

The compleat surveyor: containing the whole art of surveying of land, by a new instrument lately invented; as also by the plain table, circumferentor, the theodolite as now improv'd, or by the chain only / Containing plain and easy directions in several kinds of mensurations, and other things necessary ... in a work of this nature. By William Leybourn. The whole altered and amended, and two entire books added by the author.

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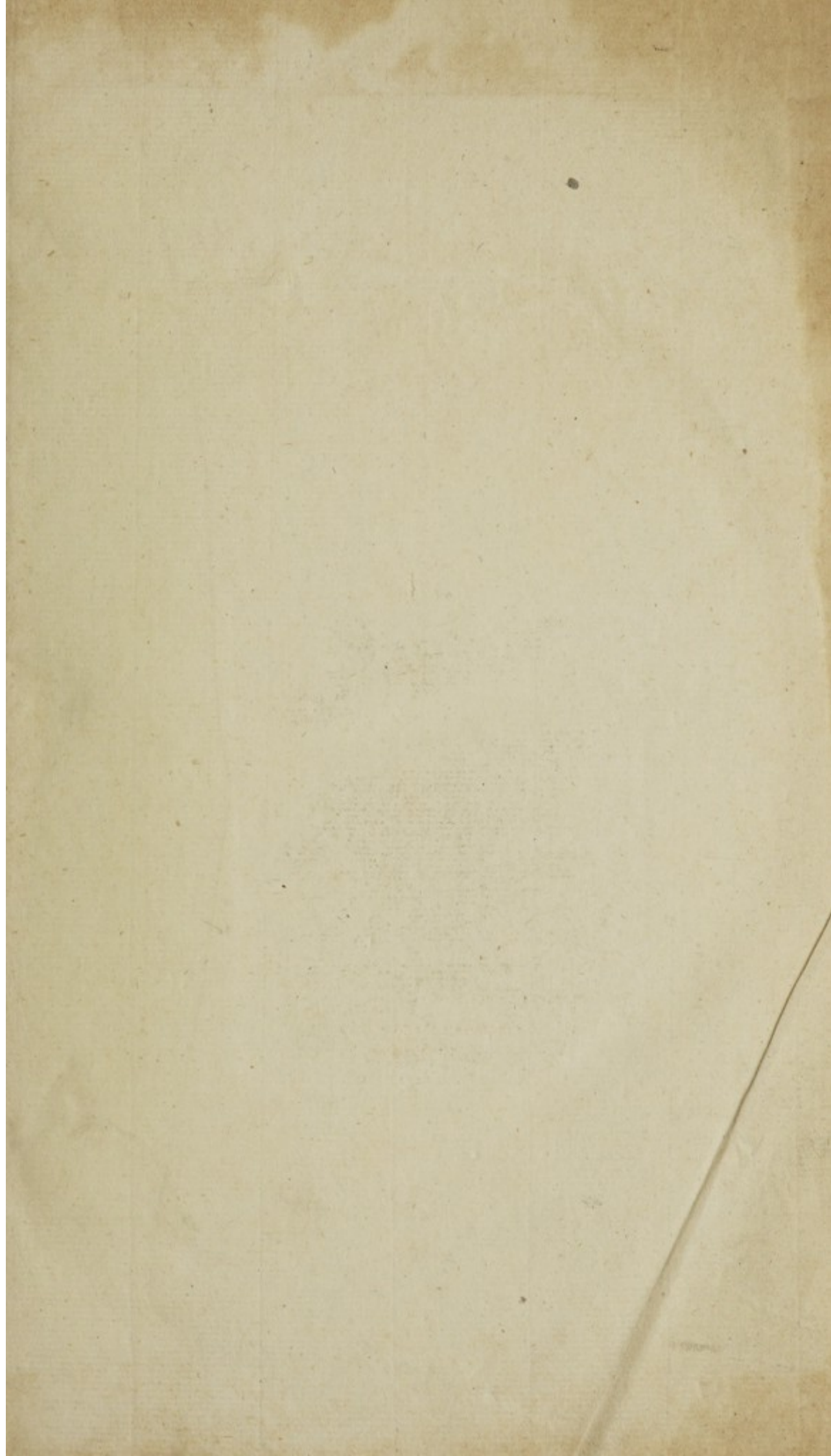


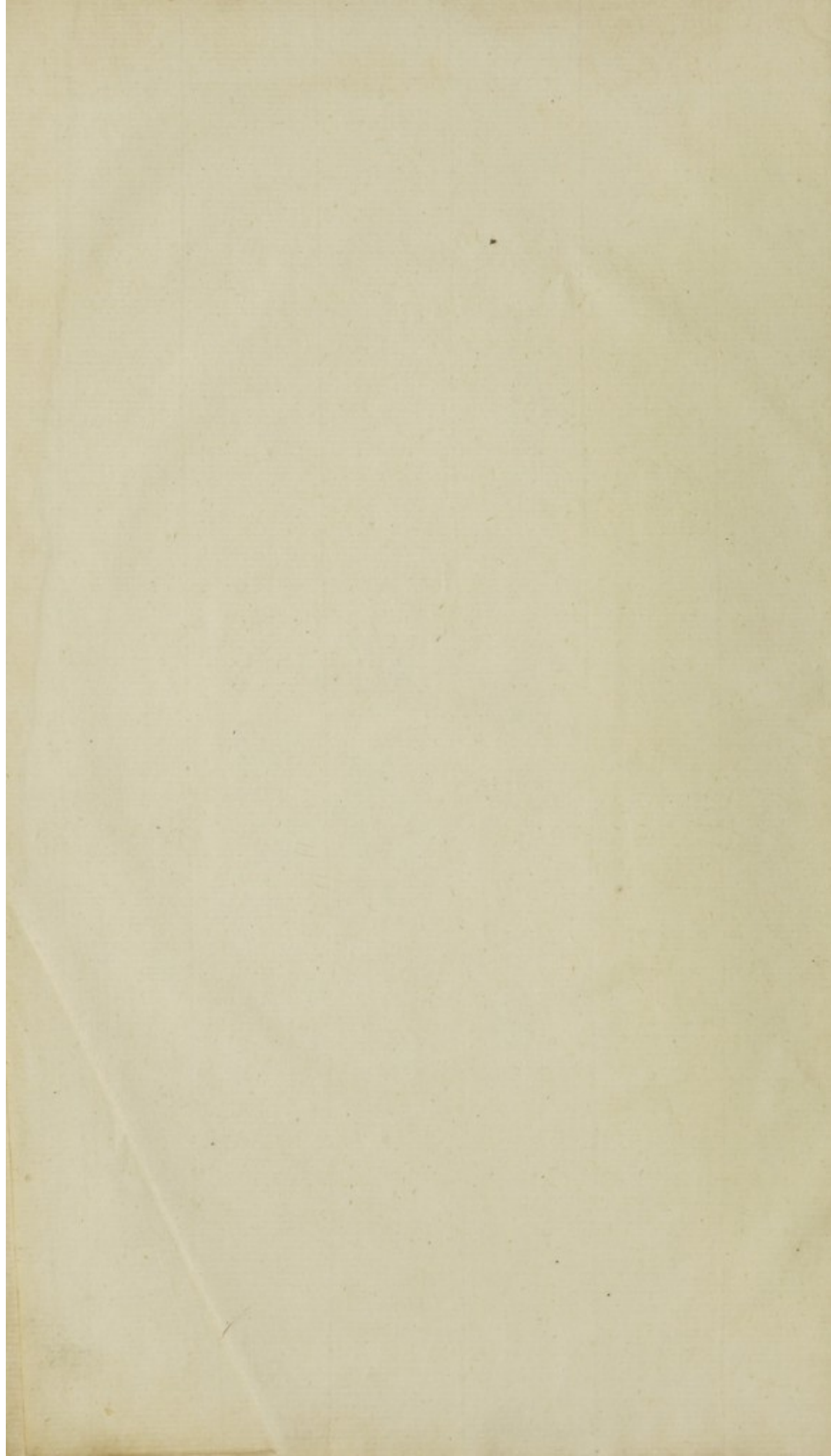
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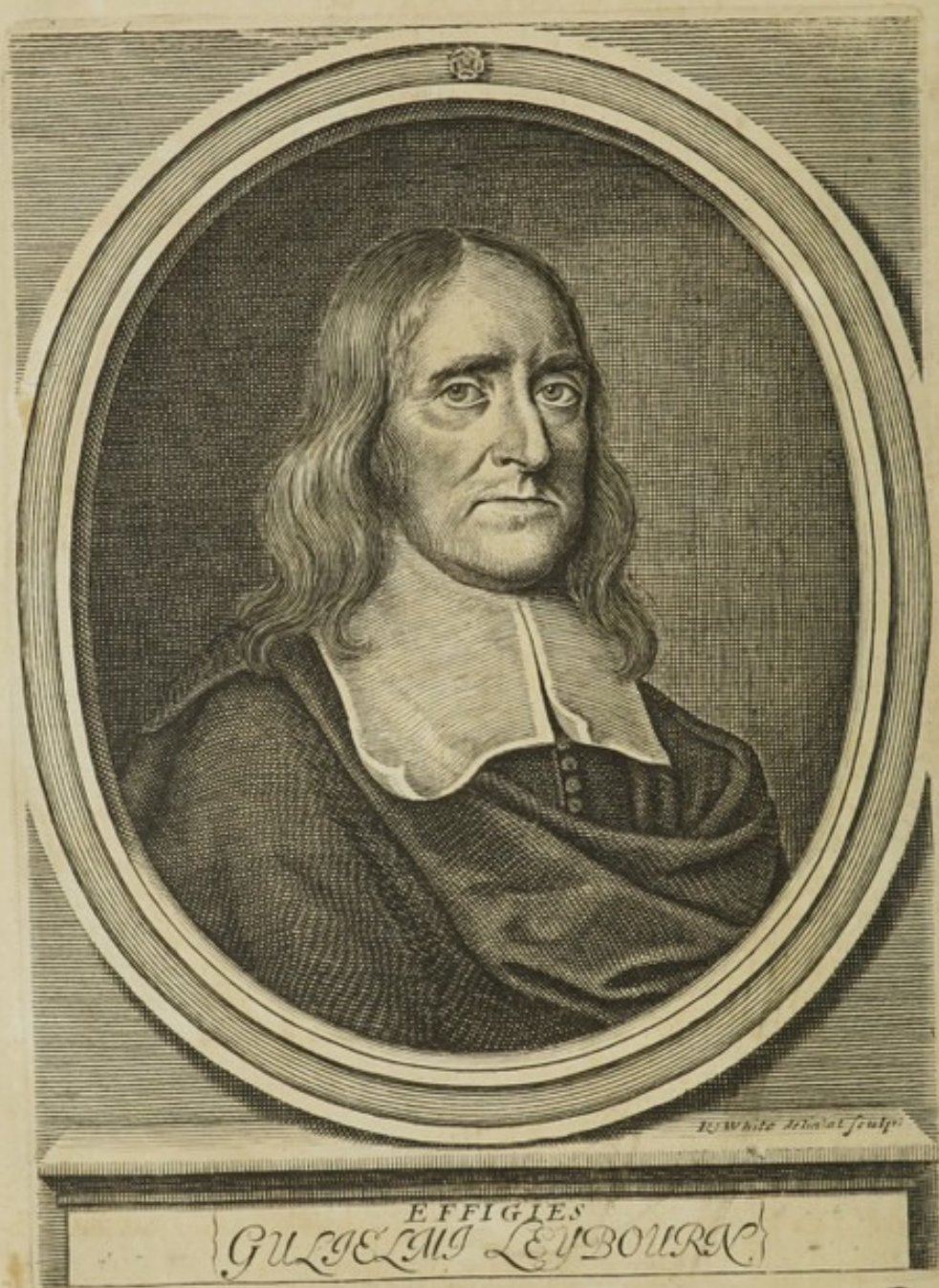








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EFFIGIES
GUILLAUME LEYBOURN

T H E

Compleat Surveyor :

Or, the W H O L E A R T of

S U R V E Y I N G

O F

L A N D,

B Y

A New I N S T R U M E N T lately invented ;

As also by the

Plain Table, Circumferentor, the Theodolite
as now improv'd, or by the Chain only.

C O N T A I N I N G

Plain and Easy D I R E C T I O N S in several Kinds of M E N S U R A T I O N S, and
Other Things necessary to be known in a Work of this Nature.

By *WILLIAM LETBOURN.*

The W H O L E Altered and Amended, and T W O entire B O O K S added
by the A U T H O R long before his D E A T H.

The F I F T H E D I T I O N, in I X B O O K S.

Every Operation both Geometrical & Arithmetical being examin'd,

A N D A N

A P P E N D I X

Added to the W H O L E, Consisting of

Practical Observations in Land Surveying,

By *SAMUEL CUNN.*

L O N D O N :

Printed for SAMUEL BALLARD at the *Blue Ball*, and AARON WARD
at the *King's Arms* in *Little Britain*, and THO. WOODWARD at the
Half-Moon against *St. Dunstan's Church* in *Fleetstreet*. 1722.

THE
Complete Surveyor
 Or, the Whole Art of
SURVEYING



BY
 A New Instrument lately invented;
 As also by the
 Plain Table, Circumferentor, the Theodolite,
 as now improv'd, or by the Chain only.

CONTAINING
 Plain and Levelling Directions in several kinds of Mensurations, and
 Other Things necessary to be known in a Work of this Nature.

By
 The Author's Third Edition, and Two former Editions added
 in the last Part of the Design.

The Fifth Edition, in IX Books.

Printed by J. Sturges, at the Sign of the Anchor, in Strand.

A P P E N D I X

Practical Observations in Land Surveying.

By **WILLIAM CUNN**

Printed by J. Sturges, at the Sign of the Anchor, in Strand.
 In the Year 1742.



TO THE
R E A D E R.



*I*s not uncommon for Persons by the Fireside to prescribe Rules, which they would have Surveyors observe Abroad: And yet if such Persons withdraw to the Field, they often find it impossible to put their Precepts, tho' Geometrically true, in Practice; and themselves as awkward to perform. So necessary, to the well Performance of any thing in the Mathematical Arts, is a former Practice under a good Guide (as well as the Theory); that no Person of sound Judgment will entrust him (either to direct or perform) who is not thus qualified.

The Author of this Treatise was frequently employed in Surveying, Measuring and Mapping Gentlemens Estates; as evidently appears from the several Draughts by him drawn, and to be met with in almost every County in England.

These Qualifications alone recommended the first Edition; and the Book itself made way for Three more afterwards.

If to these be added, the great Enquiries made for this Book (notwithstanding the many Tracts on this Subject,) and the many Improvements herein contained, which were

P R E F A C E.

not in the former Editions, and indeed most of them not before Printed; they may be justly accounted sufficient Reasons for Publishing this fifth Edition. Nevertheless, it may not be improper to give the Reader a summary Account of the principal Improvements.

The Author, long before his Death, made several Remarks, not publish'd in the former Editions. In the first Book, the various Cases, of which some Problems admitted, are in this supply'd. In the second Book is an Account of an Instrument, by him contriv'd. In the third Book the Tables of Logarithms, Sines and Tangents are more commodiously placed; and a fuller Description and Use of the Artificial Lines of Numbers, Sines and Tangents added. In the fourth Book, several Problems are omitted, because performed with more Expedition and Accuracy, by Methods laid down in the following Books. And several Problems added relating to casting up the Contents of Lands, by Methods more concise and ready, and more fit for a Practitioner, than any heretofore Publish'd. And also several Remarks on the modern Water-Level. The fifth and sixth Books are entirely new; and contain the Description and Use of a new Instrument, invented by the Author, and his Method of Surveying by the Chain only, &c. And after the seventh, eighth, and ninth Books, which in the fourth Edition, were the fifth, sixth and seventh, there is added an Appendix, by Mr. Cunn, containing several practical Observations of Matters occurring in his Method of Surveying. A more particular Account, of all which, you have in the Table of Contents.





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S U R V E Y O R.

The F I R S T B O O K.

