you call every Pole or Perch thereof (which is divided into a 100 Links) a *Unite*, and every ten of those Links you call a *Prime*, and every single Linke you call a *Second*.

Now

Now becauſe there are divers that fancy this Chain rather then any other, becauſe it giveth the content of any Superficies meaſured therewith in its ſmalleſt denomination, namely, in Perches and parts of Perches, ſo that when any Superficies is caſt up and brought to Perches, it may eaſily be reduced into Roods and Acres. Now (for their ſakes that affect this Chain) I will ſhew the uſe thereof, and afterwards of Maſter *Gunters* Chain, leaving every man to take his choice, and uſe that which liketh him beſt.



Suppoſe that the figure B were a piece of Land lying in a long ſquare, which being meaſured by Maſter *Rathborns* Chain ſhould contain in length 16 *Unites*, 2 *Primes*; and in breadth 1 *Unitte*, 3 *Primes*, 2 *Seconds*, and that it were required to finde the area or content thereof in Perches, which to effect you muſt multiply the length by the breadth as is taught in the laſt Chapter, therefore, the length being 16 *Unites*, 2 *Primes*, and the breadth 1 *Unite*, 3 *Primes*, 2 *Seconds*, theſe two numbers multiplied together ſhall produce the area.

Set your numbers down as you are taught in the 5th Chapter of the ſecond Book, or as you ſee them ſtand in this *Example*, with a prick over the head of every fraction: under theſe numbers draw a line, and multiply them together in all reſpects as if they were whole numbers, and then the work will ſtand thus, the product of your multiplication being 21384. Now becauſe in your two numbers, *viz.* your multiplicand and your multiplyer, there are three fractions, namely, one in your multiplicand, and two in your multiplyer, you muſt therefore (with a daſh of your pen) cut off the three laſt figures of the product towards your right hand, and then will your product ſtand thus, the three laſt figures wher-

16 2
: .
112

324
486
162

21624

21 384

of are the numerator of a fraction, whoſe denominator is 1000, and the other two figures towards your left hand are Integers of your multiplication; ſo that the ſum of this multiplication is 21 perches, $\frac{384}{1000}$ parts of a perch, which is ſomething more then a third part of a perch.

But to expreſs the exact quantity of theſe fractions in a buſineſs of this nature were ſuperfluous, onely obſerve this one Rule for all, namely, that if the figures cut off come neer to a Unite, that is, when the figures cut off are neer as much as thoſe underneath them, or the firſt figure cut off is either 7, 8, or 9, you may then increaſe your whole number by a Unite, and not at all regard the fraction.

But for your further practice take another Example, which let be a a piece of Land containing in breadth 5 *Unites*, 6 *Primes* 3 *Seconds*, and in length, 15 *Unites*, 4 *Primes*, and 2 *Seconds*, which place as before.

Now

Now if you multiply these numbers one by another as if they were whole numbers, then will they stand as in the margin, the product being 868146, from whence take the 4 last figures (because there are four fractions in your two numbers) there remains 86 perches, and $\frac{8146}{10000}$ parts of a perch; now because 8146 is neer to 10000, I add 1 to 86, making it 87 perches, dis-regarding the excess as immaterial.

	1542
	563
	4626
	9252
	7710
86	8146

In like manner, suppose the perpendicular of a Triangle should contain 1 *Unite*, 3 *Primes*, 2 *Seconds*, and half the Length of the base should contain 16 *Unites*, 2 *Primes*, these numbers being placed as those before, and multiplied one by another, will produce this product 21384, from whence cut off the three last figures (because there were three fractious in your numbers multiplyed) and there will remain 21 perches, and $\frac{384}{1000}$ parts of a perch, which being but of small value you may reject.

CHAP. XLV.

How to reduce any number of Perches into Roods and Acres, or any number of Acres and Roods into Perches.

BY a Statute made the 33 of *Edw.* 1. an Acre of ground ought to contain 160 square Perches, and every Rood of Land 40 square Perches, and every Perch was to contain 16 foot and a half. Now, if any number of Perches be given to be turned into Acres, you must divide the number given by 160 (the number of perches contained in one Acre) and the quotient shall shew you how many Acres are contained in that number of Perches, and if any thing remain (if it be under 40) it is Perches; but if the remainder exceed 40, then you must divide it by 40 (the number of perches contained in one Rood) and the quotient shall be Roods, and the remainder Perches.

EXAMPLE.

Let 5267 perches be given to be reduced into Acres, first, divide 5267 by 160, and the quotient will be 32, and 147 remaining, which divide by 40, the quotient will be 3, and 27 remaining, so that the whole amounteth to 32 Acres 3 Roods and 27 Perches.

Again, let 5496 Perches be given to be reduced into Acres, first, divide 5496 by 160, the quotient will be 34, and 56 remaining, which 56 being divided by 40, the quotient will be 1, and 16 remaining, so that the whole will be 34 Acres 1 Rood and 16 Perches.

To

To reduce Acres into Perches.

THis is but the converse of the former, for (as before) to reduce perches into Acres, you divided by 160, you must now, to reduce Acres into Perches, multiply by 160.

EXAMPLE.

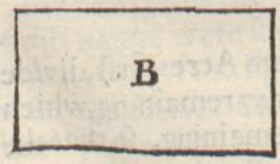
Let 32 Acres 3 Roods and 27 Perches, be given to be reduced into Perches: first, multiply the 32 Acres by 160, and the product will be 5120, then multiply the 3 Roods by 40, the product is 120, these two products, and the 27 Perches being added together, the sum will be 5267, and so many Perches are contained in the foresaid number of Acres, Roods and Perches: and thus much concerning the use of Master *Rathborns* Chain.

	5120
	120
	27
	5267

CHAP. XLVI.

How to cast up the content of any piece of Land in Acres, Roods and Perches, by Master Gunters *Chain.*

IN measuring by Master *Gunters* Chain, you are in your account only to take notice of Chains and Links, as was before intimated in the description thereof, *Cap.7.Lib-2.* Suppose then that the figure B were a piece of Land lying in a long Square, and that being measured by Master *Gunters* Chain should contain in length 9 Chains 50 Links, & in breadth 6 Chains 25 Links.



Set your numbers down as before is taught & as in this Example, drawing a line under them, then multiplying them together, you shall finde the Product to be 593750, from which Product you must always cut off the five last figures towards the right hand with a dash of your pen, then will the Product stand thus, 5|93750, so is the 5 towards the left hand compleat Acres, and the 93750 hundred thousand parts of an Acre, which 93750 being multiplyed by 4, the number of Roods in one Acre, the Product will be 375000, from which product cutting off five figures towards the right hand as before, it will stand thus, 3|75000, so is the 3 towards the left hand compleat Roods, and the

the 75000 hundred thousand parts of a Rood, which being multiplyed by 40, the number of Perches in a Rood, the product will be 3000000, from which cutting of the five last figures towards the right hand, the Product will stand thus, 30|00000, and the 30 towards the left hand is the number of Perches, and so the Area or content of the whole piece will be 5 Acres, three Roods and 30 Perches. Or the 93750 hundred thousand parts of an Acre may be reduced into Roods and Perches by help of the Table following.

```
  950
  625
 ----
 4750
 1900
 1700
 ----
5|93750
    4
 ----
3|75000
   40
 ----
30|00000
```

For if you look for 90000, under the title *Links* (which is the first figure with Cyphers added) you shal find against it 3 *Roods*, 24 *Perches*, then look for 3750, and against it you shall finde 6 Perches, all which being added together as here you see, the area or content of the whole piece will be 5 Acres, 3 Roods and 30 Berches.

A.	*R.*	*P.*
5	00	00
	3	24
		6
5	03	30

Links.	*R.*	*P.*
100000	4	0
90000	3	24
80000	3	8
70000	2	32
60000	2	16
50000	2	0
40000	1	24
30000	1	8
20000	0	32
10000	0	16
9375	0	15
8750	0	14
8125	0	13
7500	0	12
6875	0	11
6250	0	10
5625	0	9
5000	0	8
4375	0	7
3750	0	6
3125	0	5
2500	0	4
1875	0	3
1250	0	2
624	0	1

Another Example.

Suppose the base of a Triangle should contain 16 Chains 56 Links, and half the Perpendicular of the same Triangle 4 Chains 32 Links, these being multiplyed one in the other will produce the area or consens of the whole Triangle.

```
16,56
 4,31
-----
 3312
 4968
 6624
-----
7|15392
```

Set your numbers down as in the margine is done, and multiply one by the other, so will the Product be 715392, from which cutting off the five last figures towards the right hand, there will be left before the line of partition 7, which is 7 compleat Acres, and behinde the line there will be 15392, which are hundred thousand parts of an Acre, and how much that is, the Table will easily shew; for if you looke in the first Columne for 10000, against it you shall finde 00 Roods 16 Perches; then looking for 5392 you find it not, but the neerest thereto is

A.	R.	P.
7	00	00
		16
		9
7	00	27

5625, against which there standeth 9 Perches, all these numbers being added together will produce 7 Acres, 00 Roods, 27 Perches, which is the Area of the Triangle.

Thus may you finde the area of any Triangle or Parallelogram very easily by one multiplication and addition, which is much easier then the way of casting up by Master *Rathborns* Chain.

By this manner of work if the length and breadth of a long Square or Parallelogram given should be 9 Chains 75 Links, and 6 Chains 25 Links, the area of such a long Square would be found to be 6 Acres, 00 Roods 15 Perches. Or the length and breadth being 12 Chains, 42 Links, and 1 Chain 36 Links, the area or content will be found to be one Acre, two Roods, 30 Perches. Also, the length and breadth being 12 Chains 86 Links, and 5 Chains, 25 Links, the area will be found to be six Acres, three Roods, 00 Perches.

But lest you should be destitute of this Table when you have need thereof, you may have it put upon some spare place of your Instrument, or rather (instead of this Table) a Scale, which I will now shew you the use of, which performeth that work far better and more easily then the Table, and may conveniently be graduated upon the Index of your Table, the dividing and numbering whereof is well known to the Instrument maker.

The Scale consisteth of two parts, one whereof is square Perches, the other square Links, the Scale, of square perches proceedeth gradually from 1 to 40 with sub-divisions, and is numbred by 5, 10, 15, 20, &c. to 40. The Scale of square Links proceedeth gradually from 1 to 25000, and is also sub-divided and nnmbred by 1000, 2000, &c. to 25000, equal to 1 Rood or 40 Perches.

The use of the Scale of Reduction.

We will instance in the second example before-going, where the length and breadth of the long Square was 16 Chains 56 Links and 4 Chains 32 Links, these being multipyed together produce 715392, and the five last figures being cut off, there is 7 Acres and 15392 remaining, now to finde how many Roods and Perches this is, look in the Scale of Square Links for fifteen thousand three hundred ninety two, and against it, in the Scale of square Perches you shall finde 24 Perches, and above half a Perch.

Another Example.

Let us take the first Example before-going, where the numbers multiplyed were 9.50, and 6.25, these being multiplyed one by another produce 593750, and the five last figures being cut off, there will be 5 Acres, and 93750 remaining: now to know how many Roods and Perches are contained therein by the Scale.

¶ You must consider that 25000 square Links are equal to one Rood or 40 Perches, as appeareth by the Scale it self, and also by the Table, then 50000 equal to two Roods, and 75000 equal to 3 Roods; therefore, if your number remaining exceed 25000, and be under 50000, you may conclude 1 Rood and odd Perches to be contained therein. If it exceed 50000, and be under 75000, you may conclude two Roods and some odd Perches to be therein. If above 75000, you may then conclude 3 Roods and odd Perches to be therein.

Now in this Example, the number remaining is 93750, which because it exceedeth 75000, I conclude there is 3 Roods contained therein, which I set to the 5 Acres, and substract 75000 from 93750, the remainder being 18750, this number, eighteen thousand seven hundred and fifty, I seek in the Scale of Square Links, and right against it I find 30 Perches, which added to the former, giveth 5 Acres, 3 Roods, and 30 Perches, which is the area or content required.

	A.	*R.*	*P.*
	5	3	30

Thus you see with what celerity and exactness the Scale effecteth your desire, and therefore let it be graduated upon the Index of your Table that it may always be ready at hand when you have need thereof. The construction of this Reducing Scale I received of my honour'd Friend *S. F.* deceased.