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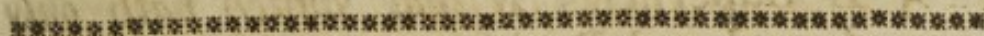


HIS first Book consisteth of divers Definitions and Problems Geometrical, extracted out of the Writings of divers Antient and Modern Geometricians, as Euclid, Ramus, Bagdedine, Clavius, &c. which are here so methodically disposed, that any man may gradually proceed from Problem to Problem without Interruption, or being referred to any other Author for the practical Performance of any of them. Only the
B De-

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 Problems been demonstrated) must of necessity have been inserted. Also, the Figures would have been so incumbred with multiplicity of Lines, that the intended Problems would have been thereby much darkned. 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 Problems as I conceived most useful for my present purpose, and come most in use in the practice of Surveying. They are in Number 40, and ought of necessity to be known by every Man that intendeth to attain to a competent Proficiency in the Practice thereof: And those are chiefly such as concern the reducing of Plots from one Form to another, and to enlarge or diminish them according to any assigned Proportion. Also divers of the Problems in this Book will abundantly help the Surveyor in the Division and Separation 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-divided, if need be. Also, for the better satisfaction of the Reader, I have performed divers of the following Problems as well Arithmetically as Geometrically.



GEOMETRICAL DEFINITIONS.



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



Point or *Sign* is that which is void of all *Magnitude*, and is the least thing that by Mind and Understanding can be imagined and conceived, than which there can be nothing less. As the *Point* or *Prick* noted with the Letter *A*, which is neither Quantity nor Part of Quantity, only the Term or End of Quantity. And herein a *Point* in Geometry differeth from *Unity* in *Number*.

2 *A Line is a Length, without Breadth or Thickness.*

A *Line* is created or made by the moving or drawing out of a *Point* from one place to another: so the *Line* *AB* (fig. 1.) is made by moving of a *Point* from *A* to *B*: and according as this Motion is, so is the *Line* thereby created, whether *Straight* or *Crooked*. And of the Three kinds of *Magnitudes* in *Geometry*, viz. *Length*, *Breadth*, and *Thickness*, a *Line* is the first, consisting of *Length* only

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 (*fig. 1*) the Ends or Bounds whereof are the Points A and B: But in a Circular *Line* it is otherwise, 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 between his Points.*

As the *Right Line* A C D B (*fig. 1*) lieth straight and equal 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 kind of Magnitude; so the motion of a *Line* produceth a *Superficies*, which is the second kind of Magnitude; and is capable of two Dimensions, namely, Length and Breadth: and so the *Superficies* A B C D (*fig. 2*) may be divided in length from A to B, and also in breadth from A to C.

6 *The Extrems of a Superficies are Lines.*

As the Extrems or Ends of a *Line* are Points, so the Extrems or Bounds of a *Superficies* are *Lines*; and so the Extrems or Ends of the *Superficies* A B C D, (*fig. 2*) 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 right-lined Angle is the Inclination or Bowing of two right Lines, the one to the other, the one touching the other, and not being directly joined together.*

As the two right Lines AB and BC (*fig. 3.*) incline the one to the other, and touch one another in the Point B , in which Point, by reason of the inclination of the said Lines, is made the *Angle* ABC . 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 CD and DE 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 ABC , you are to understand the very Point at B , the Quantity of which Angle is measured by an Arch of a Circle described upon the angular Point B . And note also, that the Length of the Sides containing any Angle, as the Sides AB and BC do not make the Angle ABC either greater or lesser; but the Angle still retaineth the same Quantity, be the containing Sides thereof either longer or shorter.

9. *When a right Line standing upon a right Line maketh the Angles on either Side equal, 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 CD , (*fig. 4.*) suppose there do stand another right Line AB , in such fort that it maketh the Angles on either Side thereof equal, namely, the Angle ABD on the one Side, equal to the Angle ABC on the other Side; then are either of the two Angles ABC and ABD right Angles, and the right Line AB , which standeth erected upon the right Line CD , without inclining to either Part thereof, is a Perpendicular to the Line CD .

10. *An obtuse Angle is that which is greater than a right Angle.*

So the Angle CBE (*fig. 5.*) is an obtuse Angle, because it is greater than the Angle ABC, which is a right Angle; for it doth not only contain that right Angle, but the Angle ABE also, and therefore is obtuse.

11. *An acute Angle is less than a right Angle.*

So the Angle EBD (*fig. 5.*) is an acute Angle, for it is less than the right Angle ABD (in which it is contained) by the other acute Angle ABE.

12. *A Limit or Term is the end of every thing.*

As a *Point* is the Limit or Term of a *Line*, so a *Line* likewise is the Limit and Term of a *Superficies*, and a *Superficies* is the Limit and Term of a *Body*.

13. *A Figure is that which is contained under one Limit or Term, or many. Vid. Fig. 6.*

As the Figure A is contained under one Limit or Term; 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 D 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 unequal (as the Figure E) a *Plot*, or *Plat*, as of a Field, Wood, Park, Forest, and the like.

14. *A*

14. *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. Vid. Fig. 7.*

As the Figure BCDE is a Circle contained under the crooked Line BCDE, which Line is called the Circumference or Peripherie, In the middle of this Figure is a Point A, from which Point all Lines drawn to the Circumference thereof are equal, as the Lines AB, AC, AF, AD; and this Point A is called the Center of the Circle.

15. *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 equal Parts. Vid. Fig. 7.*

So the Line BAD 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 equal Parts, namely, BCD being on one side of the Diameter, equal to BED on the other side of the Diameter. And this Observation was first made by *Thales Milesius*; 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 equal.*

16. *A Semicircle is a Figure contained under the Diameter, and that Part of the Circumference cut off by the Diameter. Vid. Fig. 7.*

As in the former Circle the Figure BED is a Semicircle, because it is contained under the right Line BAD, which is the Diameter, and the crooked Line BED being that Part of the Circumference which is cut off by the Diameter; also the Figure BCD is a Semicircle.

17. A Quadrant is the fourth Part of any Circle, and is contained under two right Lines drawn from the Center of the Circle, and one fourth Part of the Circumference of the same Circle. Fig. 7.

18. A Segment of a Circle is a Figure contained under a right Line, and a Part of a Circumference greater or less than a Semicircle. Fig. 7.

So in the former Circle, the Figure B A C is a Quadrant, for that it is contained under the two right Lines A B and A C, and the crooked (or arch) Line B H C, which is one fourth Part of the Circumference B C D E.

So in the former Figure B C D G E, G B F which is contained under the Part of the Circumference G B F, and the right Line G F is a Segment of a Circle greater than a Semicircle.

Also the other Figure G D F, which is contained under the right Line G F, and the Part of the Circumference G D F is a Segment of a Circle less than a Semicircle.

¶ And here note. That a Segment is such a Part as is either greater or lesser than a Semicircle; so that a Semicircle cannot properly be called a Segment of a Circle.

19. Right-lined Figures are such as are contained under right Lines.

Three-sided Figures are such as are contained under three right Lines.

Four-sided Figures are such as are contained under four right Lines.

Many-sided Figures are such as have more Sides than four.

20. All three-sided Figures are called Triangles.

And such are the Triangles A, B, C. Fig. 8.

21. *Of four-sided Figures; a Quadrat, or Square, is that whose Sides are equal, and its Angles right: As the Figure A. Vid. Fig. 9.*

22. *A Long Square is that which hath right Angles, but unequal Sides. As the Figure B. Vid. Fig. 10.*

23. *All other Figures of four unequal Sides and Angles are called Trapezias.* A

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 equal Sides nor equal Angles. *Vid. Fig. 11, 12.*

24. *Parallel or Equidistant right Lines are such, which being drawn in one and the same Superficies, and produced infinitely on both Sides, will never in any part concur or meet.*

As the right Lines A B and C D (*fig. 17*) are parallel one to the other, if they were infinitely extended on either Side, would never meet or concur together, but still retain the same Distance.

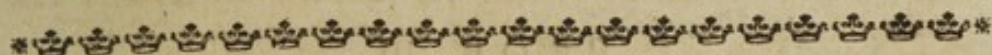


Geometrical Theoremes.

1. **A**N *T*wo 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 multiplied 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 containing 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 lye between two parallel Lines, are equal one to the other. Euclid. 37. 1.



GEOMETRICAL PROBLEMS.



PROBLEM 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 AB (fig. 13) upon which from the Point E it is required to erect the perpendicular EH.

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 than the former, place one Foot in C, and with the other describe the Arch GG; also (the Compasses remaining at the same Distance) place one Foot in the Point D, and with the other describe the Arch FF: 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 AB, which was the thing required to be done.

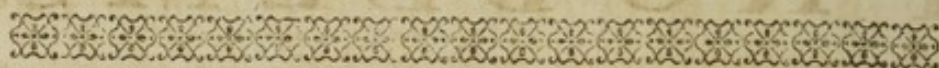
PROB.

P R O B. II.

How to erect a Perpendicular upon the end of a right Line given.

LET AB (*fig. 14.*) be a right Line given, and from the end thereof, at B , let it be required to erect the Perpendicular BF .

First, your Compasses being opened at any convenient Distance, place one Foot in B , and with the other make the Mark C ; the Compass point resting in C , with the other Foot make the Mark D , in the given Line AB ; and then lay a Ruler from D to C , and draw the Line DE , making CE equal to CD . Lastly, from B , through E , draw the Line BF , which shall be perpendicular to the given Line AB .

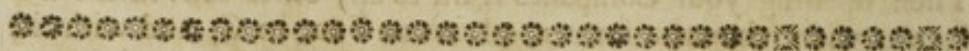


P R O B. III.

How to let fall a Perpendicular from any Point assigned, upon a right Line given.

THE Point given (*fig. 15.*) is C , from which Point it is required to draw a right Line, which shall be perpendicular to the given right Line AB .

First, from the given Point C , to the Line AB , draw a Line by Chance, as CE , which divide into two equal Parts in the Point D : then placing one Foot of the Compasses on the Point D , with the Distance DC , describe the Semicircle CFE , cutting the given Line AB in the Point F . Lastly, if from the Point C you draw the right Line CF , it shall be a Perpendicular to the given Line AB , which was required.



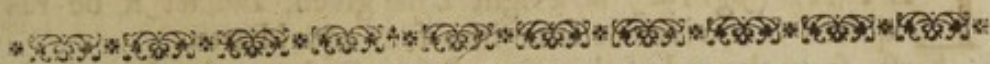
P R O B. IV.

How to make an Angle equal to an Angle given.

LET the Angle given be ACB (*fig. 16.*) and let it be required to make another Angle equal thereunto.

First,

First, draw the Line EF at pleasure; then upon the given Angle at C , (the Compasses opened to any Distance) describe the Ark AB ; also upon the Point F , (the Compasses unaltered) describe the Ark DE : then take with your Compasses the Distance AB , and set the same Distance from E to D . Lastly, draw the Line DF , so shall the Angle DFE be equal to the given Angle ACB .

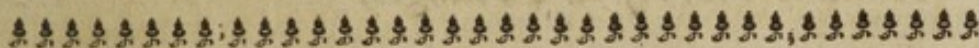


P R O B. V.

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 AB (*fig. 17.*) unto which it is required to draw another right Line parallel thereunto, at the Distance MN .

First, Open your Compasses to the Distance MN , then placing one Foot in A , with the other describe the Ark C ; also place one Foot in B , and with the other describe the Ark D . Lastly, draw the Line CD , so that it may only touch the Arks C and D ; so shall the Line CD be parallel to the Line AB , and at the Distance MN , as was required.



P R O B. VI.

A right Line being given, how to draw another right Line parallel thereunto, which shall also pass through a Point assigned.

LET AB (*fig. 18.*) be a Line given, and let it be required to draw another Line parallel thereunto, which shall pass through the given Point C .

First, take with your Compasses the Distance from A to C , and placing one Foot thereof in B , with the other describe the Ark DE ; then take in your Compasses the whole Line AB , and placing one Foot in the Point C , with the other describe the Ark FG , crossing the former Ark DE in the Point H . Lastly, if you draw the Line CH , it shall be parallel to AB .

E

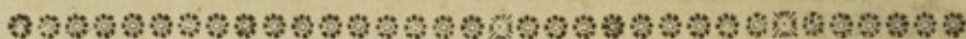
P R O B.

P R O B. VII.

To divide a right Line given into any Number of equal Parts.

LET AB (*fig. 19.*) be a right Line given, and let it be required to divide the same into four equal Parts.

First, from the end of the given Line A, draw the Line AC, making any Angle; then from the other end of the given Line, which is at the Point B, draw the Line BD parallel to AC, (or make the Angle ABD equal to the Angle CAB;) then upon the Lines AC and BD, set off any three equal Parts (which is one less than the Number of Parts into which the Line 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 AB, shall divide it into four equal Parts as was required.



P R O B. VIII.

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

LET it be required to make a Triangle of the three Lines A, B, and C, (*fig. 20.*) the two shortest whereof, *viz.* A and B together, are longer than the third Line C.

First, draw the Line DE equal 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 HG; also take the given Line A in your Compasses, and placing one Foot in D, with the other describe the Arch KF, cutting the former Arch HG in the Point O. Lastly, if from the Point O, you draw the Lines OE and OD, you shall constitute the Triangle ODE, whose Sides shall be equal to the three given Lines A, B, C.

In like manner a Triangle l m n may be made equal to L M N, another given. *See Fig. 21.*

Also any rectilineal Figure a b c d e f g, equal to any other rectilineal Figure ABCDEFG, by making the Triangles a b g, b g f, b f e, b c e, c e d, respectively equal to the Triangles ABG, BGF, BFE, BCE, CED. *See Fig. 22.*

P R O B.

P R O B. IX.

Having a right Line given, how to make a Geometrical Square, whose Side shall be equal to the right Line given.

THE Line given is QR (*fig. 23.*) and it is required to make a Geometrical Square, whose Side shall be equal to the Line QR.

First, draw the Line AB, making it equal to the given Line QR; then (*by the first or second Problem*) upon the Point B, raise the Perpendicular BC, making the Line BC equal to the given Line QR also; then taking the Line QR in your Compasses, place one Foot in C, and with the other describe the Arch DE; also the Compasses so resting, place one Foot in A, and with the other describe another Arch FG, crossing the former in the Point H. Lastly, draw the Lines HC, and HA, which shall include the Geometrical Square ABCH.



P R O B. X.

Two right Lines being given, how to find a third right Line, which shall be in proportion unto them.

LET the two given Lines be A and B, (*fig. 24.*) and let it be 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 OP, and ON, making the Angle PON; 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 SD, and from the Point R draw the right Line RC parallel to SD; so shall OC be the third Proportional required. For,

As OS to OD; so is OR to OC.

8 12 12 18.

P R O B.

P R O B. XI.

Three right Lines being given, to find a fourth in Proportion to them.

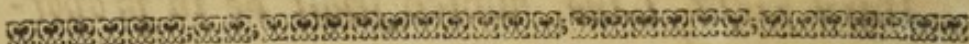
THE three Lines given are A B.C, (fig. 25.) unto which it is required to find a fourth proportional Line. *This is to perform the Golden Rule, or Rule of Three in Lines.*

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 Problem, the first and the third Terms (namely, the Lines A and C) must be set upon the same Line, as here upon 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.



P R O B. XII.

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, (fig. 26.) and it is required to divide the same into two Parts, which shall have 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 E B; then from the Point F draw the Line F G parallel to E B, cutting the given Line A B in the Point G; so is the

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 :: fo A F to A G.

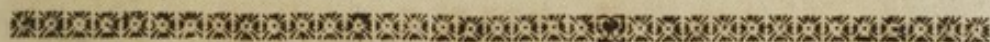
Arithmetically.

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, 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 :: fo F E to G B.

50 40 30 24



P R O B. XIII.

How to divide a Triangle into two Parts, according to any Proportion assign'd, by a Line drawn from any Angle thereof, and to lay the lesser Part towards any Side assigned.

LET A B C (*fig. 27.*) 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 *Problem* 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,

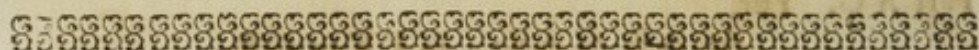
As the Line F is to the Line G;
So is the Triangle A D C to the Triangle A B D.

P R O B. XIV.

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

SUPPOSE the Base of the Triangle B C, (*fig. 27.*) 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) give? 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.



P R O B. XV.

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. Fig. 27.

LET the Triangle A B C 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.

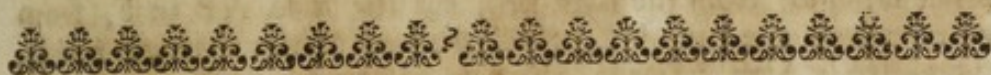
First, measure the whole Length of the Base, which suppose 40, then say, If 8 Acres (the Quantity of the whole Triangle) give 40, (the whole Base) what Parts of the Base shall 5 Acres give? Multiply and divide, the Quotient will be 25 for the greater Segment of the Base C D, which being deducted from 40 (the whole Base) there will remain 15 for the lesser Segment of the Base B D: then draw the Line A D, which shall divide the Triangle A B C according to the Proportion required.

P R O B. XVI.

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 A B C, (*fig. 28.*) 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 A E. 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.



P R O B. XVII.

To perform the foregoing Problem Arithmetically.

IT is required to divide the Triangle A B C (*fig. 28.*) from the Point E, into two Parts, in Proportion as 5 to 2.

First, divide the Base B C, 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 A B 31, give? Multiply and divide, the Quotient will be 15½, which lay from B to F; then from F, draw the Line F E, which shall divide the Triangle, according to the required Proportion.

P R O B. XVIII.

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 Acres, Roods, and Perches.

IN the foregoing Triangle ABC , (*fig. 28.*) whose *Area* or *Content* is 5 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 $\mathcal{B}$ and $\mathcal{R}$, so that $\mathcal{B}$ may have 3 Acres, 3 Roods thereof, and $\mathcal{R}$ may have 1 Acre and 2 Roods thereof.

First, reduce the Quantity of $\mathcal{R}$ (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 $\mathcal{R}$, 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 $\mathcal{R}$; then will the Trapezia $A FEC$ (which is the part belonging to $\mathcal{B}$, contain the Residue, namely, 3 Acres, 3 Roods.

But of this see more in the laying out of Lands.



P R O B. XIX.

How to divide a Triangle, according to any Proportion given, by a Line drawn parallel to one of the Sides given.

THE Triangle ABC (*fig. 29.*) is given, and it is required to divide the same into two parts, by a Line drawn parallel to the Side AC , which parts shall be in proportion one to the other, as the Line I is to the Line K .

First, (*by the 12th Problem*) divide the Line BC in E , in Proportion as I to K ; then (*by the 24th Problem following*) find a mean Pro-

proportional between BE and BC , which let 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 Triangle HFB , which are in proportion one to the other as the Line K is to the Line I .

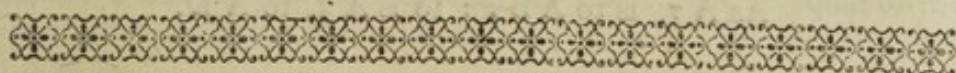


P R O B. XX.

To perform the foregoing Problem Arithmetically.

LET the Triangle be ABC (*fig. 29.*) and let it be required to dividethe fame 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 BC containing 54, be divided according to the Proportion given, so shall the lesser Segment BE contain 24, and the greater EC 30; then find out a mean proportional Line between BE 24, and the whole Base BC 54, by multiplying 54 by 24, whose Product will be 1296, the square Root whereof is 36, the mean Proportional sought, which is BF ; then through F draw a Line parallel to AC , and it is the Partition required; or else, by the Rule of Proportion say, If BC 54, give BF 36, what will AB 39 give? Answer, BH 26; therefore draw HF , and it is the Partition required.



P R O B. XXI.

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.

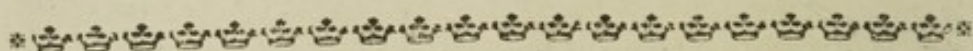
THE Triangle given is ABC , (*fig. 29.*) whose Quantity is 8 Acres, 0 Roods, 16 Perches; and it is required to divide the same (by a Line drawn parallel to the Side AC) into two parts, *viz.* 4 Acres, 2 Roods, 0 Perches, and 3 Acres, 2 Roods, 16 Perches.

G

First,

First, reduce both Quantities into Perches, *as is hereafter taught in the 28th Problem*) 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 Proportion between B E and B C, which Proportional is B F 36, of which 36 take the half, 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.

But of this see more in the laying out of Lands.



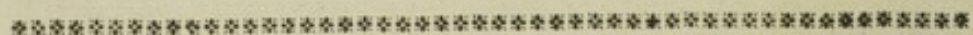
P R O B. XXII.

From a Line given, to cut off any Parts required.

THE Line given is A B, (*fig. 30.*) 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.



P R O B. XXIII.

To find a mean proportional between two Lines given.

IN Figure 31, let the two Lines given be A and B, between which it is required to find a mean proportional.

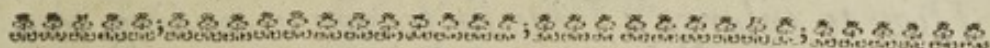
Let the two given Lines A and B be joined together in the point E, making one right Line, as C D, which divide into two equal parts in the point G, upon which point G, with the Distance G C or G D, describe the Semicircle C F D; then, from the point E, (where

(where the two Lines are joined together) raise the Perpendicular EF, cutting the Periferie of the Semicircle in F; so shall the Line EF be a mean Proportional between the two given Lines A and B. For,

As ED to EF :: fo EF to CD.

9 12 12 16

In Numbers, thus multiply the Numbers expressing the given Lines together, and extract the Square Root of the Product, which Root gives the Length of the mean Proportional sought.

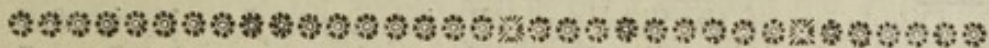


P R O B. XXIV.

How to find two Lines, which together shall be equal in power to any Line given, and in power the one to the other, according to any Proportion assigned.

IN Figure 31. let CD be a Line given, whose Power shall be equal to the Sum of the Powers of two sought lines, which shall be to one another as A to B.

First, divide the Line CD in the point E, in proportion as A to B, (*by the 12th Problem*) then divide the Line CD into two equal parts in the point G, and on G at the Distance GC or GD, describe the Semicircle CFD, and upon the point E, raise the perpendicular EF, cutting the Semicircle in F. Lastly, draw the Lines CF and DF, which together in power shall be equal to the power of the given Line CD, and yet in power one to the other as A to B.



P R O B. XXV.

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

First, divide the Line CD (*fig. 32.*) in the point E, in proportion as A to B; then divide the Line CD in two equal parts in the point G; and upon G, as a Center, at the Distance GD describe the Semicircle CFD, and on the point E raise the perpendicular EF, cutting the Semicircle in F; then draw the
Lines

Lines CF and DF , and produce the Line CF to H , till FH be equal to FD , and draw the Line HD and FK parallel thereunto: then shall the Line CD be divided in K , so that the Square of CK shall be to the Square of KD , as CE to ED , or as B to A .

P R O B. XXVI.

How to enlarge a Line in power according to any proportion assigned.

IN Fig. 32, let CE be a Line given, to be enlarged in power, as the Line B to the Line G .

First, (by the 12th Problem) find a Line in proportion to the given Line CE , as B is to G , which will be CD ; upon which Line describe the Semicircle CFD , and on the point E erect the perpendicular EF ; then draw the Line CF , which shall be in power to CE , as G to B .

P R O B. XXVII.

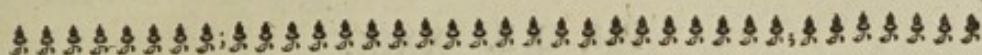
To enlarge or diminish a Plot given according to any Proportion required.

LET $ABCDE$ (fig. 33.) be a Plot given, to be diminished in Power as L to K .

Divide one of the Sides (as AB) in power as L to K , in such sort, that the power of AF , may be to the power of AB , 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 BC , to cut AC in G , as FG . Again, from G draw a parallel to DC , to cut AD in H . Lastly, from H draw a parallel to DE , to cut AE in I ; so shall the Plot $AFGHI$ be like $ABCDE$, and in proportion to it, as the Line K to the Line L , 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 AC and AD at length, also increase AF , and AI ; that done, enlarge AF in power as L to K , which set from A to B ,
then

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 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 Line L, which was required.



P R O B. XXVIII.

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. See Fig. 34.

IF it be required to make a Triangle, which shall contain 5 Acres, 2 Roods, 30 Perches, whose Base shall contain 50 Perches, you must first reduce your 5 Acres, 2 Rood, 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.

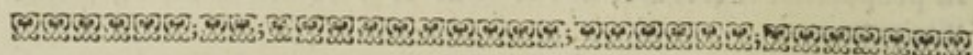
Now, to make a Triangle, which shall contain 910 Perches, and whose Base shall be 50 Perches, do thus; double the number of Perches given, namely, 910, and they make 1820; then, because the Base of the Triangle must contain 50 Perches, divide 1820 by 50, the Quotient will be 36½, which will be the Length of the Perpendicular of your Triangle. This done, from any equal Scale lay down the Line A B equal to 50 Perches; then upon B, raise the perpendicular B D equal to 36½ 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 and E B, including the Triangle A E B, which shall contain 5 Acres, 2 Roods, 30 Perches, which was required.

In like manner, if the Lines E B A B, and also the point E, were given in Position, and it be required to draw from E, the Line E A; so that the Triangle E A B may contain 910 Perches, and the nearest Distance of E from the Line B A be 36 Perches and ½; then divide 1820, the double of 910, and the Quotient 50

H

gives

gives the Length of B A ; therefore make B A 50 Perches, and draw E A, and so will the Triangle E A B contain as required.

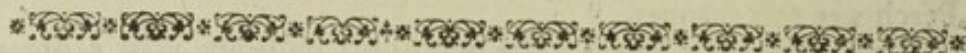


P R O B. XXIX.

How to reduce a Trapezia into a Triangle, by a Line drawn from any Angle thereof.

THE Trapezia given is A B C D, (*fig. 35.*) and it is required to reduce the same into a Triangle.

First, extend the Line D C, and draw the * Diagonal B D ; then from the point A draw the Line A E, parallel to B D, extending it till it cut the side C D extended, 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.



P R O B. XXX.

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 (*fig. 36.*) 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 ways to E and F, and farther if need require; and then from the point H, draw Lines to the Angles C and D, as the Lines H C 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.

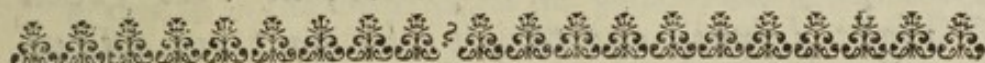
* A *Diagonal Line* is a Line drawn from any Angle of a Figure, to the opposite Angle of the same Figure.

P R O B. XXXI.

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

THE irregular Plot given is A B C D E, (*fig. 37.*) and it is required to reduce the same into a Triangle.

First, extend the Side A E both ways 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 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 A E 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.



P R O B. XXXII.

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

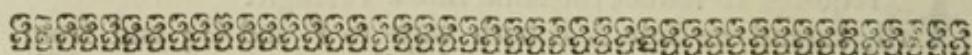
LET A B C D E F G, (*fig. 38.*) be an irregular Plot given, to be reduced into a Triangle.

I have chosen this Figure, where the Angles C and F are without the Field, because it often comes in practice, and hath not been taught by any to my knowledge.

First, draw the line B D, and parallel thereto the line C K; then if you draw the line B K, it will cut off from the Figure the Triangle D K S, and will take in the Triangle B C S equal therunto, and the side B K will supply the use of the two sides B C and C D. Also draw the line G E, and parallel thereto F L; then if you draw the line G L, it shall cut off from the Figure the Triangle L R E, and take in the Triangle G R F equal thereto, and the line or side G L will supply the use of the other two sides G F and F E, 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, into 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 Problem. First, produce the side D E of the given Figure, on both sides to H and M; then draw the lines A K and A L,

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 A 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 if the number of sides be never so many, yet this way of reduction will bring them to Triangles.



P R O B. XXXIII.

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; (*fig. 39.*) 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 lye towards the side A B.

First, (*by the 29th Problem*) 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 A B C D; 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 B E, 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. But, as in this Problem, so in all those that follow, we must continue that line on which the partition falls, in order to reduce it to a Triangle, otherwise this method of parting will not succeed.

¶ 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.

P R O B.

P R O B. XXXIV.

A Trapezia being given, how, from a point given 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 $ABCD$ (*fig. 40.*) 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 CD , and reduce the whole Trapezia into the Triangle HEF (*by the 29th Problem*); then divide the line EF in proportion as O to Q , which will fall in the point G ; therefore draw the line HG , which shall divide the Trapezia into two parts in proportion as O to Q , which was required.

In this, as in the foregoing, if the point G had fallen between C and E , the line AC must have been produced instead of DC ; and then the point G would have fallen between C and A .

P R O B. XXXV.

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

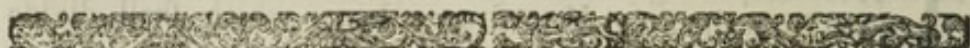
THE Trapezia given is $ABCD$, (*fig. 41.*) and it is required to divide the same into two parts, which shall be in proportion one to the other, as the line K is to the line L , and that the line of partition may be parallel to the side BD .

Consider first, through which side of the Trapezia the line of Partition will pass, as in this figure it will pass through the sides AB and CD (because parallel to BD); therefore extend the sides AB and CD , till they concur in E ; then (*by the 29th Problem*) reduce the Trapezia $ABCD$ into the Triangle BGD , whose Base is GD , which line GD divide in the point H in proportion as K to L ; so that,

As K to L :: So DH to HG .

This done, find a mean proportional between ED and EH, (*by the 23d Problem*) as ER. Lastly, through this point R, draw the line RF parallel to BD, 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 CA and DB must have been extended, but the rest of the work must be performed, as is before taught.



P R O B. XXXVI.

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 drawn from an Angle assigned.

LET the Figure ABCDE (*fig. 42.*) 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 ABCDE, into the Triangle BFG, (*by the 31st Problem*) so shall the line FG be the Base of a Triangle equal to the given Plot; then (*by the 12th Problem*) divide this line FG 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 GH to HF.

Lastly, draw the line BH, 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.

If H (in this work) falls between $\left\{ \begin{array}{l} D \text{ and } G \\ E \text{ and } F \end{array} \right\}$ then the Figure must be reduced to a Triangle, by producing $\left\{ \begin{array}{l} D C \\ A E \end{array} \right\}$ and so then G will fall between $\left\{ \begin{array}{l} D \text{ and } C \\ A \text{ and } E \end{array} \right\}$

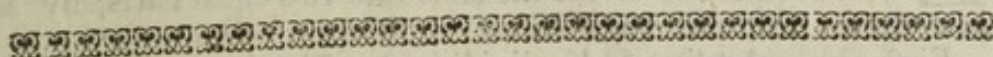
P R O B.

P R O B. XXXVII.

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 ABC , (*fig. 43.*) 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 DB ; then divide the side AC of the Triangle into five equal parts, as E, F, G and H ; and through each of those points, draw lines parallel to DB , as EM, FL, GK , and HI ; then from the point D , draw the lines DI, DK, DL , and DM , which shall divide the Triangle ABC into five equal parts from the point D , as was required.



P R O B. XXXVIII.

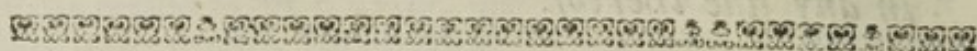
How to divide an irregular Plot of six sides, into two parts, according to any assigned proportion by a right line drawn from a point limited in any of the sides thereof.

THE irregular Plot given is $ABCDEF$, (*fig. 44.*) 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 HK , and (*by the 29th Problem*) reduce the Trapezia $ABFC$ into the Triangle HGK , then divide the Base thereof, namely, HK , into two parts in proportion as R to S , which will be in the point O ; then draw the line GO , which will divide the Trapezia $ABFC$ 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 29th Problem*) reduce the Trapezia $FCE D$ into the Triangle OLM , and divide the Base thereof, namely, LM in the point N , in proportion as R to S , and draw the line ON , which will divide the Trapezia $FCE D$ into two parts in proportion as R to S : and by this means is the whole Plot $ABCDEF$ divided into two parts in proportion as R to S , by the lines GO and ON . But it is required to resolve the

the Problem by one right line only drawn from the point G; therefore from the point G, draw the line G N, and through the point O, draw the point 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 R is to the line S.



P R O B. XXXIX.