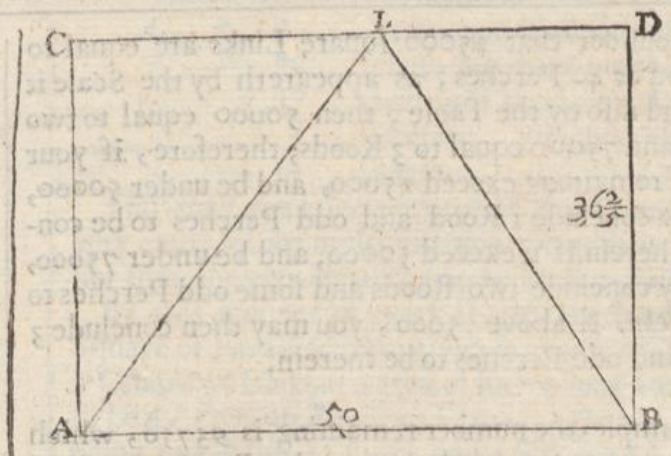
CHAP. XLVII.

Containing divers compendious Rules for the ready casting up of the Content of any plain Superficies, and other necessary Conclusions incident to Surveying, by the Line of Numbers.

THe line of Numbers is of singular use in casting up of the Content of any Superficies, and for Land measuring especially Master *Gunter* hath several Propositions, like unto which, I will insert seven other Propositions which will be of singular use in the practice or Surveying.

1 *The length and breadth of a right angled Parallelogram or long Square being given in Perches, to finde the content thereof in Perches.*

As 1 Perch, is to the breadth of the Parallelogram in Perches;
So is the length in Perches, to the content in Perches.



In this long Square or Parallelogram A B C D, if the breadth thereof C B be 36 2/5 Perches, and the length thereof A B 50 perches, the content will be found to be 1820 Perches: for,

If you extend the Compasses from 1 to 36 2/5 the length, the same extent will reach from 50 the breath, to 1820, the area or content in Perches which you may reduce into Acres as is taught in the 41 *Chap.*

2 *The length and breadth of a long Square being given in Perches, to finde the content in Acres.*

As 160, to the breadth in Perches;
So the length in Perches, to the content in Acres.

So in the former figure, if the length thereof A B be 50 Perches, and the breadth thereof 36 2/5, the content will be bound to be 11 Acres 40 parts, which is 1 Rood 20 Perches; for,

If you extend the Compasses from 160 to 36 2/5, the same extent will reach from 50 to 11 Acres 40 parts.

3 *The length and breadth of a Parallelogram being given in Chains, to find the content in Acres.*

As 10, to the breadth in Chains;
So the length in Chains, to the content in Acres.

So the length of the long Square A B being 12 Chains 50 Links, and the breadth B C 9 Chains 10 Links, the area will be found to be 11 Acres, 37 parts, or 1 Rood 20 Perches, for,

If you extend the Compasses from 10 to 9 Chains 10 Links, the same extent will reach from 12 Chains 50 Links, to 11 Acres 37 parts.

4 *Having the Base and perpendicular of a Triangle given in Perches, to finde the content in Acres.*

As 320, to the Perpendicular;
So the length of the Base, to the content in Acres.

So

So in the Triangle L A B, if the line B D be taken for the Perpendicular of the Triangle, then the length of the base being 50 Perches, and the perpendicular $36\frac{2}{7}$, the area will be found to be 5 Acres 22 parts, which is 2 Roods 30 Perches, then,

If you extend the Compasses from 320 to $36\frac{2}{7}$ the Perpendicular, the same extent will reach from 50 the length of the base, to 5 Acres 22 parts.

5 *The Base and Perpendicular of a Triangle being given in Chains, to finde the content in Acres.*

As 20, to the Perpendicular,
So the Base, to the content in Area.

So in the former figure, If A B 12 Chains 50 Links be taken for the Base, and B D 4 Chains 55 Links for the Perpendicular of the Triangle A L B, the area (by this proportion) will be found to be 5 Acres 68 parts, that is, 5 Acres 2 Roods 30 Perches, therefore,

If you extend the Compasses from 20, to 4 Chains 55 Links, the same extent will reach from 12 Chains 50 Links, to 5 Acres 68 parts, which is 2 Roods 30 Perches.

6 *The Area or superficial content of any piece of Land being given according to one kinde of Perch, to finde the content thereof according to another kinde of Perch.*

As the length of the second Perch,
To the length of the first Perch;
So the content in Acres,
To a fourth number.

And that fourth number to the content in Acres required.

Suppose the figure B were a piece of Land, which being plotted and cast up by a Chain of 16 foot and an half to the Perch, should contain 8 Acres, and that it were required to finde how much the same piece would contain if it were measured with a Chain of 18 foot to the Perch, if you work according to the proportion here delivered, you shall finde it to contain 6 Acres 72 parts; for,

If you extend the Compasses from 18 to $16\frac{1}{2}$, that extent will reach from 8 to 7.30, and from 7.30 to 6.72, and so many Acres would the figure B contain if it were measured by a Perch of 18 foot.

7 *Having the length of the Furlong to find the breadth of the Acre.*

As the length of the Furlong in Perches, to 160;
So is 1 Acre to the breadth in Perches.

So if the length of the furlong be 50 Perches, the breadth for one Acre will be 3.20: for,

If you extend the Compasses from 50, the length of the Furlong in Perches, the same extent will reach from 1 Acre to 3.20 Perches.

But if the length of the Furlong be given in Chains, then,

As the length of the Furlong in Chains, is to 10;
So is 1 Acre, to the breadth of the Furlong in Chains.

So the length of the Furlong being 12 Chains 50 Links, the breadth thereof will be found to be 00 Chains 80 Links: for,

If you extend the Compasses from 12 Chains 50 Links, to 10, that extent will reach from 1 Acre to 80 Links, which is the breadth of the Furlong required.

CHAP. XLVIII.

How to reduce one kinde of measure into another, as Statute Measure to Customary Measure, and the contrary.

BY the *6 Proposition* of the last Chapter you may perform this work by the Line of Numbers as is there taught, but however, it will not be amiss in this place to shew how to perform the same Arithmetically, that the reason thereof may the better appear. Now whereas (by the fore-mentioned Statute) an Acre of ground was to contain 160 square Perches, measured by the Pole or Perch of 16 foot and a half, but in many places of this Nation (through long custome) there hath been received other quantities called Customary, as namely, of 18, 20, 24, and 28 foot to the Pole or Perch.

It is therefore necessary for a Surveyor to know how readily to reduce Customary measure to Statute measure, and the contrary.

Suppose then, that it were required to reduce 5 Acres, 2 Roods, 20 Perches, measured by the 18 foot Pole into Statute measure, you must seek out the least proportional terms between 18 foot, and 16 foot and a half, which to perform do thus. Because 16 and a half

half beareth a fraction, reduce 16 and a half into halves, and that both your numbers may be of one denomination, you muſt reduce 18 (the cuſtomary Pole) into halves alſo, then will your numbers ſtand thus $\frac{33}{36}$, which abreviated by 3, by ſaying how many times 3 in 33? the quotient will be 11, and again, how many times 3 3 in 36? the quotient will be 12, ſo will two proportional terms between 16 and a half and 18, be 11 and 12.

This done, reduce your given quantity (5 Acres, 2 Roods, and 20 perches) into Perches, which makes 900 Perches: Now conſidering that what proportion the ſquare of 11, which is 121, bears to the ſquare of 12, which is 144, the ſame proportion doth the Acre of 16 foot and a half to the Perch, bear to the Acre of 18 foot to the Perch.

Now (becauſe the greater meaſure is to be reduced into the leſſer) multiply the given quantity 900 Perches by 144, the greater ſquare, and the product will be 129600, which divided by 121, the quotient will be $1071\frac{9}{11}$ Perches, which being reduced into Acres, giveth 6 Acres, 2 Roods, 31 Perches, and $\frac{9}{11}$ parts of a Perch, according to Statute meaſure.

Bnt on the contrary, ſuppoſe it had been required to reduce Statute meaſure into Cuſtomary meaſure, then you muſt have multiplyed 900 perches (your given quantity) by 121 the leſſer Square, (becauſe the leſſer meaſure is to be reduced into the greater) the product will be 108900, which divided by the great Square 144, the quotient will be $756\frac{1}{4}$ perches, which reduced into Acres is 4 Acres, two Roods 36 perches and a quarter.

The ſame manner of work is to be obſerved in the reducing of any Cuſtomary quantity whatſoever.

CHAP. XLIX.

How to lay out ſeveral Furlongs in Common fields unto divers Tenants.

HAving plotted the whole Field, Common, or other Incloſure, with its particular bounds, as you obſerve them in the ſurvey of the whole Manor, or if you only ſurvey that particular, you muſt take ſpecial notice of all the bounds thereof, then provide a Book or paper which muſt be ruled or divided into 8 columns, in the firſt whereof towards the left hand is to be written the Tenants name, and the tenor by which he holds the ſame Land, the two next columns are to contain the length of every mans Furlong in Chains and Links. In the two next columns is expreſſed the breadth of every mans Furlong in Chains and Links, as by the Letters over the head of each Column doth appear.

In the three laſt Columns is to be expreſſed the quantity of each Tenants Furlong in Acres, Roods and Perches.

In

In the laying out of several parcels in this kind, you will have use onely of your Chain; then when you begin your work, you must first write the name of the field, and in the first column of your Book or paper, you must write the Tenants name, and the tenour by which he holds the same, from what place you begin to measure, and upon what point of the Compasse you passe from thence, and observing this direction in all the rest, you may (if need require) bound every parcel.

This being noted in your Book, observe the species or shape of the furlong, whether it be all of one length or not, if of one length, then you need take the length thereof but once for all, but if it be irregular, that is, in some places shorter and in others longer, then you must take the length thereof at every second or third breadth, and expresse the same in your Book, under the title of length. As for the expressing of the several breadths, you need but to crosse over the whole Furlong, taking every mans breadth by the middle thereof, and entering the same as you passe along, but in case there be a considerable difference at either end, then I would advise you to take the breadth at either end, and find a line which shall be a proportion between them, for your mean breadth, and enter this in your Book or paper under the title of breadth.

In this manner you may proceed from one Furlong to another till you have gone through the whole field, which when you have done and noted down the several lengths and breadths in your book, you may multiply the length and breadth of every parcel together, as is taught before, and so shal you have the quantity of every parcel by it self, which quantity must be noted down in the three last columns of your Book, as in the following example appears.

Mordon Field.

The Tenants names and tenour.	*Length.*		*Breadth.*		*Content.*		
	C.	L.	C.	L.	A.	R.	P.
Abel Iohnson from the pond S. E. free.	32	76	3	45	11	1	12
Nicholas Somes, for three lives.	30	12	2	63	7	3	30
Robert Dorton, for Life.	28	60	8	12	23	0	36
Iames Norden, at Will.	25	11	12	35	31	0	2

CHAP.

CHAP. L.

How a Lordship lying in Common Field is to be inclosed.

THis Chapter was wholly omitted in the former Edition of this Book, and indeed had not been thought of this second Edition, had not my worthy friend Master *Vincent Wing* (hearing my Book was in the Press, the second time) sent me word that this Chapter would be necessary to be inserted, and withall sent me in writing, the way which he useth to effect the same, which method I liking well, have made bold to insert *verbatim*, as he sent it to me; which take as followeth.

Short Directions shewing how a Lordship lying in Open Field, is to be inclosed.

IT most commonly hapneth when a Lordship is to be improved, wherein are many Free-holders, that their ground (consisting of different Qualities) lies for the most part dispersed, and intermixt one amongst another in all parts and quarters of the Field, therefore to finde the just Quantity of every mans ground, both Arrable, Ley-ground and Medow, the Surveyor is to prepare a Field-book, wherein towards the right hand of every Page, let there be three small Columns distinguished one from another by a black line made with a pen or pensile, and one greater Columne towards the left hand, which shall contain the butting, bounding and number of every mans particular Lands, Leys, Doles of Medow, or the like, which being thus fitted for use, the Surveyor when he comes into the Field, is to begin in some corner thereof, as he shall finde most convenient for taking the Field in order, and then entring upon the Furlong, he shall first set down the name of the Furlong, and upon what point of the Compass he begins; next put down the name of the Free-holder, that first begins it, with the number of his lands, against which in the first of the three lesser colmns, write the length of the lands in the second put the bredth, & in the third and last, the Quantity. Which done, set down the name of the Free-holder, that lies next, and the number of his Lands, together with the length, breadth, and quantity as before; and so proceed in order till you have finished the Furlong.