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, (*fig. 45.*) 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 31st Problem*) 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 29th Problem*) reduce the Trapezia F C E D into the Triangle O L M, and divide the Base thereof L N into two equal parts in the Point P, and draw the Line O P, which will divide the Trapezia F C E D into two equal parts by the lines A O and O P: but to perform this Problem 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.*

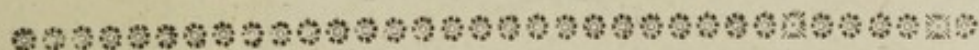
P R O B.

P R O B. XL.

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 $ABCD$ (*fig. 46.*) 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 BC and AD , till they concur in H ; then through the point E draw the line EI parallel to AH , till it meet with the line BH being extended to I ; then (*by the 29th Problem*) reduce the Trapezia $ABCD$ into the Triangle ABK , and from the point B let fall the perpendicular BZ ; then (*by the 12th Problem*) divide the Base of the Triangle AK into two parts, in proportion as F to G , which point of Division will fall in L . This done, find a fourth Line, which will be in proportion to these three Lines IE , HL , and HB , that is, as IE to HL : , so HB to HM , so is HM the fourth proportional; then (*by the 23d Problem*) find a mean proportional between the lines IH and HM , which is HN ; then set HN perpendicular upon BH , 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 EP , it shall divide the Trapezia $ABCD$ into two parts, which shall be in proportion one to the other, as the line F is to the line G .



P R O B. XLI.

From any Irregular Plot, to cut off therefrom any (possible) number of Acres, Roods, and Perches, and that by a strait Line drawn from any Angle of the Field.

LET $ABCDEFGH K$, (*fig. 47.*) be a Field given, containing 15 Acres and 14 Perches, and let it be required to cut off from the same Field 5 Acres and 12 Perches, and that by a right line drawn from the Angle C .

K

First,

First, reduce the 15 Acres, 14 Perches all into Perches (as is taught in the fourth Book) and they make 2414. Also reduce the 5 Acres and 12 Perches into Perches, and they make 812.

Secondly, from the Angle C draw a right line to any other Angle of the Field, which may seem most convenient for your Purpose, as to G, by which line C G, you have cut off a part of the Field, *viz.* the part C D E F G.

Thirdly, find (as is hereafter taught) how many Perches is contained in the Part cut off C D E F G, which suppose to be 700; but the part of the Field to be cut off should contain 812 Perches, too little by 112 Perches, and therefore the line C G is not the true line of Division, but is drawn too much towards the Angle F. Wherefore to find the true line of Division, you must,

Fourthly, measure the Length of the line C G (by the same Scale as you cast up your Plot by) and you shall find it to contain 36 Perches in Length, the half whereof is 18. By which divide 112 (the Difference before found) and the Quotient will be six Perches $\frac{2}{3}$ of a Perch. Wherefore,

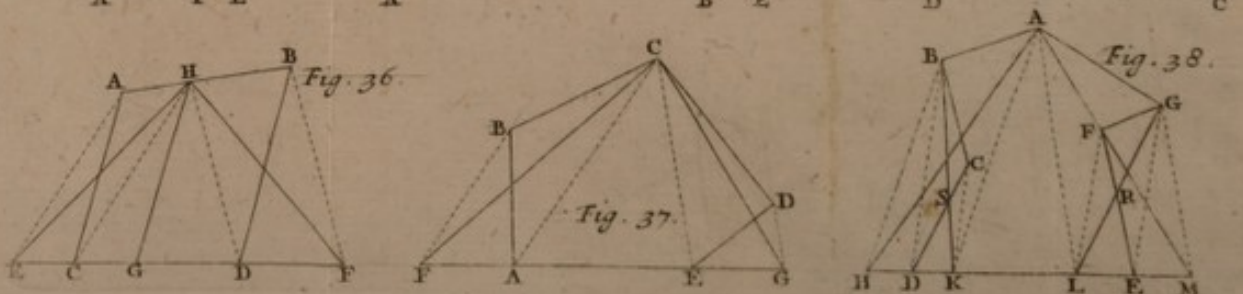
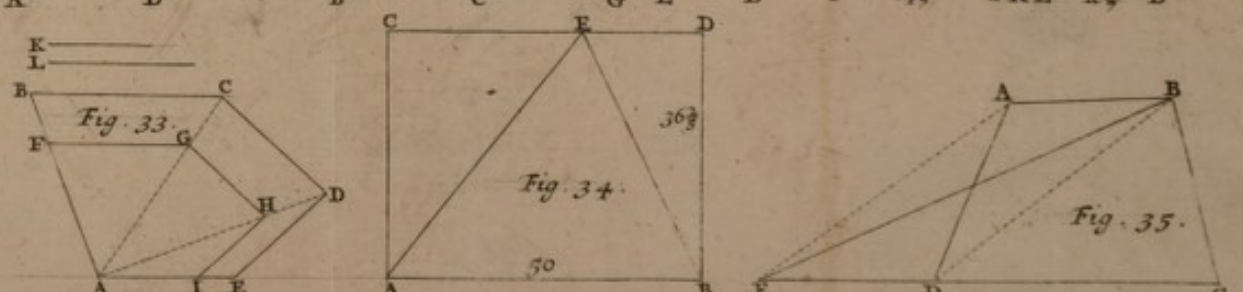
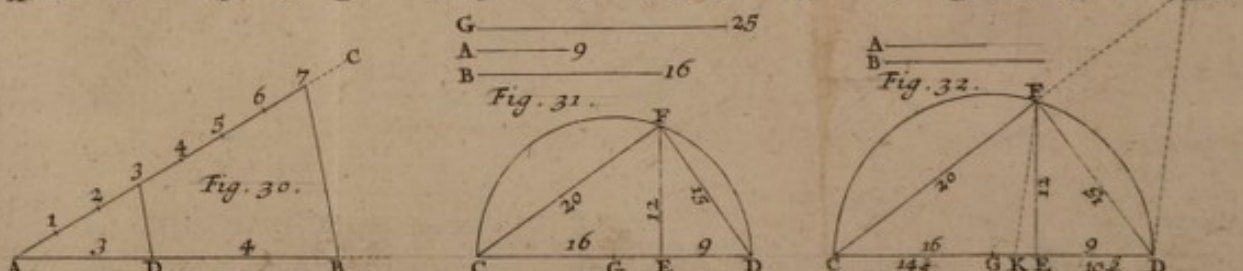
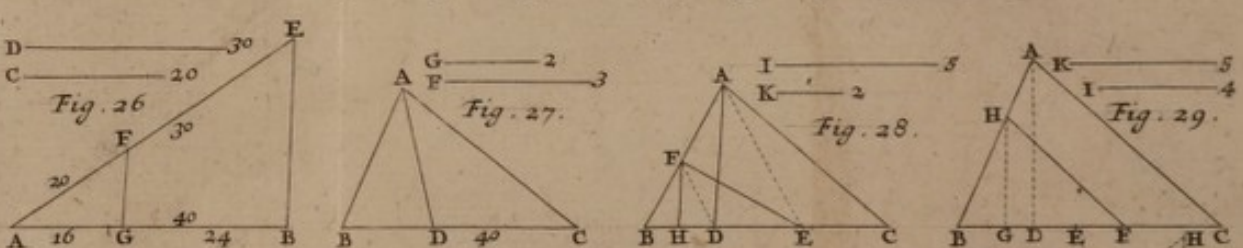
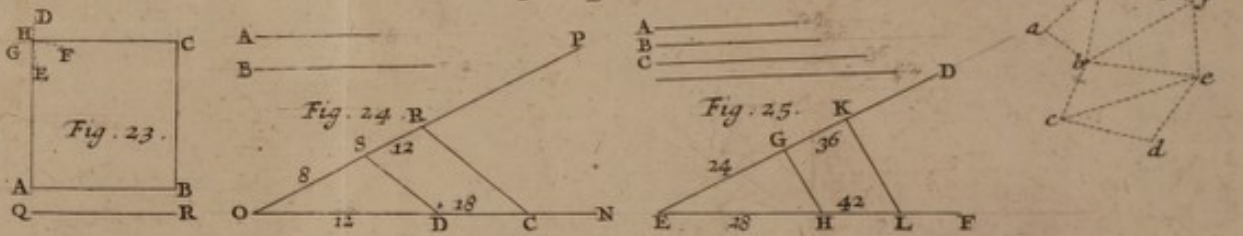
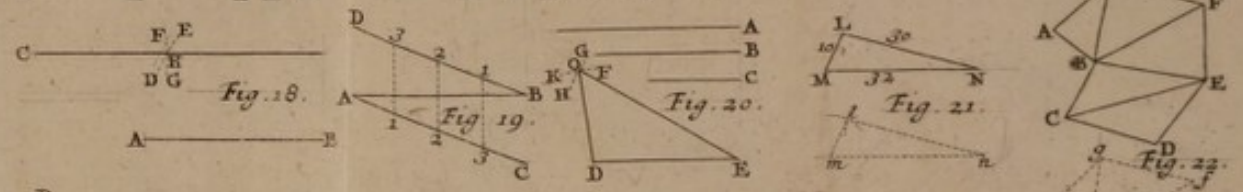
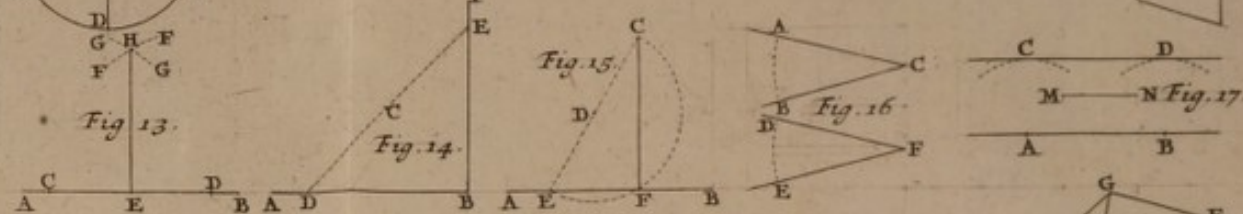
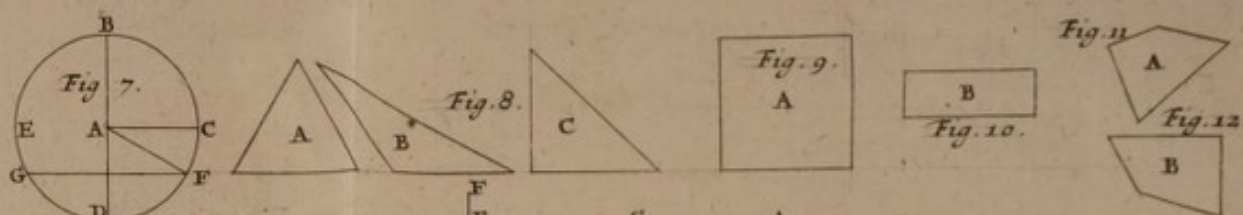
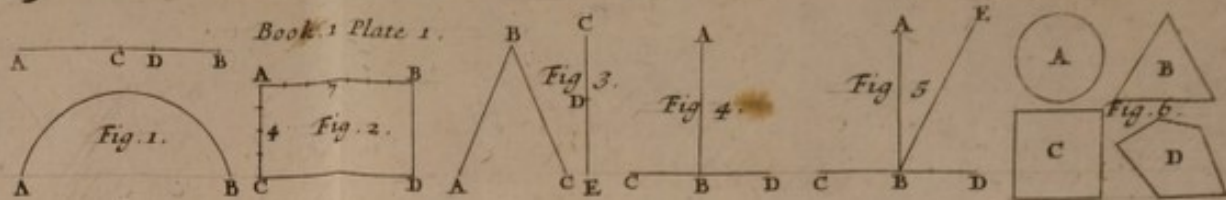
Fifthly, take 6 $\frac{2}{3}$ Perches from your Scale, and with what distance, from the points C and G, draw a line parallel to your first supposed line C G, as the line L O, cutting the side of the Plot H G in O.

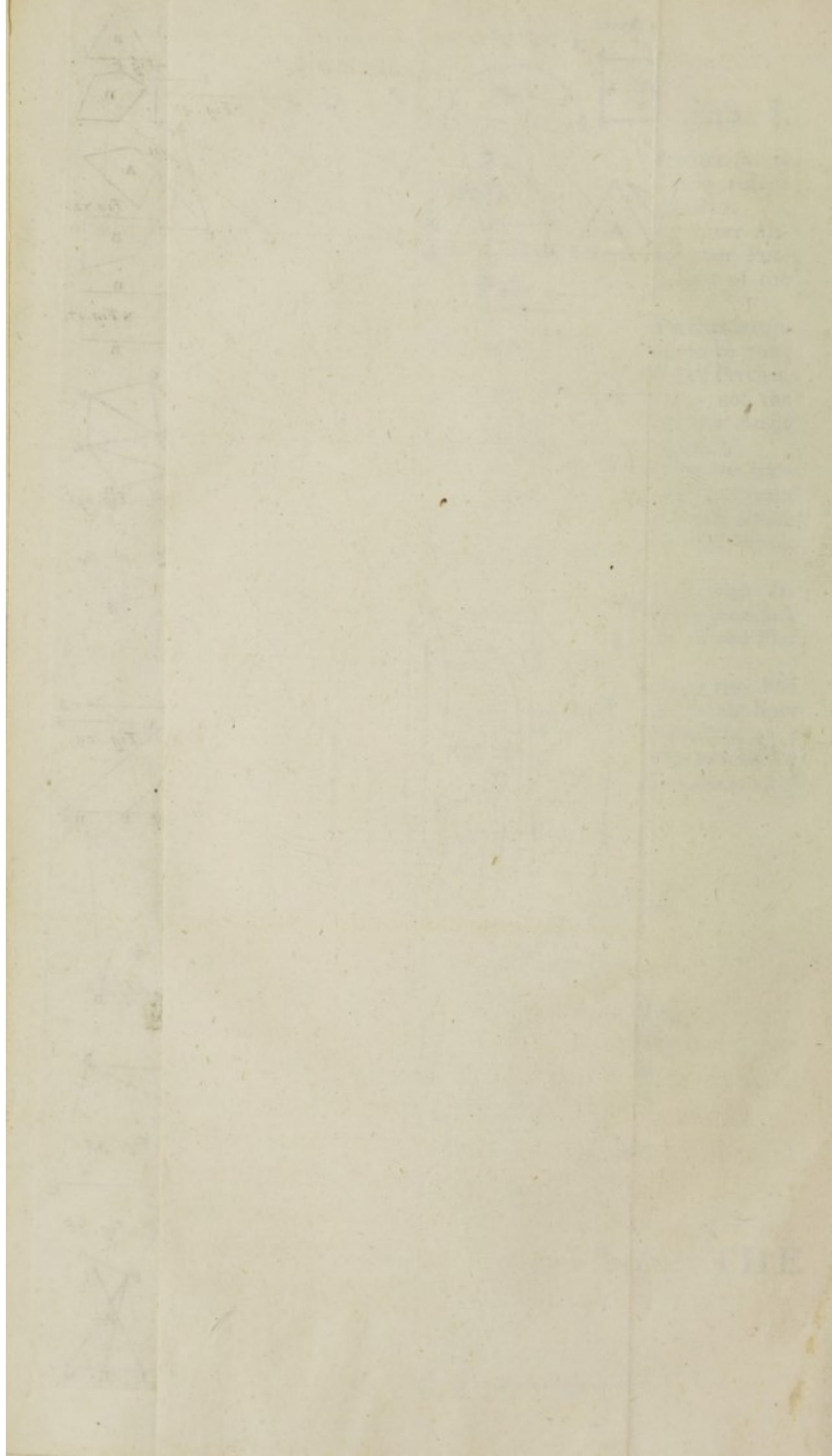
Lastly, draw the right line C O, and it shall be your true line of Separation. And so that part of the Plot inclosed by the lines C D, D E, E F, F G, and G O, shall contain 812 Perches, or 5 Acres and 12 Perches. And the other part of the Plot inclosed by the Lines C B, B A, A K, K H, and H O, shall contain 1602 Perches, or 10 Acres and 2 Perches.

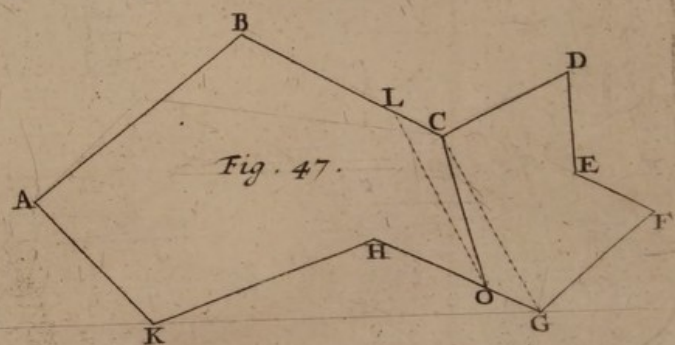
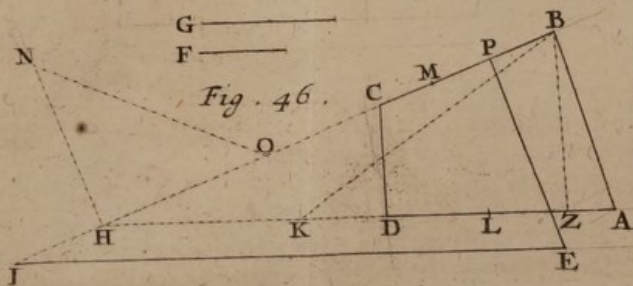
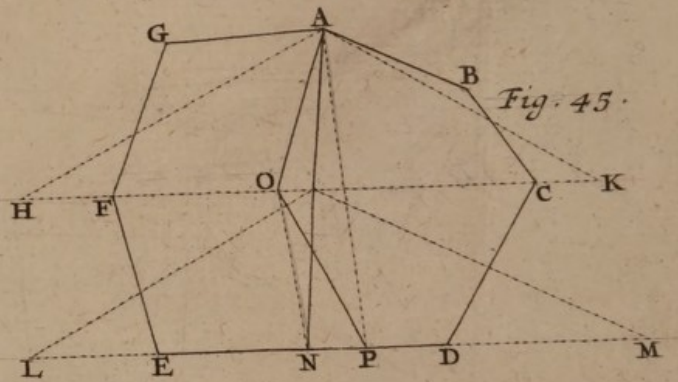
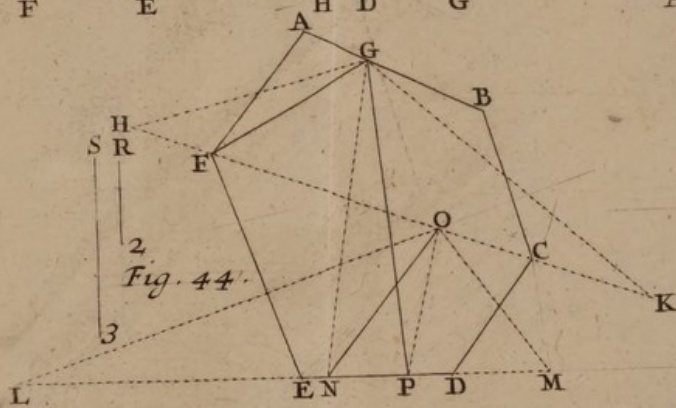
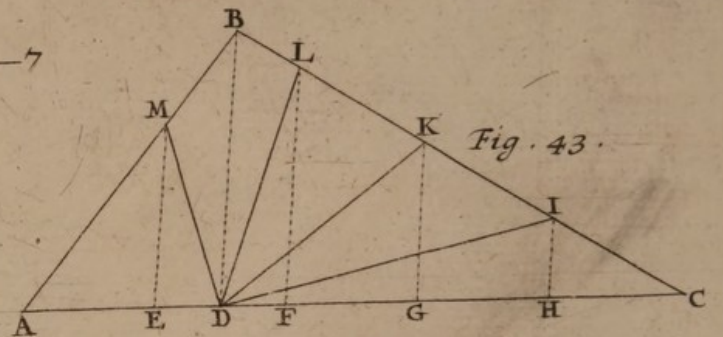
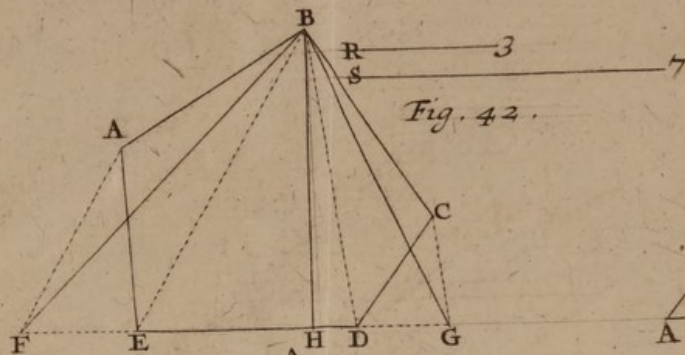
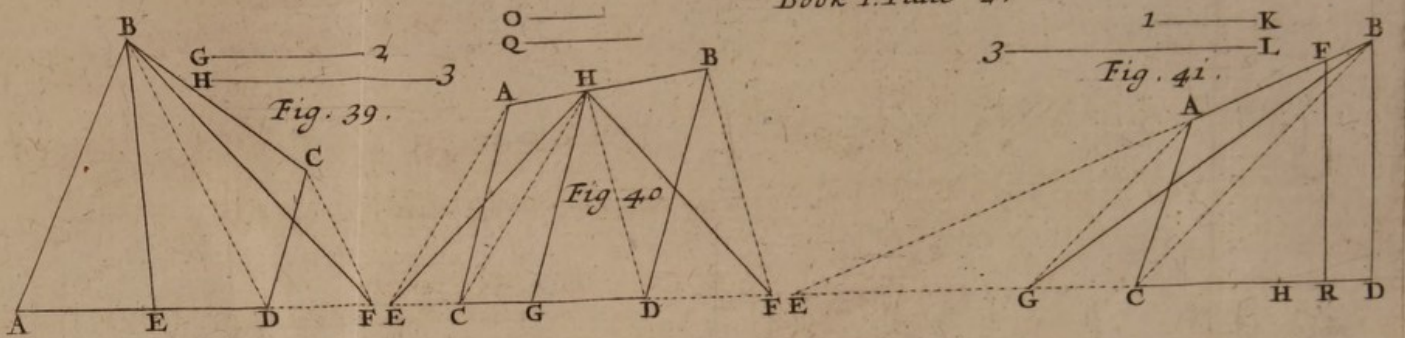
The End of the First Book.

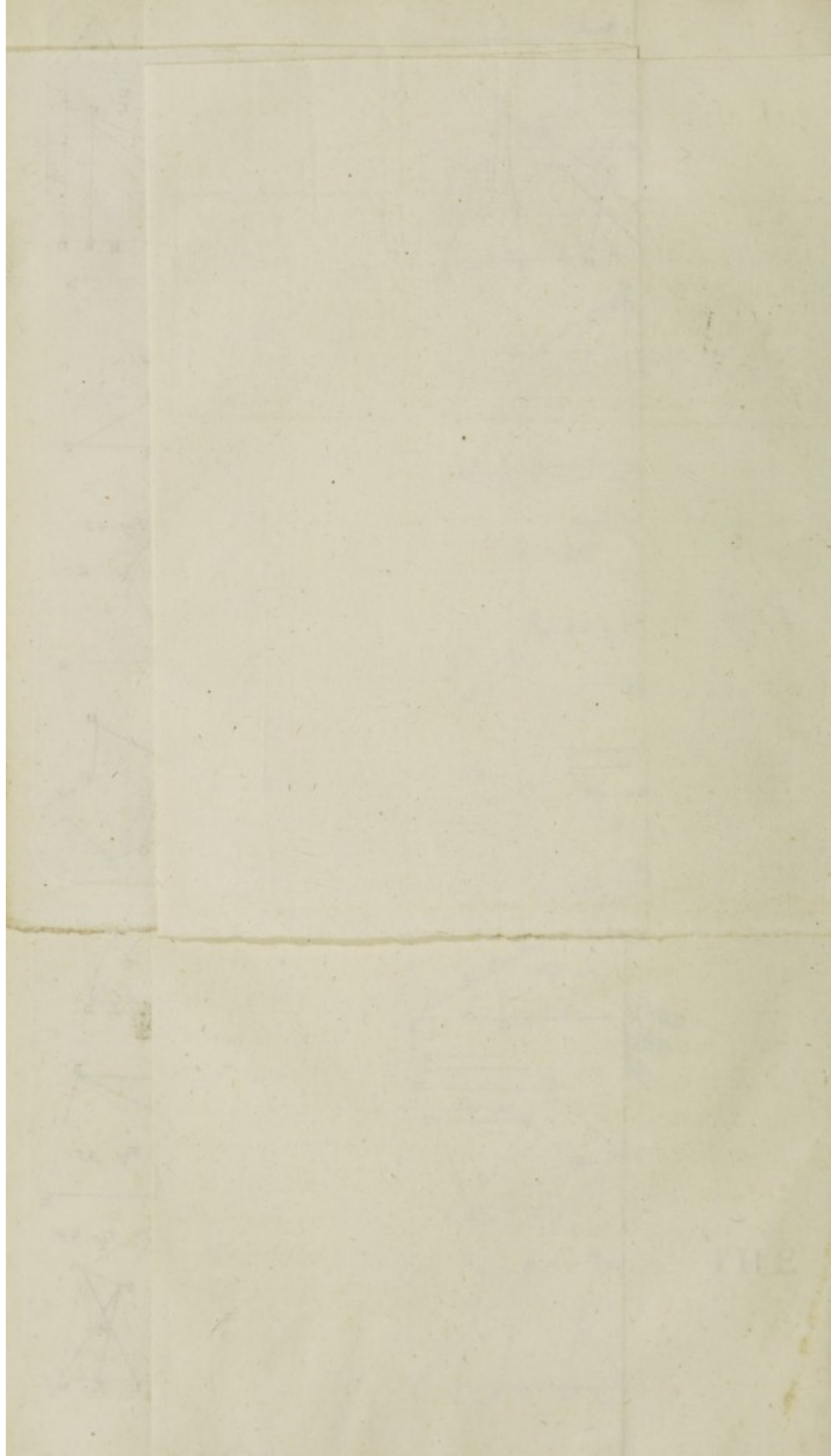


THE











The COMPLEAT
SURVEYOR.

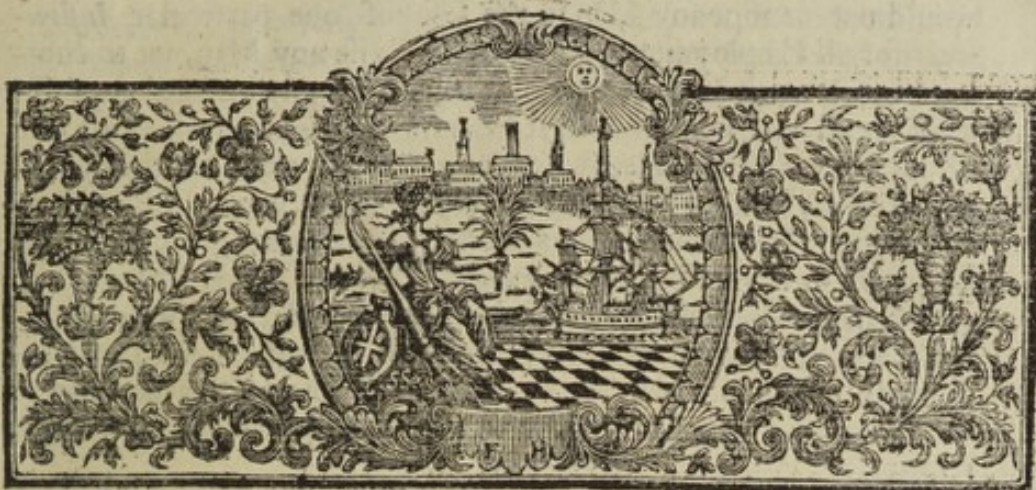
The Second BOOK.

The ARGUMENT.

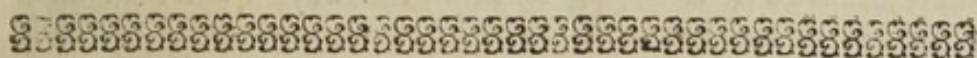


*I*N this Book is contained both a general and particular Description of all the most necessary Instruments belonging to Surveying, as the Theodolite, Circumferentor, and Plain Table, with all the Appurtenances thereunto belonging, as the Staff, Sockets, Screws, Index, Label, and other Necessaries. Now, 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 Plain Table, Theodolite, and Circumferentor are particularly described, as they have usually been made; I come to another Description of the Plain Table, and therein have shewed how
that

that Instrument may be order'd 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 only, as it is here contriv'd, with the same Ease, Dispatch, and Exactness, and in many respects better, as in chap. 1 doth plainly appear : so that this Instrument only is sufficient for all manner of Practices whatsoever. And besides the forementioned Instruments for Mensuration, there is described divers other Instruments belonging thereunto, as Chains, Scales, Protractors, and the like ; all which are describ'd and figur'd, according to the best Contrivance yet known. Unto these Instruments I have (in this Edition) added the Use of another Instrument very portable ; the which will perform with Exactness all the Uses that can be effected, either by Circumferentor, Theodolite, or Peractor. And whereas in the Description of the Plain Table, thus altered, I do commend it above all other, because indeed it comprehendeth, and performeth the Work of any other yet invented ; yet notwithstanding I do not enjoyn every Man to have his Instrument so absolute ; for that (for many Purposes) the Semicircle or Circumferentor is more convenient. And (in all Cases) the Perambulator, whose Description and Use is in this Edition added at the End of the Fourth Book, exceedeth them all, as in the Uses of it will appear.



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 particular Treatises, having been large in their Construction. To omit therefore the Description of the *Topographical Instrument* of Mr. Leonard Diggs, the *Familiar Staff* of Mr. John Blagrove, the *Geodetical Staff* and *Topographical Glafs* of Mr. Arthur Hopton, with divers other Instruments invented and 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

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would

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 Business, I would advise him to use the *Circumferentor*, *Theodolite*, or *Perambulator*, 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 my *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 of which I shall make use 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 describ'd 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 ever yet invented; so that having that one Instrument (made according to the following Direction) you shall have need of no other for the due, exact, and

The Plain Table used as the Theodolite.

speedy Performance of any thing belonging to the Art of Surveying. For the Frame of the Table being graduated according to that Description, it will be an absolute *Theodolite*, and perform the Work thereof with the same Facility and Exactness; and whatsoever may be done by the Limb of the *Theodolite*, the same the Degrees on the Frame of the Table will as well perform.

The Plain Table us'd as a Circumferentor.

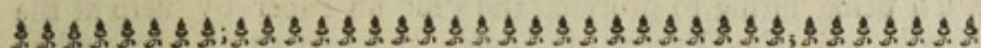
Likewise the Index and Sights, together with the Box and Needle, being taken from the Table, and screw'd to the Staff (as in the Description thereof it is so conveniently order'd) will be an absolute *Circumferentor*, and in some respects better than the ordinary one hereafter described, because the Sights thereof stand at a greater Distance, so that thereby the visual Line may be the better directed.

The Plain Table not one, but all Instruments.

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.

Besides,

Besides, there is another great Convenience, which doth ensue by the Degrees on the Table's 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 by the uses of these Instruments, severally, will appear. And what benefit a Surveyor, will receive by having all Instruments in one, I shall refer to himself to judge.



C H A P. II.

Of the Theodolite, the Description thereof, and the Detection of an Error frequently committed in the making thereof, with the manner how to correct the same.

THE *Theodolie* is an Instrument consisting of four Parts principally. The first whereof is a Circle, divided into 360 equal Parts, called Degrees, and each Degree subdivided 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 Brasses are about 12 or 14 Inches, and the Limb thereof Divided as aforesaid into 360 Degrees, and subdivided into other Parts by Diagonal Lines, drawn from the outmost, and inmost concentrick Circles of the Limb.

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.

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 distance.

The fourth part of this Instrument is a Socket, to be screwed on the back-side of the 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.

C H A P. III.

The Description of the Circumferentor.