Then go to the next Furlong, writing the name thereof, and where you begin, and proceed as before, and so on from Furlong to Furlong, till you have finished the Field. But to explain it further; I shall here give you a more particular draught of the Field-book.

The Survey of the Lordship of PILTON *in the County of* Rutland, *made in* Octob. 1656.

Middle-Hill Furlong begin. South.

	Long.	*Lant.*	*Quantity.*
	P.	*P.*	*P.*
John Falkner 5 lands	51.18	7.60	393.9680
Tho. Tomlinson 2 lands	49.42	3.29	150.6150
Peter Blackley 8 lands	47.10	10.16	478.5360
Abrahã Falkner 6 lands	46.70	7.12	332.5040
Tho. Tomblinsom 1 lands	45.00	1.30	58.5000
John Falkner 10 lands	44.15	12.00	529.8300
Thomas Falks 6 lands	44.00	8.00	352.0000
Andrew Cook 3 lands	43.10	4.11	176.9560

West Furlong begin. East.

	Long.		*Quantity*
	P.	*P.*	
Tho. Tomblinson 1 land	36.20	2.50	90.5000
The Parsonage 4 land	34.80	8.10	281.8800
John Falkner 6 land	34.00	11.0	374.0
Peter Blackley 2 land	34.00	4.0	136.
Henry Swift 5 lands	34.00	9.20	312.8000
Abrahã Falkner 4 leys	33.50	7.0	234.5000
The Parsonage 4 leys	33.0	7.0	231.
John Falkner 1 ley	33.0	2.50	82.5000

South Meadow begin. East.

Peter Blackley one dole	36.20	2.50	90.5000
John Falkner one dole	40.00	8.0	320
Abraham Falkner 1 dole	42.00	10.0	420
The Parson one dole	41.00	8.0	328
Tho. Tomblinson 1 dole	40.50	6.50	263
Tho. Falks one dole	40.00	6.00	240
Andrew Cook one dole	40.00	6.00	240
Peter Blackley two doles	40.00	11.50	460
John Falner one dole	39.50	3.00	118.5000

Red-hill Furlong begin. South.

John Falkner 3 lands.	45.00	12.0	540
Abrah. Falkner 10 lands	45.00	20.0	900
Tho. Tomblinson 3 lands	45.00	12.0	540
The Parsonage 3 lands	50.00	12.0	600
Peter Blackley 6 leys	50.00	20.0	1000
Henry Swift 2 leys	50.00	5.0	250
Thomas Falks 4 leys	50.00	10.0	500
Andrew Cook 1 land	50.00	2.0	100
P. Blackley 8 lands	50.00	4.0	200

Having finished your rough Book (after this manner) you are next to make a particular of every Mans Arable, Leys, and Medow ground severally, that so you may be ready to give a just account of what every man holds distinctly, that by help thereof you may be enabled (with the help of Arbitrators chosen to assist you) to give every man, not onely the true quantity in his Plot, but also consideration, for the Quality of his ground, as neer as may be. To which end in drawing your Particulars you are to make so many Columns as there are Free-holders, every one whereof is to be subdivided into three, so shall you have one for Arable Land, another for Ley-ground, and a third for Medow. Then turning to the Field-book, I begin with *John Falkner*, and write in the particular in its proper Column, under Arable 393 *P.* 968 then *Thomas Tomblinson* 150. *P.* 6150, next *P. Blackley*, 478.5360. which I place likewise, under their names, and in their due place, and so I proceed till I have finished the Book, placing every mans Arable Leys, and Medow in their order, which being effected, then make your *Summa totalis*, as you may see in the following Synopsis.

A Particular of all the Arrable, Leys, and Meadow Ground in the Lordship of Pilton, *Com.* Rutland.

John Falkner			*Tho. Tomblinson*			*Peter Blackley*			*Abrahã Falkner*		
Arable	Leys	Med.	Arab.	Leys	Med.	Arab.	Leys	Med.	Arab.	Leys	Med.
393	82	320	150		263	478	1000	90	332	234	420
529		118	58			136		460	900		
374			90			200					
540			540								
1836	82	438	838	0	263	814	1000	550	1232	234	420
1836			838			1000			1232		
82			0			814			234		
438			263			550			420		
Sũ.tot. 2356			*Sum* 1101			*Sum* 2364			*Sum* 1886		

Thomas Falks			*Andrew Cook*			*The Parsonage.*		
Arab.	Leys	Med.	Arab	Leys	Med.	Arab	Leys	Med
352	500	240	176		240	281	231	328
			100			600		
352	500	240	276	0	240	881	231	328
352			276			881		
500			0			231		
240			240			328		
Sum 1072			*Sum* 516			*Sum* 1440 *total*		

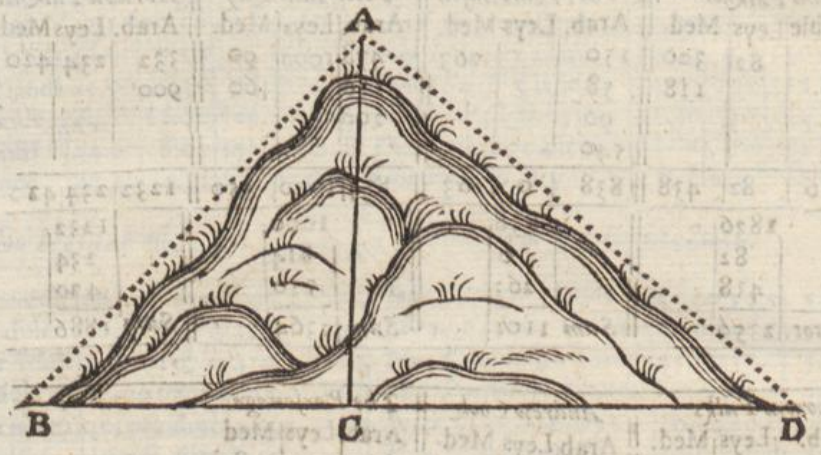
The particular being finished, I next proceed to take a general Survey, and Plot of the whole Field to be inclosed, according as hath been shewed at large in the former Chapters, which being done, you shall see if the general Survey, and the particulars agree, which if they do, you may conclude your work is exact, and then you may proceed to the plotting of every mans ground, and to lay it out in such part of the Field, as the Free-holders (or their Arbitrators) shall agree, and when that is done, you are to do in like manner with the rest, and at last when a Plot of the Town, Streets, Lanes, Houses, Woods, and all the new Inclosure, which being garnished with Colours upon Velome, or Royal-paper, will most neatly shew the true proportion and Symmetry thereof.

And lastly, Let there be a Book drawn very fair, shewing the Butting, Bounding, and Quantity of every ground, and C.

CHAP. LI.

To find the horizontal line of any hill or mountain.

THis Propoſition differeth nothing from thoſe formerly taught in the taking of Altitudes. Wherefore, ſuppoſe you ſhould meet with a hill or mountain as A B D, the thing required is finde the length of the line B D on which the mountain ſtandeth.



Firſt, place your Inſtrument at the very foot of the Hill, exactly level, then let one go to the top of the hill at A, and there place mark, which muſt be ſo much above the top of the hil, as the top of the Inſtrument is from the ground; then move the Label up and down till through the ſights thereof you ſee the top of the mark at A, and note the degrees cut by the Label one the Tangent line, for that is the quantity of the angle A B C, which ſuppoſe 47 degrees, then by conſequence the angle B A C, muſt be 43 degrees, the complement of the former to 90 degrees, then meaſure the ſide of the Hill A B C, which ſuppoſe to contain 71 feet, then in the Triangle A B C there is given the ſide A B 71 feet, and the angle B A C 43 degrees, together with the right angle A C B 90 degrees, and you are to finde the ſide B C, which to perform, ſay,

As the Sine of the angle A C B, 90 degrees,
Is to the ſide A B, 71 feet;
So is the Sine of the angle B A C, 43 degrees,
To the ſide B C, 48½ feet.

Then (becauſe the hill deſcends on the other ſide) you muſt place your Inſtrument at D, obſerving the angle A D C to contain 41 degrees, and the angle D A C 49 degrees, and the ſide A D 80 feet: now to finde the ſide C D the proportion will be,

As the Sine of the angle A C D, 90 degrees,
Is to the ſide A D, 80 feet;
So is the Sine of the angle C A D, 49 degrees,
To the ſide C D, 60½ feet.

Which added to the line B C, giveth 109 feet, which you may redu-

reduce into Chains, by dividing it by 66, and this line must be protracted instead of the hypothenusal lines A B and A D.

Another way.

There is another way also used by some for the measuring of horizontal lines, which is without the taking of the Hils altitude, or using of any Arithmetical proportion, but by measuring with the Chain only, the manner whereof is thus.

Suppose A B C were a hill or mountain, and that it were required to finde the length of the Horizontal line thereof A C. At the foot of the Hill or Mountain, as at A, let one hold the Chain up, then let another take the end therof, and carry it up the Hill, holding it level, so shal the Chain meet with the Hill at D, the length A D being 60 Links, then at D let the Chain be held up again, and let another carry it along level til it meet with the side of the hil at E, the Length being 54 Links: then again let one stand at E, & hold up the Chain, another going before to the top of the Hil at B, the length being 48 Links, these three numbers being added together make 162 Links or 1 Chain 62 Links, which is the length of the horizontal Line A C. This way of measuring is by some practised, but the other (in my opinion) is far to be preferr'd before it, only when you are destitute of better helps you may make use hereof.

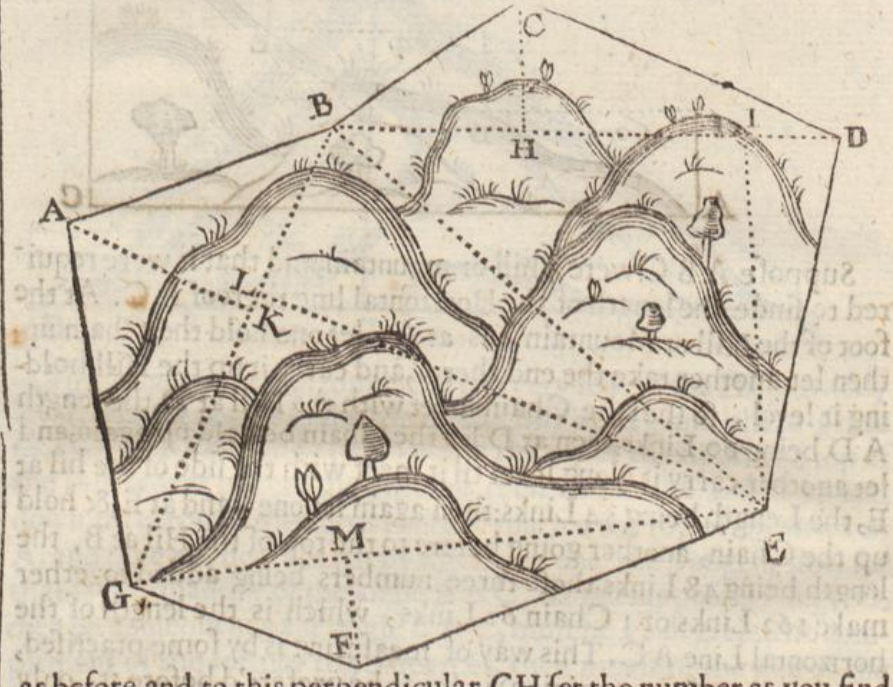
¶ But if the Hil or Mountain should have a descent back again on the other side, you must then use the same way of working as before, and add all together for the Horizontal Line.

CHAP. LII.

How to plot Montanous and uneven grounds, with the best way to finde the content thereof.