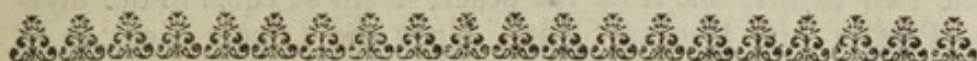
THIS Instrument, hath been much esteemed by many, for the Portability thereof, it being usually made to contain in Length about 8 Inches, in Breadth 4 Inches, and in Thickness about three Quarters of an Inch; one side whereof is divided into divers equal Parts, most fitly of 10 or 12 in an Inch; so that 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 turn'd 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 3, 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 clear 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 do belong two Sights, one double in Length to the other, the Longest Containing about 7 Inches, being placed and divided in all Respects, as those hereafter mentioned in the Description of *Plain Table*. On the Edge of the shorter Sight, toward the upper Part thereof, is placed a small Wire representing the Center of a Supposed Circle, the Semidiameter whereof is the Distance from the Wire, to the Edge of the Instrument underneath the same, which Parts are imaginarily divided into 60 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 Rular, at one end whereof is a little Hole to put it upon the Wire, on the Edge of the shorter Sight; and at other end of this Rular; is placed a small Sight, directly over the fiducial Edge thereof, which Edge is likewise divided according to those Divisions on the

the edge of the Instrument. To this short Sight is added a Plummets 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 Hypotenusal, to Horizontal Lines.



C H A P. 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, Peractor, Perambulator, or any other graduated Instrument, with the same ease and Exactness.

THE Table it self is a Parallelogram, containing in Length about 14 Inches and a half, and in Breadth 11 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 thereupon. This Frame must have upon it, near the inward Edge, 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 16 Inches or more, it being full as long as from Angle to Angle, of your Table: it ought to be about 2 Inches in Breadth, 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 12 Inches, the other 6. On the top of this shorter Sight is placed a Brass Pin, and also a Thread and Plummets to

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place

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 Wire 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 Long Sight, (through the whole Breadth 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 Hypotenusal Lines, of the same Square, as they increase by Units, and are likewise numbered upwards, and downwards, from the Line of Level, from 1 to 12, by 1, 2, 3, &c. Sometimes, signifying 101, 102, 103, &c. These Divisions shew how much any hypotenusal 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, upwards and downwards, by Fives and by Tens to 25: which Divisions, are called the Quadrant.

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

¶ According to this Description have *Plain Tables* formerly been made: But if unto it be added these additional Parts, and Alterations, (which make it less cumbersome, then before) it will be the most exact, absolute and universal Instrument for a Surveyor, 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 numbred from the left hand towards the right, (when

(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 Wind. 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 Rular 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 Thread above, and the other a Slit above, and a Thread 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 appear by Practice; for using these, you shall need (in going about a Field) to plant your Instrument but at every second Angle.

Thirdly, For the ready taking of Heights, and the reducing of the Hypotenusal to Horizontal Lines, of Hills, and in taking of Altitudes, (instead of the Divisions on the Sights before mention'd) let there be projected a Tangent Line along the side of the Rular, whose Divisions must touch the very Edge thereof; so that a Label or Rular of Box or Brass, 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 along the side of the Index. Then (the Instrument standing Horizontal) if you look thro' this small Sight, and by the Pin on which the Label hangeth, move the Label to and fro, till you espy the Mark you look at, then will the Label shew you what Degree of the Tangent-line is cut thereby. This one Line thus projected upon the side of the Rular, performeth all the Uses of those divided Sights, and is far better, and less cumbersome than 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 farthermost Sight, all along the Rular, to the foot of the nethermost Sight, and up the side thereof, and is numbered from 1 to 90, by 10, 20, 30, 40, 50, &c. ending at the foot of the farthermost Sight, from whence the line proceeded.

The use of this line of Tangents, in taking of Heights, is shewed in the fourth Book, and used with the Tables of Sines and Logarithms, treated of in the third Book; without which Tables, (or 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 are destitute of your Tables, these Lines will sufficiently help you.

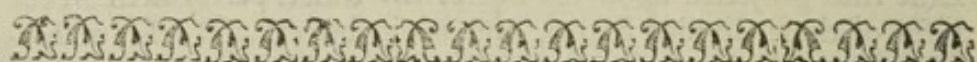
Now, when I come to shew you the Use of this Line of Tangents, with the Tables of Sines and Logarithms in the resolving of Triangles, I will also shew you how to perform the same Propositions

positions 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, and the Numbers and Sines back to back, on the same common Line.

Fourthly, Unto this Instrument also belongeth a Box and Needle, which is to be fasten'd 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, number'd (if you please) after the usual manner, from the North Eastward: But the Card, by which all the Examples in this Book were framed, was number'd from the North Westward, by 10, 20, 30, &c. to 360, contrary to the common Custom. But the best way of numbering will be from the North and South, towards the East and West, by 10, 20, 30, &c. to 90, at the East and West Points.

There belongeth also to this Instrument, a Socket of Brass, 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 joined in the middle, so that it may be the more portable. For the Socket it may be a plain one, or rather a Ball-socket; for by help thereof, you may place the Table (or any other Instrument) either Horizontal, Vertical, or in any other Position, without altering to Legs of your Staff when once set.

¶ *Note*, That the Instrument, (if made according to these Directions) is the most absolute Instrument for a Surveyor to use; a small Figure whereof, all the Parts thereof being put together, may be seen in the Diagram or Scheme, at the end of this Second Book annexed.



CHAP. VII.

Of Chains, the several Sorts thereof.

OF Chains 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 16; 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 Practices.

The Chains now used, and most esteemed by Surveyors, are especially two: Namely, that generally used by Mr. *Rathborn*, which hath every Perch divided into 100 Links; and that of Mr. *Gunter*, which hath four Poles divided into 100 Links; so that

that each Link of Mr. *Gunter's* Chain is as long as four of Mr. *Rathborn's*; and 50 Links of this Chain is two Pole, 25 one Pole, and 75 three Pole.

Now, because these Chains are most esteemed of and used by Surveyors, I will therefore make a general Description of them both, leaving every Man at liberty to take his choice.

I. Of Mr. *Rathborn's* Chain.

THE Chain which Mr. *Rathborn* ordinarily used (as himself saith) contained in length two Statute Poles or Perches, each Pole containing in length $16\frac{1}{2}$ Feet, which is 198 Inches: Then each Pole was divided into 10 equal parts, called *Primes*, every of which contained in length $19\frac{1}{2}$ Inches. Again, every of those *Primes* was subdivided into 10 other equal parts, called *Seconds*; so that every of these *Seconds* contained in length $1\frac{1}{2}$ Inches; so that the Pole, Perch, Unite, or Commencement (as he calleth it) was divided into 100 equal parts or Links, called *Seconds*.

This Chain being thus divided and marked, you have every whole Pole equal to ten *Primes*, or 100 *Seconds*; every three-quarters of a pole equal to seven *Primes* and an half, or 75 *Seconds*; every half Pole equal to five *Primes*, or 50 *Seconds*; and lastly every quarter of a Pole equal to two *Primes* and a half, or 25 *Seconds*.

II. Of Mr. *Gunter's* Chain.

AS every Pole of Mr. *Rathborn's* Chain was divided into 100 Links, so Mr. *Gunter's* whole Chain (which is always 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 $\frac{1}{4}$ of an Inch, and the whole Chain 792 Inches, or 66 Feet.

In measuring with this Chain, you are to take notice only of Chains and Links, as saying, such a line measured by the Chain, contains 72 Chains 48 Links; which you may express more briefly thus, 72, 48. And these are all the Denominations which are necessary to be taken notice of in surveying 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, so is the whole Chain by this divided into two equal Parts.

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

Thirdly, At every ten Links let be fasten'd a lesser Ring than the former : And lastly, at every fifth Link, (if you please) may be fasten'd 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. But it is very convenient, and I always use it, to tie at my middle Ring a good large Rag of some light-colour'd Cloth, and at the two other great Rings, two other lesser Rags of some other Colour ; for in long Grass, or the like, the Rings are not to be seen : And a great Advantage you'll find in your counting, by means of these Rags.

¶ Here *Note*, That in the Examples in this Book, the Lines are supposed to be measured by this four-Pole Chain of Mr. Gunter, it being the best of any other. The manner how to cast up the content of any Plot measured therewith, 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 miss a Chain or two in keeping your Account, from whence will ensue a considerable Error : Also in measuring of Distances, (when you go not along a Hedge side) you can hardly keep your Instrument, Chain, or Mark, in a right line, which if you do not, must necessarily make your measured Distance greater than in reality it is. For the avoiding 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 Chain stick one 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 farther 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 the right line or not, and accordingly guide those that carry the Chain, with the more exactness to direct it to the Mark intended. And, that

that no Mistakes may be made by those that carry the Chain, let them be made to understand (or look thereafter your self) the following Directions.

Directions for those that carry the Chain.

LET the former Man which leads the *Chain*, be sure to lead strait in a line from the Place where he that hath the other end of the *Chain* begins to measure, and the Work to which you are to measure, which for his Guide herein he hath these Helps: Suppose you were to measure from A to B. Let the hindermost Man standing at A, guide the foremost right in a Line to B; and at the first *Chain's* length, let the foremost prick down a Stick (or Wire) to which, when the hindermost cometh, let him take up: And all the way afterwards, let the hindermost guide the foremost, and the foremost the hindermost: For, if the hindermost see the foremost right in a Line between him and B, and the foremost see the hindermost in a right Line between him and A, then are they both in the right Line between A and B: Then, to go forward, let the fore-man take all the Ten Sticks, and tell them at the beginning and ending of every *Change*, (for the most common Mistake is, the loosing, or mis-telling of a Stick or Wire) and carry all of them, save one, in his left-Hand, and that one, and the *Chain's* end in his right-Hand; and let him go on in a strait line towards B, not looking behind him, till he feel the Chain check him; then stick down that Stick, and away as fast as you can; and as you go, shift another Stick, or Wire, into your right-Hand, to be ready to stick down at the *Chain's* end; in the mean time the hinder-Man holding the Chain in his Right-hand; let him look that it be not tangled, and go on till he come to the next Stick, and then clapping the end of the *Chain* to the Stick, let him take it up with the same Hand that he holds the *Chain* with, and away after his Leader: And when all the Ten Sticks are run out, and you are not yet at the end of that Station (that is, not come to B,) let the fore-Man run one *Chain* more, holding still the Ring in his Hand, and at the end thereof set his Toe, there standing still, and let the hinder-Man take up the tenth Stick, and hold that in one Hand, and the other nine in the other, and deliver the nine to the Fore-man, setting his Toe to the Fore-man's, and let the Fore-man count the Nine; and if they be right away forward, but if they be not, you must measure that Length again, and seek the Stick, for you know not which of you lost it; and thus go on to the End.

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: As also in the measuring of Tofts of Ground, Ground-plots of Houses, Yards, Gardens, &c. 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 the five Chains, 32 Links, by 66, the Product will be 35112, from which, cut off the two last Figures towards the Right-hand, with a Comma, then will the Number be 351, 12. which is 351 Feet, and $\frac{12}{100}$ parts of a Foot, or 351 Feet, one Inch and a half; and so many Feet are contained in five Chains, 32 Links.

Example I.

$$\begin{array}{r} 5,32 \\ 66 \\ \hline 3192 \\ 3192 \\ \hline 351,12 \end{array}$$

Example II.

$$\begin{array}{r} 9,05 \\ 66 \\ \hline 5430 \\ 5430 \\ \hline 597,30 \end{array}$$

But let the number of Chains be what they will, if the number of Links be less than 10, as in the second Example it is 9 Chains, 5 Links, you must place a Cypher before the 5 Links, as there you see, and then multiplying that Number (*viz.* 9, 05) by 66, the Product will be 59730, from which taking the two last Figures, there will remain 597 Feet, and $\frac{30}{100}$ parts of a Foot, which is 595 Feet, one quarter, and half of an Inch. 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 and Links, from five Links to eight Chains, for every fifth Link, which is sufficient for ordinary Use. By which Table you may see, that in 6 Chains 40 Links, is contained 422 Feet, and $\frac{40}{100}$ parts of a Foot: Also in five Chains 55 Links, is contained 366 Feet, and $\frac{55}{100}$ parts of a Foot: And so of any other.

A TABLE shewing how many Feet and parts of a Foot, are contain'd 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
6	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	524,70

To this Table I will add this useful and necessary Table of Mr. Gunter's enlarged, which sheweth how many square Inches, Feet, Yards, Paces, Chains, &c. are contained in a square Acre of Land.

		Length in							
Square.		Inch	Links	Feet	Yards	Pace	Perch	Cha	Mile
	Inch.	1	7.92	12	36	60	198	792	63360
	Links	62.726	1	1.515	4.56	7.575	25	100	8000
	Feet	144	2.295	1	3	5	16.5	66	5280
	Yard	1296	20.755	9	1	1.66	5.50	22	1760
	Pace	3600	57.381	25	2.778	1	3.3	13.2	1056
	Perch	39204	625	272.25	30.25	10.89	1.	4	320
	Chain	627264	10000	4356	484	174.24	16	1	80
	Acre	6272640	10000	43560	4840	1742.4	160	10	8
	Mile	4014489600	64000000	27878400	3097600	1115136	102400	6400	640

By this TABLE you may plainly discover, that

In one square Acre, there are contained	6272640	Square	Inches	And in a square Mile	4014489600	Inc.
	100000		Links		64000000	Lin.
	43560		Feet		27878400	Feet.
	4840		Yards		3097600	Yar.
	1742.4		Paces		1115136	Pac.
	160		Perch		102400	Perc.
	10		Chain		6400	Cha.
	1		Acre.		640	Acr.

CHAP. VIII.

Of Protractors.

(Fig. 1.)

A *Protractor* is an Instrument by which you are to protract or lay down upon Paper, Parchment, Velum, or the like, the true Symmetry or proportion of any Field, having made observation of the Sides and Angles thereof, by some of the Instruments before described.

I. Of the Common Protractor.

This Instrument consisteth 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 Semi-circle 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, or what other number you please.

The Scale being thus divided, on the middle of the line A B, as at H, describe the Semi-circle E G F, which divide into two Quadrants in the point G, by the help of the perpendicular H G; then divide each of those Quadrants into 90 equal parts, called Degrees; so shall the whole Semi-circle contain 180 Degrees, which must be num-

number'd 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 Semi-circle 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 sometimes 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 A B being taken for the Meridian in general, the Semi-circle of the *Protractor* may be turned any way, (either upward or downward) and so one Semi-circle being divided will be sufficient. Yet if any Man be desirous, he may have it made according to his own Fancy: But this manner of numbring (in my Opinion) is the best, it being most agreeable to your Instruments. But if you use the *Circumferentor*, *Theodolite*, or *Perambulator*, your *Protractor* were best to be a whole Circle, numbered like to your Instrument. And this numbring you are to take particular care of when you buy.

II. Of a Square Protractor.

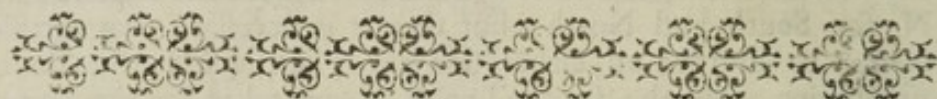
(Fig. 2.)

THE *Protractor* consisteth of a piece of thin Brass, in form of a rectangled *Parallelogram*, upon which, at the distance of half 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 Semi-circle in the other *Protractor* was numbred.

¶ Now, because that in protracting (many times) the Parallels will fall off your Paper or Parchment, so that you must add a piece thereto for the present, there is in the *Protractor*, the *Parallelogram* I M O L, cut quite out, that you may see your Work through; and either side of the narrow slip of Brass 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 far 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. The *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 other Uses in drawing your Plot, and is called a protracting Pin.



C H A P. IX.

Of Scales.

(Fig. 3.)

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 protracting of Lines; and *Secondly*, Of Chords, for the protracting of Angles. Unto these may be added, *Thirdly*, A Diagonal Scale, which is (indeed) no other than a Scale of equal 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 equal parts, 12 of which parts would make 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 than 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 long Plots; out of which you may very well take the hundredth 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

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.

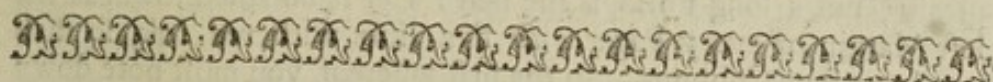
But if you would have the Scales to be answerable to your Chain, and to agree with the Divisions thereof, then you are to take notice, that

A Scale of	10	Pole in an Inch must be a Scale of	10	in 4 Inches, or	2½	in one Inch.
	11		11		2¾	
	12		12		3	
	16		16		4	
	20		20		5	
	24		24		6	
	30		30		7½	

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, Signs, 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, and Screws to alter the points, so that you may draw Lines or Circles with black Lead, or any colour'd Ink; which will be very necessary and convenient in beautifying of your Plots after Protraction.