FOr the plotting of any mountanous or uneven piece of ground, as A B C D E F G, you must first place your Instrument at A, & direct the sights to B, measuring the line A B, then in regard that from B to C there is an ascent or hill, you must finde the horizontal Line thereof, and draw that upon your Table,

Table, accounting thereon the length of the hypothenusal Line, then measure round the field according to former directions, and having the figure thereof upon your table reduce it into Trapezias, as into the Trapezias A B E G, B C D E, and the Triangle G E F; then from the angles A C E and F let fall the perpendiculars A K, C H, E I, and F M. Now in regard there are many Hils and Valleys all over the field, you must measure with your Chain in the field over Hill and Dale from B to D, and to the Line B D set the number of chains and Links as you find them by measuring, which wil be much longer then the straight line B D measured on your Scale, then by help of your Instrument finde the point H in the line BD, and measure with your Chain from C to H, over hill and dale



as before, and to this perpendicular CH set the number as you find it by the Chain: then find the perpendicular I E, and measure that with your Chain also, all which Lines (in respect of the Hils and Valleys) will be found much longer then if they were measured by your Scale: then by the measured Lines B D, C H and I E, cast up the content of the Trapezia B C D E. In this manner you must cast up the content of the Trapezia A B E G, and the Triangle G E F, and this is the exactest way I can prescribe for the mensuration of uneven grounds, which being well and carefully performed, will not vary much of the true content: For it is apparent that if such mountanous grounds were plotted truly according to their area *in Plano*, the figure thereof would not be contained within its proper limits, and being laid down amongst other grounds would swell beyond the bounds, and force the adjoyning grounds out of their places; now for distinction in your Plot you may shadow them off with Hils as in this figure, lest any man seeing your Plot should measure by your Scale, and finde your work to differ.

CHAP.

CHAP. LIII.

How to take the Plot of a whole Manor, or of divers parcels of Land lying together, whether Wood-lands or Champion Plains, by the Plain Table.

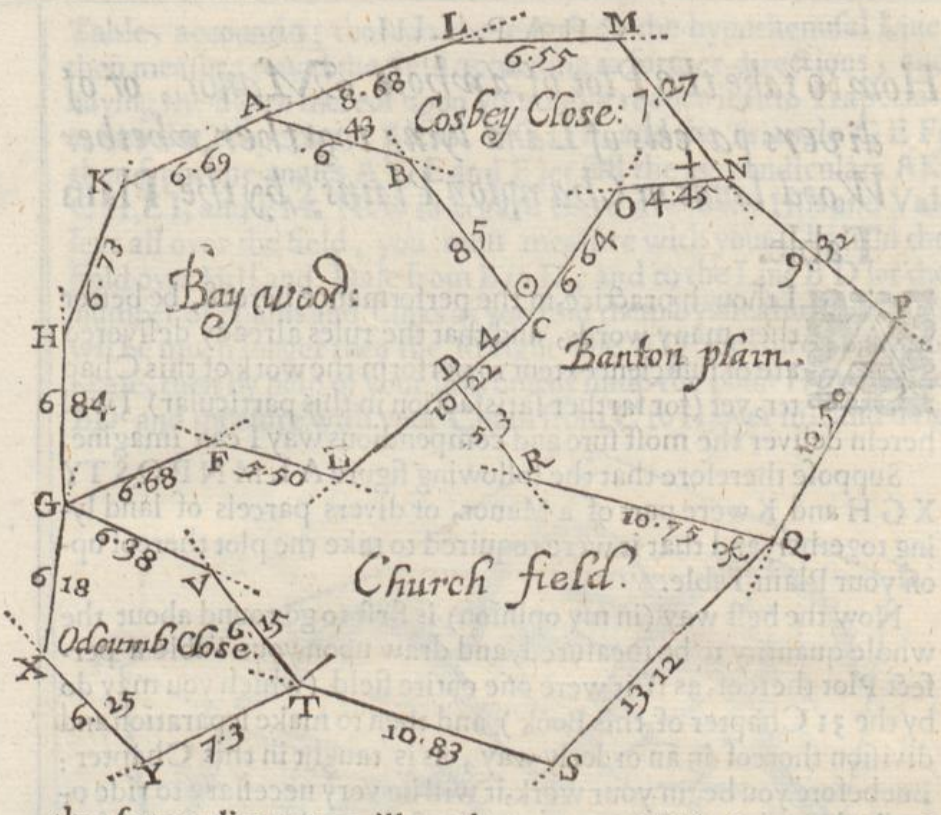
ALthough practice, in the performance hereof, be better then many words, and that the rules already delivered are of sufficient extent to perform the work of this Chapter, yet (for farther satisfaction in this particular) I will herein deliver the most sure and compendious way I can imagine.

Suppose therefore that the following figure A L M N P Q S T Y X G H and K were part of a Manor, or divers parcels of land lying together, and that it were required to take the plot thereof upon your Plain Table.

Now the best way (in my opinion) is first to go round about the whole quantity to be measured, and draw upon your Table a perfect Plot thereof, as if it were one entire field (which you may do by the 31 Chapter of this Book) and then to make separation and division thereof in an orderly way, as is taught in this Chapter: But before you begin your work, it will be very necessary to ride or walk about the whole Manor, or at least so much as you are to survey, that you may be the better acquainted with the several bounders, and in your passage you ought to take special notice of all eminent things lying in your way, as Churches, Houses, Mils, Highways, Rivers, &c. which will much help you, also in this your passage it were necessary to take notice of some convenient place to begin your work as followeth.

Having made choice of some convenient place in the periphery or outward part of the Manor, as at A, place there your Table, turning it about till the Needle hang over the Meridian line in the Card, and there fix it, then upon the Table (with most convenience) assigne any point at pleasure, as A, unto which point lay the Index, and turn it about till through the sights you see a mark set up at the next angle at L, then by the side of the Index draw the line AL, which suppose to contain 8 Chains 68 links, take these 8 Chains 68 links from any Scale, and place that length upon your Table from A to L.

2 Bring your Instrument to L, and lay the Index upon the line L A, turning the whole Table about till through the sights you see a mark set up at A where your Table last stood, and there fix it, so will the Needle hang directly over the Meridian line in the Card as before, then lay the Index upon the point L, and turn it about till through the sights you see a mark set up at the next angle at M, and draw a line by the side of the Index, which suppose to contain 6 Chains 55 links, this length being taken from the same Scale as the



the former line was, will reach upon your Table from the point L unto M.

3 Remove your Table to M, and lay the Index upon the line M L, turning the Table about till through the sights you espie a mark set up at the angle L, where your Table last stood, and there fixing it, you shall still finde the Needle to hang directly over the Meridian line, if you proceed truly in your work: then laying the Index to the point M, turn it about till through the sights you espy some mark set up at the next angle at N, and draw a line by the side of the Index, then measuring with your Chain from M to N, you shall find it to contain 7 Chains 27 links, which take from the same Scale as before, and place the length thereof upon your Table from M unto N.

4 Place your Instrument at N, laying the Index upon the line N M, and turn the Table about till through the sights you see a mark set up at your former station at M, and there fix the Table, so will the Needle hang over the Meridian line as before, then turn the Index about upon the point N, till through the sights you espy the next angle at P, and draw a line by the side thereof, then measure the distance N P 9 Chains 32 links, which take from the Scale, and set it upon your Table from N unto P.

In this manner must you go round about the whole Manor, making observation at every angle thereof, as at P Q S T Y X G H and K, and setting down the length of every line upon your Table as you find it by measuring with your Chain, you shall have upon

your

your Table the figure of one large Plain; which must include all the rest of the work, and in thus going about you shall (if you have truly wrought all the way) find your plot to close exactly in the point A, where you began, but if it do not, go over your work again, for otherwise, all that you do afterwards within the same will be false.

¶ Here note, that if one sheet of paper will not contain your whole Plot, you must then shift your paper in this manner: when any Line falleth off of your Table, draw two lines at right angles cross your paper, which the equal divisions on the frame wil help you to do; then lay another clean sheet of paper upon your Table, and by the same parallel divisions at the contrary end of the Table, draw two other Lines at right angles, and upon them note what part of your Plot crossed the two other Lines before drawn, and at those points begin to go forward with the rest of your work: and thus may you shift divers Papers one after another, if need be.

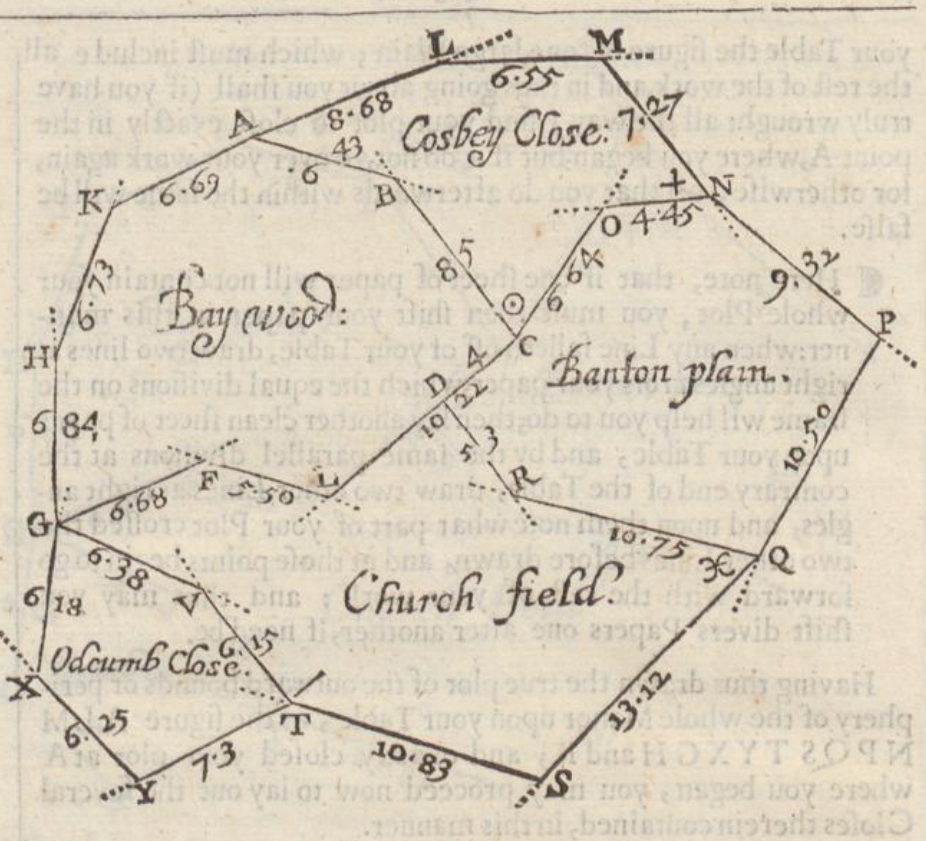
Having thus drawn the true plot of the outward bounds or periphery of the whole Manor upon your Table, as the figure A L M N P Q S T Y X G H and K; and exactly closed your plot at A where you began, you may proceed now to lay out the several Closes therein contained, in this manner.

1 Place your Table at A, laying the Index and sights upon the Line AL before drawn, and turn it about till through the sights you espy the angle L, and there fixing it, the Needle will hang directly over the Meridian line in the Card: then turn the Index about upon the point A, till through the sights you espy a mark set up at the angle B, and by the side of the Index draw the line AB containing 6 Chains 43 Links.

2 Remove the Table to B, laying the Index on the Line B A, and turn the Table about till through the sights you see the angle A, then fix it, and turn the Index about upon B, till you see the next angle at C, drawing the line B C by the side of the Index, which suppose to contain 8 Chains 5 Links.

3 Place the Table at C, laying the Index upon the Line C B, & turn it about till through the sights you see your former station at B, and there fixing it, turn the Index about upon the point C, till through the sights you see the angle at E, and draw the line C E containing 10 Chains 22 Links, which set from C to E, and again (before you move your Table) direct the sights to O, and draw the line OC containing 6 chains 64 Links, which take from your Scale and set from C to O, and (because O is the next angle to the bounder) you may (without placing your Instrument at O, or measuring the distance O N) draw the Line O N upon your Table, which (if the rest of the work be true) will contain 4 Chains 45 Links.

4 Remove your Table to E, laying the Index upon the Line E C, and turn the Table about till through the sights you see the angle at C, then fix it, and turn the Index about upon the point E, till



you espy the next angle at F, and draw the line E F containing 5 Chains 50 Links, which set from E to F, now (because the angle at F is the next angle to the bounder) you may draw the Line F G upon your Table without any further trouble, which (if the rest of your work be true) will contain 6 Chains 68 Links.

5 Remove your Instrument to T, laying the Index upon the line T S, and turn it about till through the sights you espy the angle at S, and there fixing it, turn the Index about upon the point T, till through the sights you espy the next angle at V, and by the side of the Index draw the Line TV containing 6 Chains 15 Links, which set upon the Table from T to V: now (because V is the angle next the bounder) you may only draw the Line V G, without placing your Instrument at V, or measuring the distance VG, upon the ground, which (if the rest of the work be true) will contain 6 Chains 38 Links.

6 Bring your Instrument to Q, and lay the Index upon the Line PQ, turning the Table about till through the sights you see the angle at P, then fixing the Table there, turn the Index about upon the point Q, till through the sights you espy the angle at R, and by the side of the Index draw the Line Q R containing ten Chains 75 Links, which set from Q to R.

Lastly, Bring your Table to R, and laying the Index on the Line Q. R, turn the Table about till through the sights you see the angle at Q, and there fix it, then turn the Index about upon the point R, till through the sights you espy the angle at D, and draw the

Line

Line R D, which (if the reſt of the work be true) will contain 5 Chains 3 Links.

Thus have you an exact and perfect draught of the whole Manor, or of ſeveral Incloſures, in the performance whereof I have been ſomthing large, becauſe I would ſhew the moſt natural way firſt: but the ſame thing may be performed with more brevity as followeth, wherein (if you mark it well) you ſhall plainly perceive that half the work will be abreviated, and the ſame thing effected with almoſt half the meaſuring.

Having made choice of the angle A to begin your work, place your Table there, turning it about till the Needle hang directly over the Meridian Line in the Card, and there fix it, then aſſign any point upon the Table, for your beginning ſtation, as the point A, and laying the Index to this point, turn it about till through the ſights you eſpy the next angle at L, then draw the Line A L containing 8 Chains 68 Links, which take from your Scale and ſet from A to L: and alſo (before you move your Table) direct the ſights to B, and by the ſide of the Index draw the Line A B, but you need not meaſure the length thereof.

2 Then go forward with your work as in the former part of this Chapter, placing your Table at the angles L M and N, and when you come to N, and have drawn the Line N P, you may (before you move your Table) draw the Line N O, but not meaſure it.

3 Alſo when you come to the angle Q, and have drawn the Line Q S, you may draw the Line 2 R alſo, at once placing of the Table.

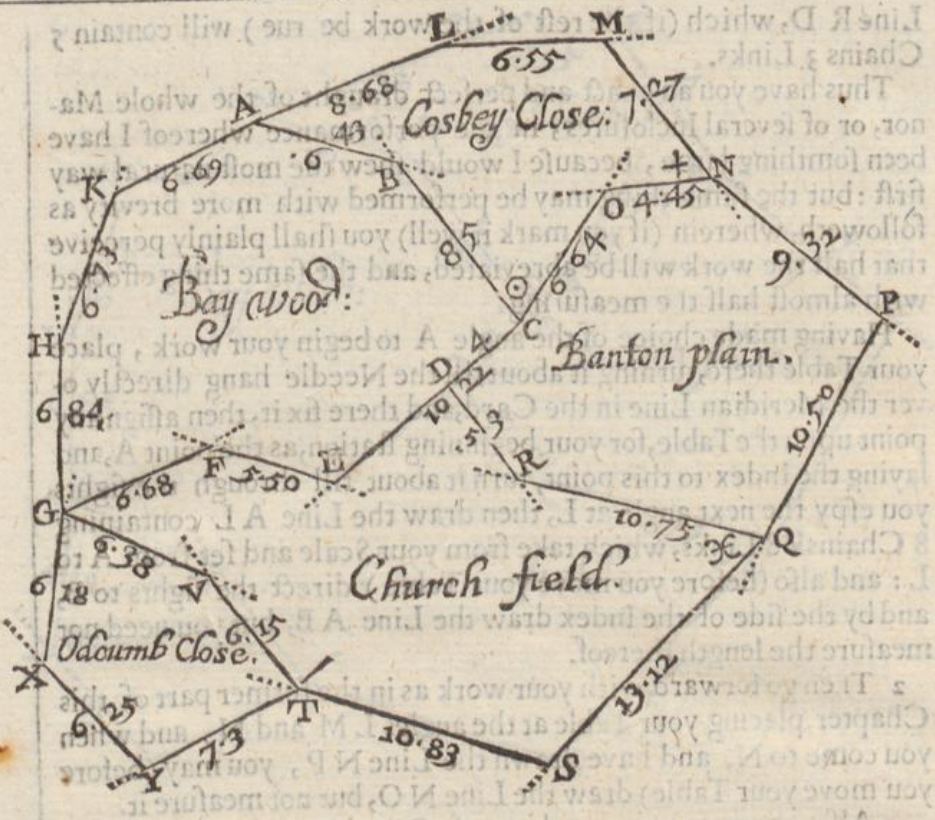
4 When you come to oberve at the angle T, and have drawn the Line T Y, you may at the ſame time alſo draw the Line T V, but need not meaſure it.

5 When you come to the angle G, and have drawn the Line G H, you may alſo draw the Line G V, which will cut the Line T V in the point V; and at the ſame time alſo you may draw the Line G F containing 6 Chains 68 Links.

Having thus gon round the whole Manor, and made a Plot of the outward part or Periphery thereof, and alſo drawn the Lines A B, N O, 2 R, T V, G V, and G F, as you went along the bounder, the remainder of the work will (by this means) be much abreviated, for you have no more to do, but

1 To place your Table at F, laying the Index upon the Line F G, and to turn it about till through the ſights you eſpy the angle at G, and fixing it there direct the ſights to E, and draw the Line E F containing 5 Chains 50 Links.

2 Place the Table at E, and lay the Index on the Line E F, turning the Table about, till you ſee through the ſights the angle F, then fix it, and turn the Index about upon the point E till through the ſights you eſpy the angle at C, and by the ſide of the Index draw the Line E D C, which containeth 10 Chains 22 Links. Then becauſe from C to D there is 4 Chains, ſet 4 Chains from C to D, and draw the Line D R, which will cut the Line 2 R in the point R, leaving the Line D R to contain 5 Chains 3 Links.



Laſtly, place the Table at C, laying the Index on the line C E, turning it about till through the ſights you ſee the angle at E, and there fixing it, turn the Index about upon the point C, and direct the ſights to B and O, drawing the Lines C B and C O. And thus have you upon your Table an exact plot of your Manor with great eaſe and celerity.

There is yet another way to perform this work: when you have taken the true plot of the outward bounds or periphery of the whole Manor upon a ſheet or more of paper; if you will take the pains to go over every particular Incloſure again, and draw particular plots of every parcel by the ſame Scale wherewith you laid down the Plot of the periphery; then over the Plot of every particular Incloſure, draw parallel Meridians, and when you have thus plotted every particular, if you cut them off by their bounders, and lay them one by another according to their ſituation within the plot of the whole periphery, you ſhall finde that thoſe Plots (if your work be true) will juſtly fill the Plot of the whole, leaving no vacuity.

CHAP.

CHAP. LIV.

How to take the Plot of a whole Manor, or of divers severals whether Woodland or Champion Plains, by the Theodolite, Circumferentor, *or* Peractor.

BY what hath been hitherto delivered concerning the harmony between the *Theodolite*, *Circumferentor*, and *Peractor*, you may perceive that the working by any one of them being rightly understood, the application thereof to any of the other will be apprehended at the first sight, I will therefore instance in the *Circumferentor* as being most general. Let the example of the last Chapter serve where the figure A L M N P Q S T V X G H K represented part of a Manor. Then having provided your Field-book ready ruled, you must at the head of one of the leaves thereof write the Title of the Manor, the County in which it is, and who is Lord thereof, As,

The Manor of Elsmore, *in the County of* S.
for the Honourable R. B. *Lord thereof.*

Then beginning with your first Close write over the head of your Field-book the Tenants name, the name of the Close, and the tenour by which he holds the same, so for the first Close.

Henry Grey, Cosbey Close, Pasture, Free.

Under this draw a Line quite through your Book, then beginning to survey this Close, place your Instrument at A, and direct your sights to L, noting the degrees there cut, which let be 160 degrees 45 minutes, which 160 degrees 45 minutes must be noted in the first and second Columns of the Field-book, then measure the distance A L 8 Chains 68 Links, which place in the third & 4th. Columns.

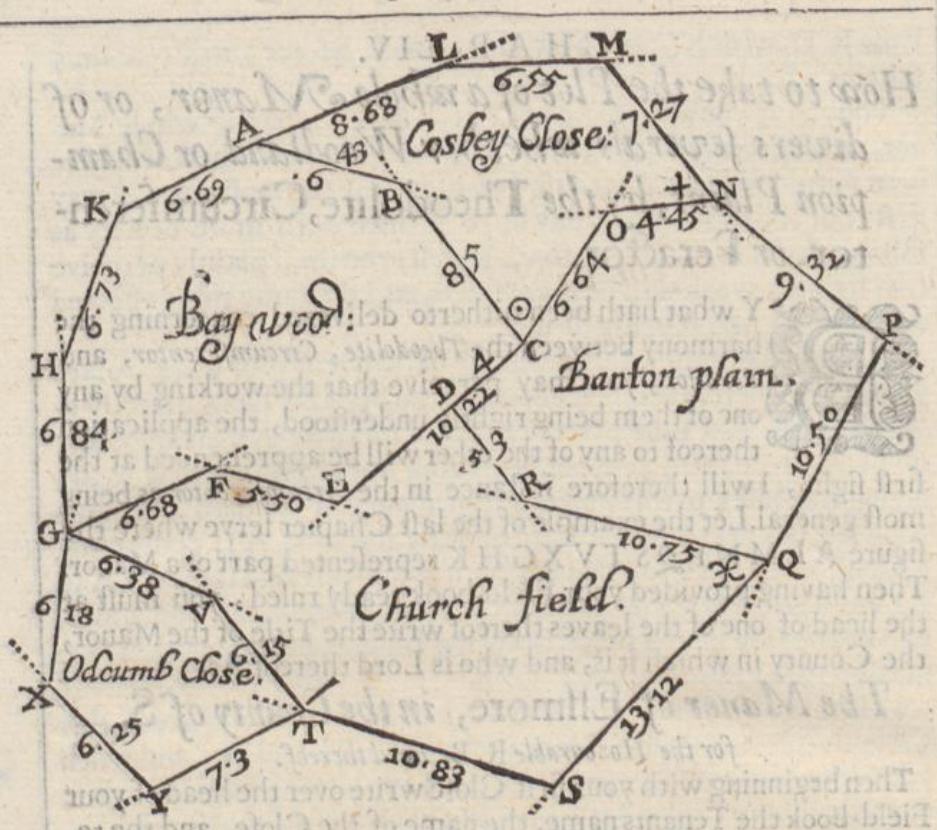
2 Remove your Instrument to L, and direct the sights to M, the Needle cutting 181 degrees 30 minutes, and the Line LM containing 6 Chains 55 Links, which note down in your Field-book.

3 Place your Instrument at M, and direct the sights to N, the Needle cutting 233 degrees, and the Line M N 7 Chains 27 Links which note in your Field-book. And in regard you are to leave the hedg or bounder A L M N, adjoyning to *Wisby Common*, (which appertaineth to another Manor, and therefore only the name inserted for your remembrance when you come to protraction) you must draw a Line quite through your Field-book, and in the last Column thereof write *Wisby Common*, which denotes unto you that you are to leave the bounder of *Wisby Common*.

4 Place your Instrument at N and direct the sights to O the Needle cutting 355 deg. 40 min. and the distance N O being 4 Chains 45 Links, which note in your Field-book as before.

5 Place your Instrument at O, and direct the sights to C, the Needle cutting 309 degrees 30 minutes, and the Line O C containing 6 Chains 64 Links, which note in your Field-book.

Now



Now becauſe at theſe two Obſervations you went againſt the hedge or bounder of *Banton Plain*, you muſt againſt them write in your Field-book *Banton Plain*, and becauſe you are now to leave the hedge or bounder of *Banton Plain*, draw a Line quite through your Field-book.

6 Place your Inſtrument at C, and direct the ſights to B, the Needle cutting 54 degrees 00 minutes, and the diſtance C B being 8 Chains 5 Links, the degrees and minutes muſt be noted in the firſt and ſecond columns of your Field-book, and the Chains and Links in the third and fourth.

7 Remove your Inſtrument to B, and direct the ſights to A, the Needle cutting 19 degrees 30 minutes, and the diſtance B A being 6 Chains 43 Links, the degrees and minutes muſt be noted in the firſt and ſecond Columns of your Field-book, and the Chains and Links in the third and fourth. Now becauſe at theſe two laſt obſervations you went againſt the hedg or bounder of *Bay Wood*, you muſt therefore againſt them write *Bay Wood*, and becauſe you have now finiſhed your firſt Cloſe, you muſt draw a double Line through your Book for your remembrance.