CHAP. X.

Of several sorts of Cards, and their Divisions.

Fig. IV.

THE Card which I have always used in all the Examples in the Fourth Book, is that which is represented by the outmost Circle of Numbers, where the numbers of Degrees are continued from 1, to 360, numbered by 10, 20, 30, 40, &c. to 360. And this is a good and general Account.

For the *Circumferentor*, because those Instruments are (oftentimes) made small, and the *Cards* in them therefore but little, they use to divide those *Cards* but into 120 Parts or Degrees, each part of them containing three Degrees. And this is represented in the Figure by the innermost Circle of Numbers and Divisions, from 1, to 120.

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 smallness of the Instruments, and therefore must only be estimated as your Eye judgeth : Yet if your Instrument be large enough, you may have each Degree divided into three equal parts, so shall every part contain 20 Minutes ; or if every Degree be divided into four parts, each part will contain 15 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 find 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 suppose 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 that hath every Quadrant thereof divided into 90 Degrees, and numbered from *North* to *South*, towards *East* or *West*, then your four Columns will represent the four Quarters of the Card, namely, the *South-East*, *North-East*, *South-West*, and *North-West* ; and then you may have two other Columns also, one for the Degrees and Minutes, the other for the lengths of the Lines : The manner whereof you shall see in the *Fourth Book*, when we come to shew the manner of Surveying by way of Traverse.

But the last broad Column of the *Field-Book* here described, is to take notice of Objects as you pass along, that so you may express them in your Plot in their due Places ; as any House, Wind-mill, Water-mill, eminent Tree for directing the Road, or such-like : Also to write the Names of the Closes, or other Crouds butting and bounding upon that Survey : Likewise to make Marks, when you leave one Field and go to another, to know where to begin to Protract ; with many other things which will fall in your way in Practice, which shall be explained in the *Fourth Book*, where the Use of the *Field-Book* is exemplified at large.

C H A P. XII.

Of Instruments for reducing of Plots.

FOR the reducing of Plots from one Form to another, there have been divers Instruments invented. One that performeth that Work very well, is a Rular 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 thereof fitted to your proportion, will be very easy and exact. The manner of using it, and the way of proportioning of it, shall be shewed hereafter. This Instrument, tho' it be not general, yet it may be fitted to five or six several proportions, which for that purpose is sufficient.

Another Instrument for the performance of the Work, is a Parallelogram, the making whereof is well known to the Instrument-maker. It is general, exact, and of quick Dispatch: All the difficulty is in the neat handling of it, which you will find somewhat difficult.

The End of the Second Book.



The

Fig. I.

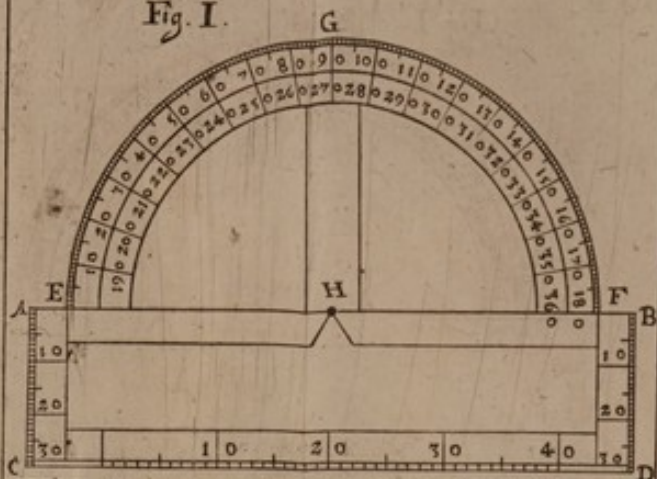


Fig. II.

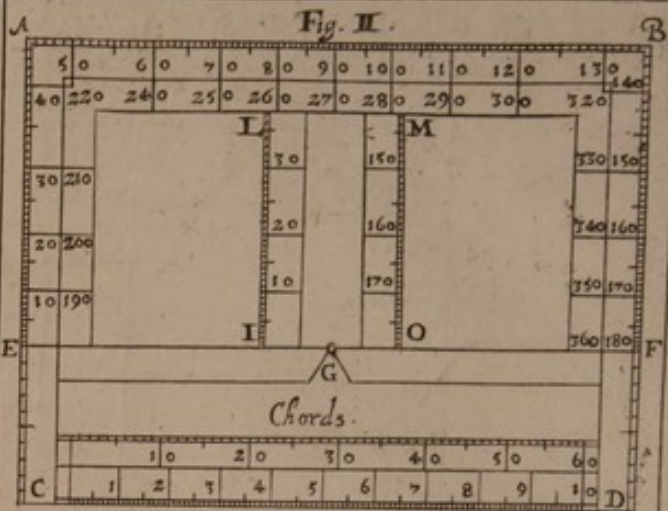


Fig. III.

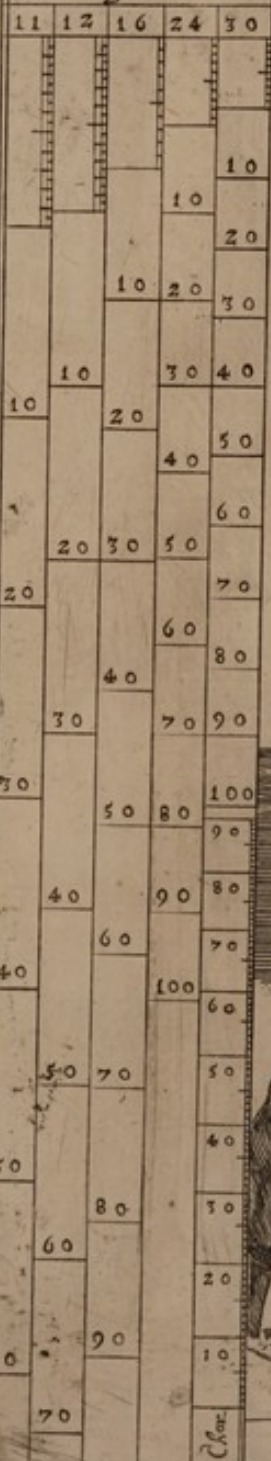


Fig.

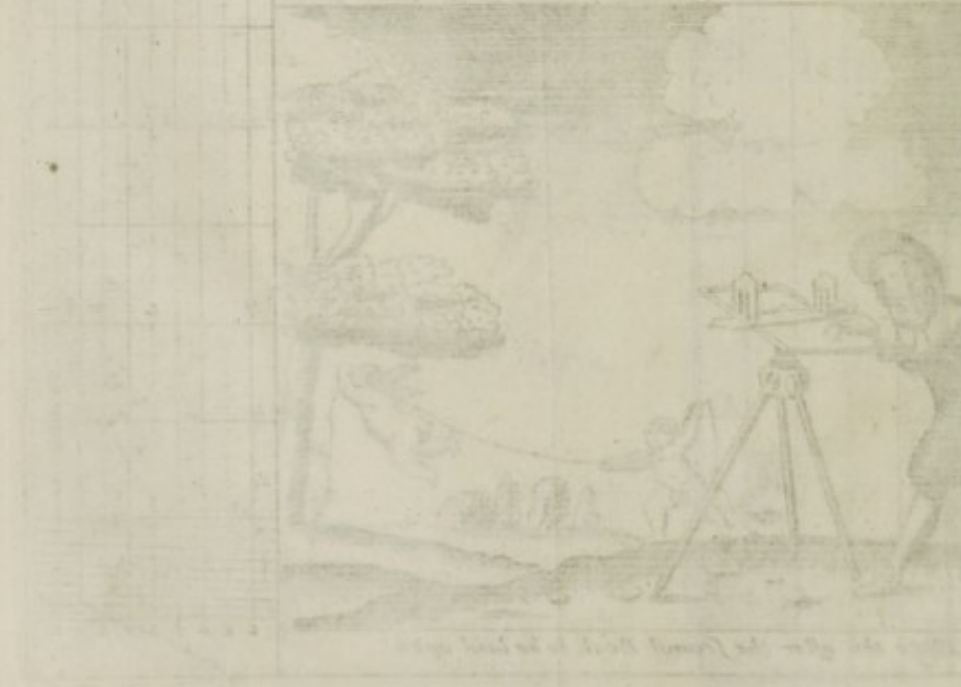
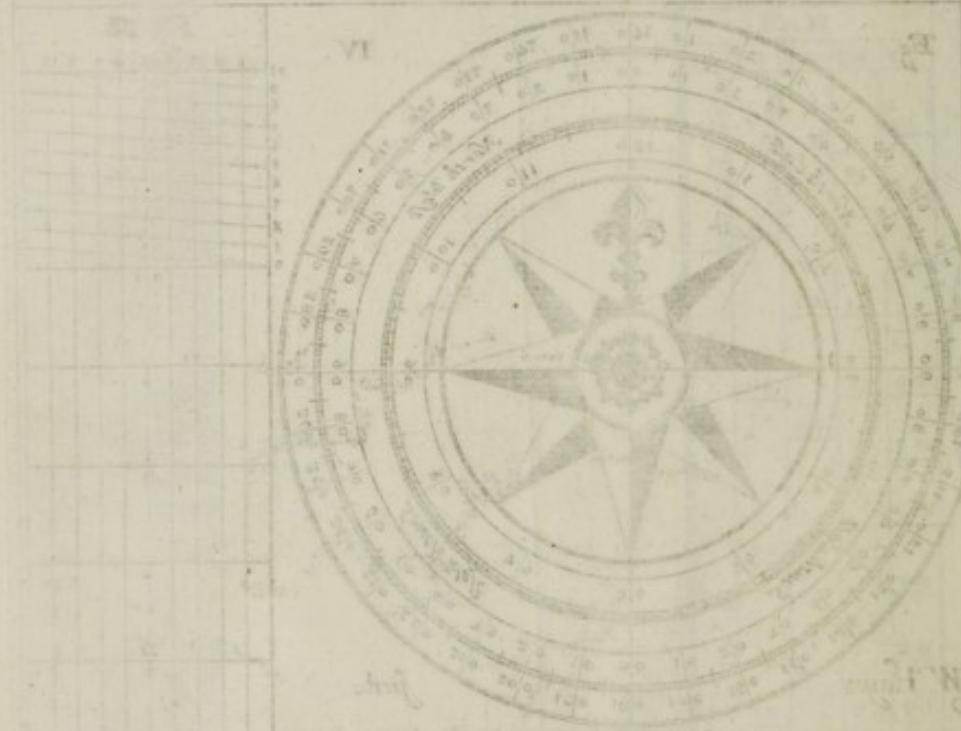
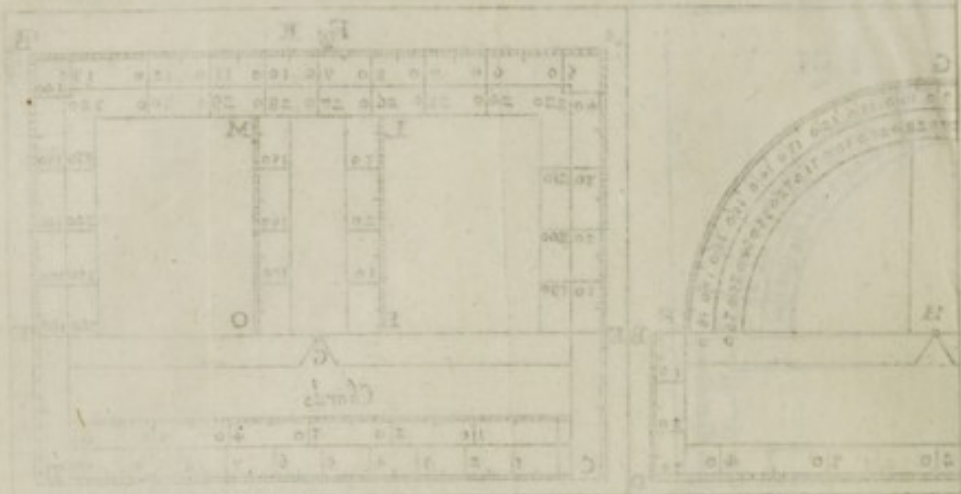


IV.

Fig. III.



Place this after the second Book to be laid open





The COMPLETE
SURVEYOR

The Third Book.

In Two Parts.

The ARGUMENT.



HIS Third Book is as it were a Key to those that follow, the Subject whereof is principally Trigonometry, or the measuring of Triangles. Now, forasmuch as the Art of measuring Heights and Distances, and plotting and protracting of Land, and all such-like lineal and superficial Dimensions, is 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 and Distances) to say something concerning Plain Triangles, (at least, so much as is necessary for a Surveyor to know) although that

Q

Subject

Subject be handled at large by divers able Mathematicians already, whose Works are extant, viz. Pitiscus, Snelius, the Lord Napier, Mr. Gunter, Mr. Norwood, Mr. Gellibrand, &c. Of which Subject I shall shortly have a Treatise extant, shewing the resolution of Triangles both Plain and Spherical, with the Application thereof in the practical parts of the Mathematicks, as in Geomecry, Astronomy, Navigation, Dialling, Fortification, &c. Now, because the readiest way of resolving Triangles, is by Sines, Tangents, and Logarithms; I have therefore added brief Tables for that purpose; viz. A Table of Sines and Tangents to every tenth minute of the Quadrant, and a Tale of Logarithms, from 1, to 1000. By which Tables may be resolved all Cases both in Right-lined and Spherical Triangles. But in this Place I have made choice only of such Cases, and other useful Problems, which are of most frequent use in the Practice of Surveying, omitting divers others to which these Tables are subservient. And of such as I have choice of. (in respect of the brevity of the Tables) I have shewed how they may also be performed 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; and therefore a Surveyor ought in no wise to be without them, but ought always, when he is employed in Surveying, to have either these Lines or the Tables at hand.



OF
TRIGONOMETRY.

The First PART.

Shewing the Use of the Tables, and *Lines of Artificial Sines, Tangents, and Logarithms*, in the Solution or Dimension of *Plain Triangles*, and in other useful Problems pertinent to the Art of *Surveying*.

CHAP. I.

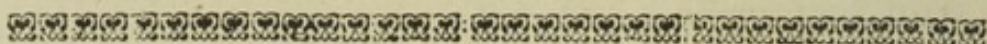
The Explanation and Use of the Table of SINES.



Efore I come to the mensuration of Triangles, and to the performance of other useful and necessary Problems in the Art of Surveying, it will be necessary to explain and shew the Use of the Tables of *Sines, Tangents, 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

The Table of *Sines* and *Tangents*, consisteth of twice three 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 and third Columns, are the Artificial *Sines* and *Tangents*, answering to every Degree and 10th Minute of the Quadrant, having the word *Sine* over the Head of the *Sines*, and the word *Tangent* over the Head of the *Tangents*. The Use of which Table will appear by the following *Propositions*.



P R O P. I.

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

First seek the Degree and Minute you desire the Sine or Tangent of, under *D. M.* the Degrees under the Letter *D.* and the Minutes under the letter *M.* and right against it, in the next Column towards the right Hand, under the word *Sine*, or *Tangent*, you shall have your Desire.

EXAMPLE I.

Suppose it were required to find the Sine and Tangent of 20 Degrees. First, You must seek 20 in the first Column of the Table under *D. M.* and right against 20, in the second Column, under the word *Sine*, you shall find 9, 534052, which is the Sine of 20 Degrees: And in the next Column under *Tangent*, you shall find 9, 56107, which is the Tangent 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; And the Tangent of 50 deg. to be 10, 07619; and the Tangent of 76 deg. to be 10, 60323.

EXAMPLE II.

Let it be required to find the Sine and Tangent 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.* that is, 40 under *D.* and 30 under *M.* and against it you shall find 9, 812544, which is the Sine; and 9, 93150, which is the Tangent of 40 degrees 30 minutes.