Then conſider which parcel is next fitteſt to be taken in hand, which let be *Bay Wood*, and withall at what angle thereof it is moſt meet to begin, which ſuppoſe C; and here for your help when you come to protraction) you muſt expreſs in the title of this ſecond Cloſe at what angle you begin the ſame (unleſs you had begun it where you ended the laſt at A, & then it is not material) wherfore

ſeeing

seeing you are best to begin at C, look in your Field-book (on the work of the last Close) what degrees and minutes the Needle cut at C which were 54 degrees and 8 Chains 5 Links, therefore against that number make this ⊙ or the like mark, and write the Title for your second Close thus,

Samuel White, Baywood, by Lease,
begin at ⊙.

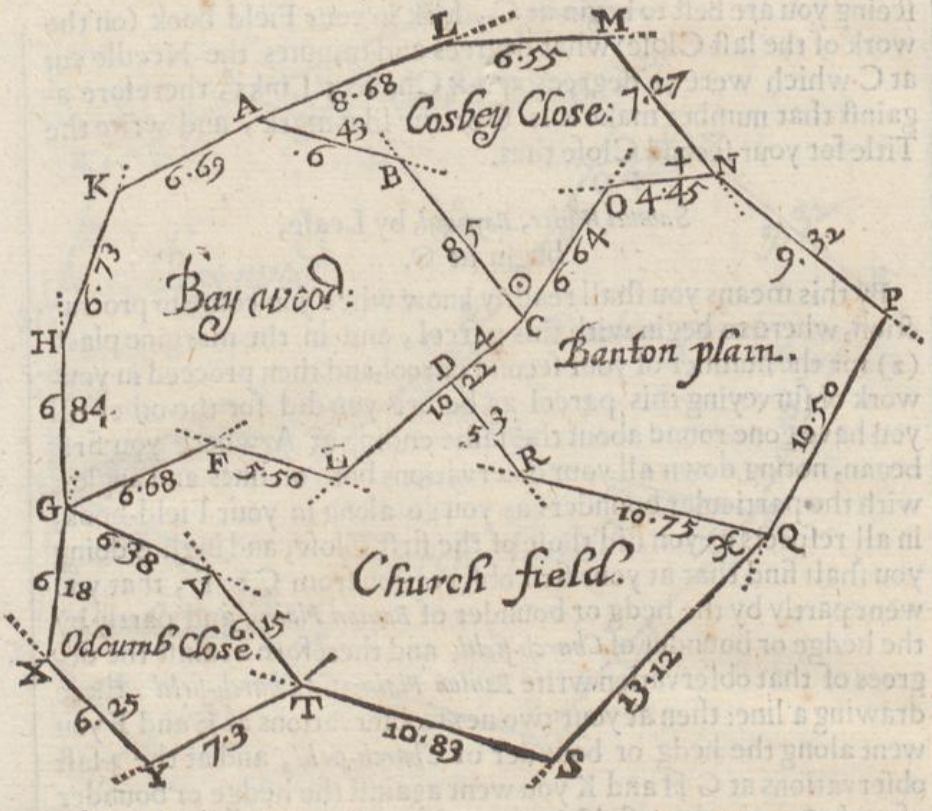
By this means you shall readily know when you come to protraction, where to begin with this parcel, and in the margine place (2) for the number of your second parcel, and then proceed in your work of surveying this parcel as before you did for the other till you have gone round about the same ending at A where you first began, noting down all your observations both of lines and angles, with the particular bounders as you go along in your Field-book, in all respects as you did those of the first Close, and in thus doing you shall find that at your first observation from C to E, that you went partly by the hedg or bounder of *Banton Plain*, and partly by the hedge or bounder of *Church-field*, and therefore against the degrees of that observation write *Banton Plain* and *Church-field*, there drawing a line: then at your two next observations at E and F you went along the hedg or bounder of *Church-field*, and at the 3 last observations at G H and K you went against the hedge or bounder of *Wisby Common*, there finishing your second parcel, wherfore draw a double line quite through your Field-book.

These two parcels being finished, consider which is next fittest to be taken in hand, and where to begin it, which suppose *Banton Plain*, and to begin at N, wherefore look in your Field-book what degrees the Needle cut when you made observation at end in the surveying of *Cosby Close*, and left the bounder of *Wisby Common*, which degrees you shall find to be 355 degrees 40 minutes, and 4 Chains 45 Links, therefore at the end of that Line where you find 355 degrees 40 minutes & 4 Chains 45 Links, make this + or some other mark for a remembrance when you come to protraction, then for the next parcel write in your Field-book.

George Burton, Banton Plain, for two lives,
begin at +.

This being done place your Instrument at N & direct the sights to P, the Needle cutting 220 degrees 20 minutes, and the line N P containing 9 Chains 22 Links, which note in your Field-book, and because at this observation you went by the hedge or bounder of *Wisby Common*, and are now to leave it, therefore draw a line and write *Wisby Common*, and in this manner must you go about this parcel also till you come to close at D, and having finished draw a double line.

Then considering that *Church field* is next fittest to be surveyed, and that it is most convenient to begin the same at Q, therefore look what degrees the Needle cut at Q in the surveying of *Banton Plain*.



Plain which were 15 degrees 40 minutes, and 10 Chains 75 Links: against which in your Field-book make ⋇ this or the like mark for your remembrance, and for your next Close write in your Field-book as followeth.

Thomas King, Church field, by Leaſe.
begin at ⋇.

Then placing your Inſtrument at Q, direct the ſights to S, noting the degrees cut, and the length of every Line meaſured, with your particular bounders, as you did in the other Cloſes before, till you come to incloſe at G, and when you have done, draw a double Line quite through your Field-book, and write the title of the next Cloſe to be ſurveyed in this manner.

John Nichols, Odcumb Cloſe Free
begin at —

Then placing your Inſtrument at T, direct the ſights to Y, and note the degrees cut and the Lines meaſured as in thoſe before, till you have gone round the field to G. And thus, if there were never ſo many Incloſures you may (without confuſion) eaſily diſtinguiſh the work of the one from the other, and be able (remembring the premiſes) to draw a plot thereof at any time, remembring alwayes that thoſe numbers in the margent of your Book, ought to be placed ſeverally in your Plot in thoſe Cloſes they repreſent.

Theſe

The Manor of Ellmore, *in the County of S. for the Honorable* R. B. *Lord thereof.*

(1) *Henry Grey, Cosby Close,* Pasture, Free.

160	45	8	68	*Wisby Common.*
181	30	6	55	
233	00	7	27	
355	40	4	45	+ *Banton Plain.*
309	30	6	64	
54	00	8	5	⊙ *Bay Wood.*
19	30	6	43	

(2) *Samuel White, Bay Wood,* by Lease, begin at ⊙.

320	00	10	22	*Banton Plain, & Church field.*
15	30	5	50	*Church field.*
337	45	6	68	
87	30	6	84	*Wisby Common.*
113	30	6	73	
153	30	6	69	

(3) *George Burton, Banton Plain,* for two Lives, begin at +.

220	20	9	22	*Wisby Common.*
299	30	10	50	*The Forrest.*
15	40	10	75	✳ *Church field.*
53	30	5	3	

(4) *Thomas King, Church field,* by Lease, begin at ✳.

316	20	13	12	*The Forrest.*
17	15	10	83	*Church Lane.*
56	00	6	15	*Odcumb Close.*
24	10	6	38	

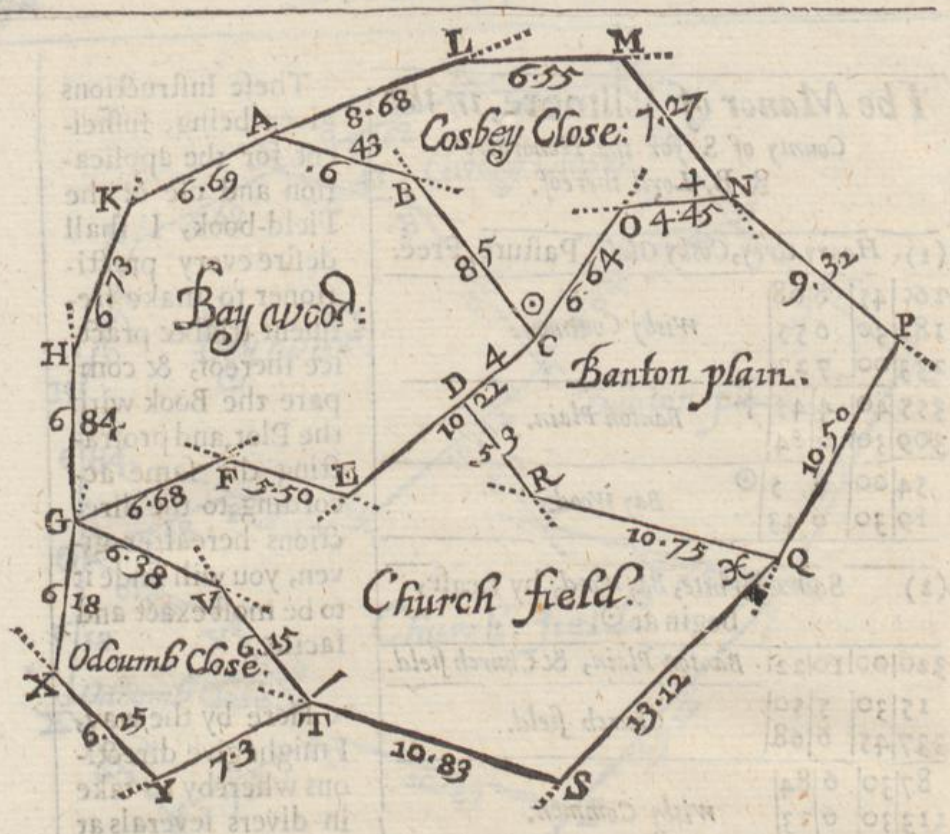
(5) *John Nichols, Odcumbe Close,* Free, begin at —

334	30	7	3	*Church Lane.*
48	30	6	25	
101	30	6	18	

These Instructions given being sufficient for the application and use of the Field-book, I shall desire every practitioner to make frequent trial & practice thereof, & compare the Book with the Plot, and protracting the same according to the directions hereafter given, you will finde it to be most exact and facile.

Here by the way, I might give directions whereby to take in divers severals at once, if the Bounders be regular, which will much ease you both in surveying & protracting, but by small practice this and divers other abreviations will appear of themselves.

I have here added one leaf of your Field-book as it ought to be ruled, which take for an example, it being the Collections of the Worke of this Chapter. with the several Lines, Angles and bounders, as you observed them in your Survey.



CHAP. LV.

How to protract or draw the plot of a whole Manor, or of divers inclosures, the observations of the several angles, lines and bounders being noted in your Field book.

PRovide a Skin of Velom, or Parchment, or divers sheets of Paper neatly fastned together with mouth-glew, according to the magnitude or greatness you intend to have your Plot, which Paper or Parchment let be ruled all over with occult parallel Lines, representing Meridians, as is taught in the 36 Chapter of this Book, the distance of which Lines one from another must not exceed the breadth of the Scale of your Protractor.

Now suppose you were to protract the observations of the last Chapter, laying your Field-book before you, consider which way your Plot will extend, and accordingly begin your work, as at the point A, upō which point A place the center of your Protractor turning it about, till the correspondent divisions at each end of the Scale of the Protractor lie directly upon one of the parallel Meridians, & staying the Protractor there, look in your field-book what deg. and min. the Needle cut at your first observation at A, which

were

were 160 degrees 45 minutes, therefore againſt 160 degrees 45 minutes of your Protractor make a mark, and through that mark and the point A, draw the Line A L, containing 8 Chains 68 Links.

Then place the center of the Protractor upon the point L, in all reſpects as before, and finding your next degrees and length to be 181 degrees 30 minutes, and the length 6 Chains 55 Links, therefore againſt 181 degrees 30 minutes of your Protractor make a mark, and through it draw the Line L M containing 6 Chains 55 Links.

Then place the center of the Protractor upon the point M, and look in your field-book what degrees were cut at M, protract thoſe degrees (as before) and draw the Line M N containing 7 Chains 27 Links.

Then place the center of the Protractor upon the point N, the degrees cut being 355 degrees 40 minutes, and the Line N O containing 4 Chains 45 Links, and becauſe againſt theſe 355 degrees 40 minutes you finde in your Field-book this mark ⊣ there placed, you muſt therefore (with Black Lead or the like) make the ſame mark at the point N upon your paper, to ſignifie that you muſt there begin to protract ſome other Cloſe.

In this manner muſt you proceed with all the other Lines and Angles, as you finde them noted in your Field-book, till you have gone over your firſt Cloſe, and cloſed your Plot at A.

Having thus finiſhed your firſt Incloſure, you muſt deal in the ſame manner with the ſecond, third and fourth, and ſo on, were there never ſo many. And to know where to begin to protract your ſecond Incloſure, you muſt have recourſe to your Field-book, where you ſhall find this mark ⊙ at which you muſt begin your ſecond Incloſure, which is *Bay Wood*, and the like mark upon your Paper at the point C, which is your remembrancer to put you in minde that at the point C you muſt begin to protract your ſecond Incloſure, as you did your firſt Cloſe.

¶ In this manner of protracting there is no difference nor cautions to be obſerved, more then thoſe already hinted in Chapter 36 and 38 of this Book *viz.* that if the degrees to be protracted be under 180, to lay the Semicircle of the Protractor upwards or from you; and if they be above 180, to lay the Semicircle downwards.

CHAP. LVI.

The figure of any plot being given, how to inlarge or diminish the same according to any assigned proportion

IT may so fall out that when you have taken the Plot of a whole Manor upon your Plain Table, in divers sheets of Paper, or observed the angles, and afterwards protracted them, as in the two last Chapters, it may so fall out that your Plot may be either bigger or lesser then is desired, now if at any time it be required to inlarge or diminish any Plot according to any proportion, this Chapter will accomplish your desire.

The Instruments for the performance hereof are divers, as was intimated in the ninth Chapter of the second Book. Now for generality and exactness, the two Indexes there spoken of, having at each end thereof a Semicircle, is inferiour to none, but the Instrument being very chargeable, and the use thereof very intricate and tedious, I shall wholly omit to speak any more of it.

There is another way also which Master *Rathborn* used, which was with a Ruler by him invented for that purpose, which would indifferent well reduce a Plot from one bigness to another according to some particular proportions. The making of this Ruler is so well known, and the use thereof so apparent, that I shall not need to say any thing concerning the description or use of it: I only intimate that there is such a Ruler, that those which please may have it made.

Another way is by one Line divided into 100 or 1000 equal parts only, which by the help of Arithmetick will perform this work very well, but this (as being very tedious) I neglect.

To pass by these and divers others which I could name, I shall say something of the Parallelogram, which for generality, exactness, and dispatch, surpasseth all the rest, unto which (in my opinion) there is none comparable. Of Parallelograms there are divers sorts, but that which I shall instance in, consisteth but of four Rulers only, the making whereof is well known to the Instrument-maker, and the manner of using it as followeth.

Take the Plot which you would reduce, and fasten it to a Table with Mouth-glew, then by it, upon the same Table, fasten your fair Paper or Parchment, upon which you would have your new Plot; then having fitted your Parallelogram according to the proportion into which you would have your Plot reduced, fix the Parallelogrā to the Table, by a point for that purpose: then put your drawing Pen into some one hole on one of the sides of the Parallelogram, and upon it a plummet of lead or brass to keep the pen down close

to

to the paper, when it is moved thereupon: and here note, that at any time when the Parallelogram is thus fitted, the point that sticketh in the Table, the Pen which is to draw, and the Tracer which you must move along the lines of your old Plot, will lie alwayes in a right Line, but this by the way: Your Parallelogram being fixed to the Table, and the Pen in its true place fitted to draw, take the Tracer in your right hand, and with it, lightly go over all the Lines of your old Plot, so shall the motion thereof occasion the Pen to draw upon your clean paper or parchment, the true and exact figure of your former Plot, though of another bigness, which will be in proportion to the greater according to the situation of the sides of the Parallelogram, which will better appear by the sight of the Instrument, then words can possibly explain it.

☞ There is yet another way how to reduce a Plot according to any proportion assigned, and that is this. Suppose you would have a Plot diminished in proportion as 4 to three. Cause a Scale to be made, of such a length that it may reach from the center to the middle of your Plot to the outermost angle thereof, which let be divided into 100, 1000, or 10000 parts, according to the length thereof, then let another Ruler be made, which shall be in proportion thereto as 4 to 3, which Ruler let be divided into the same number of equal parts as the other Ruler was: being thus provided of two Rulers, lay by your large Plot upon a Table, fastning it at the corners with mouth-glew; and underneath it lay your fair paper or parchment, then number all the angles in the field with Arithmetical figures, beginning with the outermost angle, calling that one the next two, the third three, and so forth, then as you move the Ruler from angle to angle, take notice what number of equal parts is cut by every angle, and note them down in paper, then take off your longer Ruler, and lay on your shorter in the place thereof, so moving it from angle to angle, and pricking holes with a smal protracting Pin quite through the old Plot, so when you have gone over every angle you may upon your clean paper or parchment draw lines from point to point, till you have gone over all the angles, so shall your Plot be reduced to your intended bigness.

CHAP.

CHAP. LVII.

How to draw a perfect draught of a whole Manor, and to furnish it with all necessary varieties, also to trick and beautifie the same: in which, (as in a Map) the Lord of the Manor may at any time (by inspection only) see the symetry, situation and content of any parcel of his Land.

HAving protracted your Plot according to your intended bigness, and written the content of each Close about the middle thereof, you may about the bounds of every Field or Inclosure, with a small Pencil, and some transparent green colour, neatly go over your black Lines, so shall you have a transparent stroke of green on either side of your black Line, which will add a great lustre and beauty to your Plot.

Then in your Wood-land grounds draw divers little Trees in the most material places, and shadow your mountanous and uneven grounds with Hils and Valleys, expressing all kinde of Bogs, Groves, High-ways, Rivers, &c. distinguishing them by lively colours according to their similitudes.

Then in some convenient place of the Plot, without the Inclosures, draw a Circle, and therein describe the 32 Points of the Mariners Compass according to the situation of the grounds, with a Flowre-de-luce at the North part thereof.

Then in some convenient place of your plot, make a Scale equal to that by which your Plot was protracted.

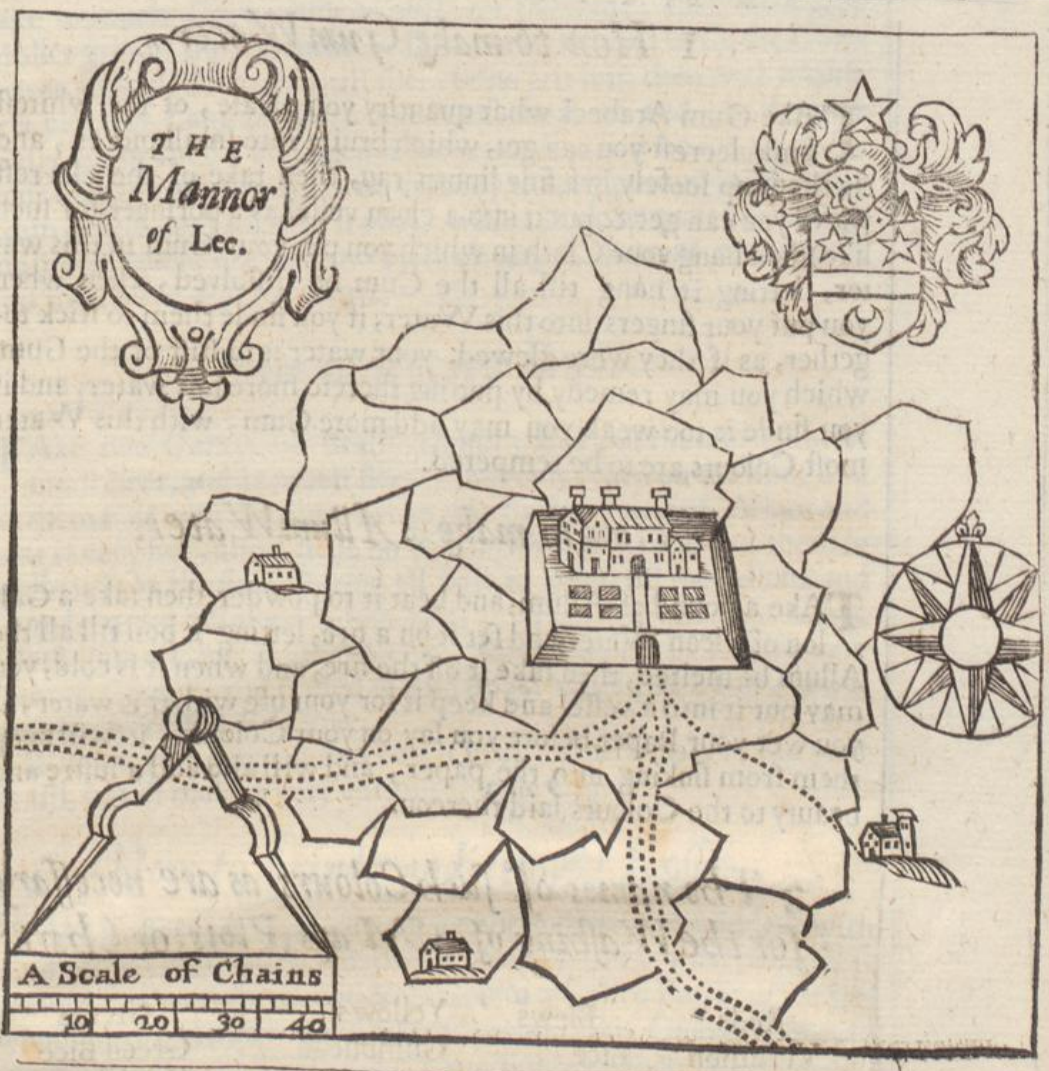
Lastly, in some other convenient place towards the upper part thereof, draw the Coat of Arms belonging to the Lord of the Manor, with Mantle, Helme, Crest, and Supporters; or in a Compartment, but be sure you blazon the Coat in its true Colours.

These things being well performed, your Plot will be a neat Ornament for the Lord of the Manor to hang in his Study, or other private place, so that at pleasure he may see his Land before him, and the quantity of all or every parcel thereof without any further trouble.

Also in your Plot must be expressed the Manor-house according to its symetry or situation, with all other houses of note, also all Water-mils, Wind-mils, and whatsoever else is necessary, that may be put into your Plot without confusion.

For farther explanation of what hath been delivered in this Chapter, I have here added the figure of a small Manor, which will be sufficient for example sake.

CHAP.



CHAP. LVIII.

The names of such Colours as are necessary for the Washing of Maps, Charts, or Plots, with the manner how to temper and use the same upon Velom, Paper, or Parchment.

IT is not convenient for a Surveyor when he hath drawn the draught of a Manor, and reduced it to his intended bigness, to repair to a Painter to finish his work, the thing it self being very gentile, and easie to be atteined: And besides a Painter is not easie to be found in every Countrey, nor is every Painter furnished with Colours fitting for such a purpose, they for the most part using more ordinary Colours, now for the benefit of such who desire to exercise themselves in this kinde of practice, I have added these necessary directions following.

1 *How to make Gum Water.*

TAke Gum Arabeck what quantity you pleaſe, of the whiteſt and cleereſt you can get, which bruiſe into ſmall pieces, and tie them up looſely in a fine linnen rag, then take of the cleereſt water you can get, & put it into a clean veſſel, as a poringer, (or ſuch like) then hang your Cloth in which you put your Gum in this water, letting it hang till all the Gum be diſſolved, then when you put your fingers into this Water, if you finde them to ſtick together, as if they were glewed, your water is to ſtiff of the Gum, which you may remedy by putting thereto more fair water, and if you finde it too weak you may add more Gum, with this Water moſt Colours are to be tempered.

2 *How to make Allum Water.*

TAke a pound of Allum, and beat it to powder, then take a Gallon of clean Water, and ſet it on a fire, letting it boil till all the Allum be melted, then take it off the fire, and when it is cold, you may put it into a veſſel and keep it for your uſe with this water, if you wet your Paper before you lay on your Colours, it will keep them from ſinking into the paper, and will alſo add a luſtre and beauty to the Colours laid thereon.

3 *The names of ſuch Colours as are neceſſary for the Waſhing of Maps, Plots, or Charts.*

Reds	Blews	Yellows	Greens
Vermiion	Bice	Gumbuege	Green Bice
Lake	Indigo	Yellow Berries	Verdegreece
Roſſet	Smalt	Orpiment	diſtilled
Braſil	Verditer		Sap-green
RedLead			

Umber, Lamp-black

Being thus provided of theſe ſeveral Colours here named, which you may have in divers places in *London*, as alſo of a grinding ſtone and Muller, which any Maſon in *London* will furniſh you with, alſo divers pencils of ſeveral ſizes and Gally pots, Gar Glaſſes, or Horſe Muſcle-ſhels, to put your Colours in when they are grounded and tempered, you are then ready at any time to make uſe of them, and now will I ſhew you how all the fore-mentioned Colours are to be ground and tempered.

How to grinde Vermillion, Lake, and Red Lead.

YOur grinding ſtone and Muller being very clean, take either Vermillion, Lake, or Red Lead, and lay it upon your Stone, then take

take so much Gum-water as will wet the same, then with your Muller grinde the Vermillion, Lake, or Red Lead with the Gum-water very well together, till there be no grit left, then with a knife or a piece of Lanthorn horn take it off the stone and put it into a Gally pot or shell, and keep it for your use: if it be too thick for your use, you may at any time remedy that by putting in of more Gum water, and stirring it about with a stick or pencil, but it is most convenient to grinde no more of any Colour at a time then you shall have occasion to use.

How to prepare Brasil.

TAke two Ounces of Brasil ground, and put thereto a pint of small Beer, and as much Beer Vineger set then on the fire, and let them boil well together, then take half an ounce of Allom and beat it very fine, also a little bit of Gum Arabeck, and put them in while it is on the fire, letting all boil to ether till the Allom and Gum be quite dissolved. then take it off and strain it through a Cloth, into a Glass or other Vessel, this liquour is of it self a very fair red Colour, and is used to rule Books with red Lines, and is commonly called Red Inke.

If you take Logwood and boil it in all respects as you did your Brasil, it will make a very curious Purple Colour.

How to grinde and temper Rosset.

TAke Rosset and lay it on your grinding stone, and grinde it with a little Gum-water, so that it be very stiff, then when it is ground fine enough, take it & put it into a Galley Pot, & when you would use it, temper it with Brasil water, this Colour differeth not much from the Colour of Lake, but it is much cheaper, and will not keep colour half so long.

How to grinde and temper Blew or Green Bice.

TAke Blew or Green Bice, and grinde it upon your stone with fair water, then take it and put it into a Galley pot, and fill the pot with fair water, and so let it rest two or three hours, often stirring it about with a stick, then let it stand till the Bice be all setled to the bottome, then poure away the water from the Bice, and put in more clean water, letting it stand, and stirring it as before, then poure that water away, and put in more clean water, thus continuing 4 or 5 times, then lastly, when you would use it temper it up with Gum-water.

How to grinde Indico.

TAke Indico, and grinde it with Gum-water upon your stone very fine, then take it and put it into a pot or shell, and it is fit for

use, this Colour of it self is a very sad blew, but you may make it lighter at pleasure, by adding thereto some white Lead ground also with Gum-water.

How to temper Smalt.

TAke fine Smalt, and put it into a Galley pot, then put thereto some Gum-water, and temper it up with a pencil, This Colour needeth no grinding, it being fine enough of it self.

How to grinde & temper Blue or Green Verditer.

TAke Blue or Green Verditer, and grinde it with Gum-water on your stone, when it is fine enough, take and put it into a pot or shell for your use.

How to use Gum-boogd.

TAke Gumboogd, and break it in small pieces, then put it into a clean pot, and put thereto clean water, letting it there lie till it be dissolved, this is a fine transparent Colour, and excellent good to wash withall.

How to use Yellow Berries.

TAke yellow Berries, and bruise them a little in a Morter, then put them into a pot, and put thereto some Allom-water, letting them steep therein, and in half an houres time the Allom-water will be a very curious transparent Colour, if the Colour be too faint you may help it by putting in more Berries, but the longer the Berries lie in steep the better the colour will be, you may (if you please) when the Colour is as you would have it strain the water from the Berries, and reserve it for your use, or you may use it without straining.

How to grinde and temper Orpiment.

THere is two sorts of Orpiment, the one is a Light Yellow, and the other is an Orient or Marigold Colour commonly called Orange Tawny. Take of either of these sorts and grinde them upon your stone with Gum-water, keep them in pots or shels for your use.

How to use Verdigrease.

THe best Verdigrease is that which is dissolved, take therefore distilled Verdigrease, and steepe it ten or twelve hours in good Muscadine, and it wil be a very fine transparent Green Colour.

How to use Sap green.

TAke Sap-green, and put it into a pot or shell, and put thereto white Wine Vineger, and a little bit of Allom, this will make an excellent Green for Trees, Hedges, &c. if at any time it grow too thick add more Vineger or Water, or rather half Water and half Vineger.

There are some other ordinary Colours, which will be very useful for you especially when you do to express Houses, Trees, Rivers, Mils, Mines, Gates, Cottages, Brooks, Pales, Barns, and such like; all which are to be ground and tempered with Gum-water, the names of which Colours are these following: White Lead, Lambe black, Umber, Spanish Brown; Almegum, and Bolearmoniack: these Colours are all very cheap, and are all to be ground with with Gum-water, and by mingling two of these or other Colours together, you may make almost what Colour you please of any Blew and Yellow mixed together make a Green, &c. of these last mentioned Colours, most of which are very sad Colours, they ought to be ground very fine, and good store of Gum-water used in the tempering of them.

CHAP. LIX.

How to find whether water may be conveyed from a Spring head, to any appointed place.

THere is an Instrument called a Water-level, for the performance hereof, the making whereof is sufficiently known. Now if it were required to know whether water may be conveyed in Pipes or Trenches from a Spring-head to any determinate place, observe the following directions.

Place your Water-level at some convenient distance from the Spring-head, in a right line towards the place to which the water is to be conveyed; as at 30, 40, 60, or 100 yards distant from the Spring-head. Then having in a readiness two long straight poles (which you may call your station staves) divided into Feet, Inches, and parts of Inches from the bottom upwards: being thus provided, cause one (whom you may call your *first assistant*) to set up one of the said staves at the Spring-head, and require another (which you may call your *second assistant*) to erect the other staff beyond your Instrument at 30, 40, 60, or 100 yards forward, towards the place to which the water should be conveyed. These station staves being erected perpendicular, and your Water-level in the midway precisely horizontal, go to the end of the Level, and looking through the sights, cause your *first assistant* to move a leaf of paper up and down your station staff, till through the sights you see the very edge thereof, and then by some known signe or sound, intimate

to him that the paper is then in its true position, then let this *first assistant* note against what number of Feet, Inches, and parts of an Inch the edge of the paper resteth, which he must note down in a paper. Then your Water-level remaining immoveable, go to the other end thereof, and looking through the sights towards your other station staff, cause your *second assistant* to move a leaf of paper along the staff, till you see the very edge thereof through the sights, and then (by some known signe or sound) cause him to take notice what number of Feet, Inches, and parts of an Inch, are cut by the said paper, which will him also to keep in minde, or note in a paper as your *first assistant* did.

This done, require your *first assistant* to bring his station staff from the Spring head, and cause your *second assistant* to take that staff and carry it forward towards the place to which the water is to be conveyed, 30, 40, 60, or 100 yards, and there to erect it perpendicular as before, letting your *first assistant* stand at that staff where your *second assistant* before stood; then in the mid way between your two assistants, place your Water-level exactly horizontal, and looking through the sights thereof, cause your *first assistant* to move a paper up and down, and when you give him a signe to note what number of Feet, Inches, and parts of an Inch are cut by the paper, and note them down, then going to the other end of your Water-level, look through the sights, and cause your *second assistant* to move a paper along the Staff, and to note the Feet, Inches, and parts of an Inch as before.

Then cause your *first assistant* to bring away his station-staff, and cause your *second assistant* to take it and carry it 30, 40, 60, or 100 yards forwarder, towards the place to which the water is to be conveyed, and leaving your *first assistant* at the place where your *second assistant* last stood, place your Water-level again in the mid-way between your two Assistants, and looking through the sights as before, cause each of them to move a leaf of paper up and down their station staves, and note down in their several papers the number of Feet, Inches, and parts of an Inch cut, when you looked through the sights of your Water-level.

In this manner you must go along from the Spring head, to the place unto which you would have the water conveyed, and if there be never so many several stations, you must, in all of them, observe this manner of work precisely, so by comparing the notes of your two Assistants together you may easily know whether the water may be conveyed from the Spring-head to the desired place or not. though there be many Hils between.

¶ Here note, that in your passage between the Spring head and the appointed place, from station to station, you must observe this order, otherwise great errour wil ensue, *viz.* that your *first assistant* must at every station, stand between the Spring head and your Water-level: and your *second assistant* must alwayes stand between your Water-level and the place to which the water is to be conveyed, thus by observing this order in your

work

work you shal have no confusion, neither shal one of your Assistants take more pains then the other.

Having thus orderly proceeded from the Spring head to the place appointed, call both your Assistants together, and cause them to give in their notes of the observations at each station, and add them together severally: then if the note of the *second assistant* exceed (or be greater then) the note of the *first assistant*, take the lesser out of the greater, and the remainder will shew you how much the appointed place to which the water is to be brought is lower then the Spring head.

The first *Assistants* Note.

Station	*Feet*	*Inch*	*Parts.*
1	15	3	1/2
2	2	1	1/4
3	1	6	0
Sum	18	10	1/4

The second *Assistants* Note.

Station	*Feet*	*Inch*	*Parts*
1	3	2	3/4
2	14	0	1/4
3	3	11	0
Sum	21	2	0

By this Table you may perceive that the notes of the *first assistant* collected at his several stations being added together, amounteth to 18 Feet, 10 Inches, and 1/4 of an Inch: and the notes of your *second assistant* at his several stations being added together amounteth to 21 Feet and two Inches, so the number of the *first assistants* observations being taken from the number of the second, there will remain 2 Feet, 3 Inches and and 1/4 of an Inch, & so much is the place to which the water is to be brought, lower then the Spring head, according to the straight Water-level, and therefore the water may easily be conveyed.

Having expressed as plainly as I can in words the manner of conveying of water from a Spring-head to any appointed place, it will not be amiss to insert a figure by the sight whereof you may plainly perceive how it is effected, in which figure note that A repre-

sents

presents the Instrument or Water-level, and the station staves: C the Spring-head, and D the place to which the water is to be conveyed.

¶ Here note that when you have called your two Assistants together, and examined their several Notes, and added them together, if then you shall finde the summe of your *first assistants* Note to be greater then the sum of your *second assistants* Note, that then it is impossible to bring the water from that Spring-head to the intended place: but if the Sums of the Notes of your two Assistants do exactly agree; there is then a possibility of effecting it, if the distance be but short, though with more charge and difficulty.

¶ Note 2, That the most approved Authours concerning his particular do aver, that at every miles end there ought to be allowed 4½ Inches more then the straight Level for the current of the water.

¶ Note 3, If there be any Hill lying in the way between the Spring-head and the place to which the water is to be conveyed you must then cut a Trench by the side of the Hill in which you must lay your pipes equal with the straight Water-level, with the former allowance. And in this case there be a Valley you must then make a trunk of strong wood well under-propped with strong pieces of timber, and well pitched or leaded, as is done in divers places between *Ware* and *London*.

¶ Note 4, That in conveying of water to an appointed place, it is not convenient to bring it from the Spring-head by the neerest distance or in a straight Line, but by a crooked or winding way; and you ought also to lay the Pipes one up and another down, but this is to be observed but in some cases only, where the water will have too violent a current.

Thus I have finished my intended discourse of Surveying of land, in which I have studied rather to make every particular therein conteined plain and perspicuous to the meanest capacity, then with too much brevity to obscure that which I chiefly aimed at, namely, to instruct the ignorant: I confess, I may be justly blamed by those who are Masters of the Art, or have a considerable knowledge thereof already, for using too many circumlocutions, but I answer, it was not written for their sakes, yet I hope it will not be rejected by them; and although I do not attempt to teach such more then they know already, yet (possibly) they may herein find something worth their perusal & practice, or (at least) it may be a Remembrancer unto them to bring to minde what otherwise they may have forgotten. But ceasing to apologize any more for my Book, let it now speak for it self.

FINIS.

y Bar

1642.

H685
(12), 92, 177-308 pp., 1 blank leaf
(lacks portrait).
JL 6/89