Also

Also the Sign of 62 degrees 10 minutes, will be found to be 9,946604; and the Tangent 10,27738. and the Sine of 86 degrees 30 minutes, will be 9,999189. and the Tangent 11,21351. And in this manner may you find the artificial Sine and Tangent of any Number of degrees and minutes expressed in the Table.

P R O P. II.

Any Sine or Tangent being given to find the number of Degrees and Minutes thereunto belonging.

E X A M P L E.

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 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 minutes, and that is the arch or degree belonging thereto.

Also, if the Tangent 9.60641 were given, the Degrees and minutes will be found to be 22 degrees: And 10.47969, will be found to be the Tangent of 71 deg. 40 min.

¶ But in case you have a number given which you cannot exactly find in the Table, you must then, instead thereof take the nearest in the Table: As if your Number given were 9,675359, if you look in the Table of Sines for this Number, it cannot be found there; but the nearest thereunto is 9,676328, which is the Sine of 28 degree, 20 minutes, which you must take instead thereof. But these Tables being only to every tenth minute, are of sufficient extent for any thing belonging to Surveying. Those that desire more exactness, must repair to such Books which have these Tables at large, of which there are divers in several Volumes eadie to be had.

R

The

The TABLE of Sines and Tangents.

D. M.	Sines.	Tang.	D. M.	Sines.	Tang.	D. M.	Sines.	Tang.
			8	09,143555	9,14786	16	09,440338	9,45750
10	7,463726	7,46373	10	09,152451	9,15688	10	09,444720	9,46224
20	7,764754	7,76476	20	09,161164	9,16577	20	09,449054	9,46694
30	7,940842	7,94084	30	09,169702	9,17450	30	09,453342	9,47160
40	8,065776	8,06581	40	09,178072	9,18306	40	09,457584	9,47622
50	8,162681	8,16274	50	09,186280	9,19146	50	09,461782	9,48080
1	08,241855	9,24192	9	09,194332	9,19971	17	09,465935	9,48534
10	8,308794	8,30888	10	09,202234	9,20782	10	09,466446	9,48984
20	8,366777	8,36690	20	09,209992	9,21578	20	09,474115	9,49430
30	8,417919	8,41087	30	09,217609	9,22361	30	09,478142	9,49872
40	8,463665	8,46385	40	09,225092	9,23130	40	09,482128	9,50311
50	8,505045	8,50527	50	09,232444	9,23887	50	09,486055	9,50746
2	08,542819	8,54308	10	09,239670	9,24632	18	09,489982	9,51178
10	8,577566	8,57788	10	09,246795	9,25365	10	09,493851	9,51606
20	8,609734	8,61010	20	09,253761	9,26086	20	09,497682	9,52030
30	8,639679	8,64009	30	09,260633	9,26797	30	09,501476	9,52452
40	8,667689	8,66816	40	09,267395	9,27496	40	09,505234	9,52870
50	8,693998	8,69453	50	09,274049	9,28186	50	09,508955	9,53285
3	08,718800	8,71940	11	09,280599	9,28865	19	09,512642	9,53697
10	8,742259	8,74292	10	09,287048	9,29535	10	09,516294	9,54106
20	8,764511	8,76525	20	09,293399	9,30195	20	09,519911	9,54512
30	8,785675	8,78649	30	09,299655	9,30846	30	09,523495	9,54915
40	8,805852	8,80674	40	09,305819	9,31488	40	09,527046	9,55315
50	8,825130	8,82610	50	09,311899	9,32122	50	09,530565	9,55712
4	08,843584	8,84464	12	09,317879	9,32747	20	09,534052	9,56107
10	8,861283	8,86243	10	09,323780	9,33365	10	09,537507	9,56498
20	8,878285	8,87952	20	09,329599	9,33974	20	09,540931	9,56887
30	8,894643	8,89508	30	09,335337	9,34575	30	09,544325	9,57274
40	8,910404	8,91185	40	09,340996	9,35170	40	09,547689	9,57658
50	8,925609	8,92716	50	09,346579	9,35757	50	09,551024	9,58039
5	08,940296	8,94195	13	09,352088	9,36336	21	09,554329	9,58418
10	8,954499	8,95627	10	09,357524	9,36909	10	09,557606	9,58794
20	8,968249	8,97013	20	09,362889	9,37476	20	09,560855	9,59168
30	8,981573	8,98358	30	09,368185	9,38035	30	09,564075	9,59540
40	8,994497	8,99622	40	09,373414	9,38589	40	09,567269	9,59909
50	9,007044	9,00930	50	09,378577	9,39136	50	09,570435	9,60276
6	09,019235	9,02162	14	09,383675	9,39677	22	09,573575	9,60641
10	9,031089	9,03361	10	09,388711	9,40212	10	09,576689	9,61004
20	9,042625	9,04528	20	09,393685	9,40742	20	09,579777	9,61364
30	9,053859	9,05666	30	09,398600	9,41266	30	09,582840	9,61722
40	9,064806	9,06775	40	09,403455	9,41784	40	09,585877	9,62079
50	9,075480	9,07858	50	09,408254	9,42297	50	09,588890	9,62433
7	09,085894	9,08914	15	09,412996	9,42805	23	09,591878	9,62785
10	9,096062	9,09947	10	09,417684	9,43308	10	09,594842	9,63135
20	9,105992	9,10956	20	09,422317	9,43806	20	09,597783	9,63484
30	9,115698	9,11943	30	09,426899	9,44299	30	09,600700	9,63830
40	9,125187	9,12909	40	09,431429	9,44787	40	09,603594	9,64175
50	9,134470	9,13854	50	09,435918	9,45271	50	09,606465	9,64517

The TABLE of Sines and Tangents.

D. M.	Sines.	Tang.	D. M.	Sines.	Tang.	D. M.	Sines.	Tang.
24	09,609313	9,64858	32	09,724210	9,79579	40	09,808067	9,92381
10	09,612148	9,65197	10	09,726225	9,79860	10	09,809569	9,92638
20	09,614944	9,65535	20	09,728227	9,80140	20	09,810061	9,92894
30	09,617727	9,65870	30	09,730216	9,80419	30	09,812544	9,93150
40	09,620488	9,66204	40	09,732193	9,80697	40	09,814019	9,93406
50	09,623225	9,66536	50	09,734157	9,80975	50	09,815465	9,93661
25	09,625948	9,66867	33	09,736109	9,81252	41	09,816943	9,93916
10	09,628647	9,67196	10	09,738048	9,81528	10	09,818392	9,94171
20	09,631326	9,67524	20	09,739975	9,81803	20	09,819832	9,94426
30	09,633984	9,67859	30	09,741889	9,82078	30	09,821264	9,94681
40	09,636623	9,68184	40	09,743792	9,82352	40	09,822688	9,94935
50	09,639242	9,68497	50	09,745683	9,82626	50	09,824104	9,95190
26	09,641842	9,68818	34	09,747562	9,82899	42	09,825511	9,95444
10	09,644423	9,69138	10	09,749429	9,83171	10	09,826910	9,95698
20	09,646984	9,69457	20	09,751284	9,83442	20	09,828301	9,95952
30	09,649527	9,69774	30	09,753128	9,83713	30	09,829683	9,96205
40	09,652052	9,70089	40	09,754960	9,83984	40	09,831058	9,96459
50	09,654558	9,70404	50	09,756781	9,84253	50	09,832425	9,96712
27	09,657047	9,70717	35	09,758591	9,84523	43	09,833783	9,96966
10	09,659517	9,71028	10	09,760390	9,84791	10	09,835134	9,97218
20	09,661970	9,71329	20	09,762177	9,85059	20	09,836477	9,97472
30	09,664406	9,71648	30	09,763954	9,85327	30	09,837812	9,97725
40	09,666824	9,71956	40	09,765720	9,85594	40	09,839140	9,97978
50	09,669225	9,72262	50	09,767474	9,85860	50	09,840459	9,98231
28	09,671609	9,72567	36	09,769219	9,86126	44	09,841771	9,98484
10	09,673977	9,72872	10	09,770952	9,86391	10	09,843079	9,98736
20	09,676328	9,73175	20	09,772675	9,86656	20	09,844372	9,98989
30	09,678663	9,73476	30	09,774388	9,86925	30	09,845662	9,99242
40	09,680982	9,73777	40	09,776090	9,87185	40	09,846944	9,99495
50	09,683284	9,74077	50	09,777781	9,87448	50	09,848218	9,99743
29	09,685571	9,74375	37	09,779463	9,87711	45	09,849485	10,00000
10	09,687842	9,74673	10	09,781134	9,87974	10	09,850745	10,00253
20	09,690098	9,74969	20	09,782796	9,88236	20	09,851997	10,00505
30	09,692339	9,75264	30	09,784447	9,88498	30	09,853242	10,00758
40	09,694564	9,75558	40	09,786088	9,88759	40	09,854480	10,01011
50	09,696774	9,75852	50	09,787720	9,89020	50	09,855710	10,01264
30	09,698970	9,76144	38	09,789342	9,89281	46	09,856934	10,01516
10	09,701151	9,76435	10	09,790954	9,89541	10	09,858150	10,01769
20	09,703317	9,76726	20	09,792557	9,89801	20	09,859360	10,02022
30	09,705469	9,77015	30	09,794149	9,90060	30	09,860562	10,02275
40	09,707606	9,77303	40	09,795733	9,90320	40	09,861757	10,02528
50	09,709730	9,77591	50	09,797307	9,90578	50	09,862946	10,02781
31	09,711839	9,77877	39	09,798872	9,90837	47	09,864127	10,03034
10	09,713935	9,78163	10	09,800427	9,91095	10	09,865302	10,03288
20	09,716013	9,78448	20	09,801972	9,91353	20	09,866470	10,03541
30	09,718085	9,78732	30	09,803510	9,91610	30	09,867631	10,03795
40	09,720140	9,79015	40	09,805038	9,91868	40	09,868785	10,04048
50	09,722181	9,79297	50	09,806557	9,92125	50	09,869933	10,04302

The TABLE of Sines and Tangents.

D. M.	Sines.	Tang.	D. M.	Sines.	Tang.	D. M.	Sines.	Tang.
48	09,871073	10,045565	56	09,918574	10,171046	64	09,953660	10,31182
	109,872208	10,04810		109,919424	10,17374		109,954274	10,31503
	209,873335	10,05065		209,920268	10,17648		209,954883	10,31826
	309,874456	10,05319		309,921107	10,17922		309,955488	10,32150
	409,875571	10,05574		409,921940	10,18196		409,956088	10,32476
	509,876678	10,05829		509,922768	10,18412		509,956684	10,32804
49	09,877780	10,06084	57	09,923591	10,18748	65	09,957276	10,33133
	109,878875	10,06339		109,924409	10,19025		109,957862	10,33463
	209,879963	10,06594		209,925222	10,19303		209,958445	10,33796
	309,881045	10,06850		309,926029	10,19581		309,959023	10,34130
	409,882121	10,07106		409,926831	10,19860		409,959596	10,34465
	509,883191	10,07362		509,927628	10,20140		509,960165	10,34803
50	09,884254	10,07619	58	09,928420	10,20421	66	09,960730	10,35142
	109,885311	10,07875		109,929207	10,20703		109,961290	10,35483
	209,886361	10,08132		109,929989	10,20985		209,961846	10,35825
	309,887406	10,08390		309,930766	10,21268		309,962398	10,36170
	409,888444	10,08647		409,931537	10,21552		409,962945	10,36516
	509,889476	10,08905		509,932304	10,21837		509,963488	10,36865
51	09,890503	10,09163	59	09,933066	10,22123	67	09,964026	10,37215
	109,891522	10,09422		109,933822	10,22409		109,964560	10,37567
	209,892536	10,09680		209,934574	10,22697		209,965090	10,37921
	309,893544	10,09939		309,935320	10,22985		309,965615	10,38278
	409,894546	10,10199		409,936062	10,23278		409,966136	10,38636
	509,895542	10,10459		509,936799	10,23565		509,966653	10,38996
52	09,896532	10,10719	60	09,937531	10,23856	68	09,967166	10,39359
	109,897516	10,10980		109,938257	10,24148		109,967674	10,39724
	209,898494	10,11241		209,938980	10,24442		209,968178	10,40091
	309,899467	10,11502		309,939697	10,24736		309,968678	10,40460
	409,900433	10,11764		409,940409	10,25031		409,969173	10,40832
	509,901391	10,12026		509,941116	10,25327		509,969665	10,41206
53	09,902349	10,12289	61	09,941819	10,25625	69	09,970152	10,41582
	109,903298	10,12552		109,942517	10,25923		109,970634	10,41961
	209,904241	10,12815		209,943210	10,26223		209,971112	10,42342
	309,905179	10,13079		309,943898	10,26524		309,971588	10,42726
	409,906111	10,13344		409,944582	10,26825		409,972058	10,43113
	509,907037	10,13609		509,945261	10,27128		509,972524	10,43502
54	09,907958	10,13874	62	09,945935	10,27433	70	09,972986	10,43893
	109,908873	10,14140		109,946604	10,27738		109,973443	10,44288
	209,909782	10,14406		209,947269	10,28044		209,973897	10,44685
	309,910686	10,14673		309,947929	10,28352		309,974346	10,45085
	409,911584	10,14941		409,948584	10,28671		409,974792	10,45488
	509,912477	10,15209		509,949235	10,28972		509,975283	10,45894
55	09,913364	10,15477	63	09,949881	10,29283	71	09,975670	10,46303
	109,914246	10,15747		109,950522	10,29596		209,976103	10,46715
	209,915123	10,16016		209,951159	10,29911		209,976532	10,47130
	309,915994	10,16287		309,951791	10,30226		309,977056	10,47548
	409,916859	10,16558		409,952411	10,30543		409,977577	10,47969
	509,917719	10,16829		509,953042	10,30862		509,977794	10,48394

The TABLE of *Sines* and *Tangents*.

D. M	Sines.	Tang.	D. M.	Sines.	Tang.	D. M	Sines.	Tang.
72 0	9,978206	10,48822	78 0	9,990404	10,67253	84 0	9,997614	10,97838
10	9,978615	20,49254	10	9,990671	10,67878	10	9,997732	10,99070
20	9,979019	10,49689	20	9,990935	10,68512	20	9,997873	11,00338
30	9,979419	10,50128	30	9,991193	10,69154	30	9,997996	11,01642
40	9,979816	10,50570	40	9,991448	10,69805	40	9,998106	11,02987
50	9,980208	10,51016	50	9,991699	10,70465	50	9,998232	11,04373
73 0	9,980597	10,51466	79 0	9,991947	10,71135	85 0	9,998344	11,05893
10	9,980980	10,51920	10	9,992190	10,71814	10	9,998453	11,07284
20	9,981361	10,52378	20	9,992430	10,72504	20	9,998558	11,08815
30	9,981737	10,52839	30	9,992666	10,73203	30	9,998659	11,10402
40	9,982109	10,53305	40	9,992898	10,73915	40	9,998757	11,12047
50	9,982477	10,53776	50	9,993127	10,74635	50	9,998851	11,13757
74 0	9,982842	10,54250	80 0	9,993351	10,75368	86 0	9,998941	11,15536
10	9,983202	10,54729	10	9,993572	10,76113	10	9,999027	11,17390
20	9,983558	10,55213	20	9,993789	10,76870	20	9,999110	11,19326
30	9,983910	10,55701	30	9,994003	10,77639	30	9,999189	11,21351
40	9,984259	10,56194	40	9,994212	10,78422	40	9,999265	11,23475
50	9,984603	10,56692	50	9,994418	10,79218	50	9,999336	11,25708
75 0	9,984943	10,57195	81 0	9,994620	10,80029	87 0	9,999404	11,28060
10	9,985280	10,57703	10	9,994818	10,80854	10	9,999469	11,3054
20	9,985613	10,58216	20	9,995012	10,81694	20	9,999529	11,33184
30	9,985942	10,58734	30	9,995203	10,82550	30	9,999586	11,35991
40	9,986266	10,59258	40	9,995390	10,83423	40	9,999640	11,38990
50	9,986587	10,59788	50	9,995573	10,84312	50	9,999689	11,42212
76 0	9,986904	10,60323	82 0	9,995753	10,85220	88 0	9,999735	11,45692
10	9,987217	10,60864	10	9,995928	10,86146	10	9,999778	11,49473
20	9,987526	10,61411	20	9,996100	10,87091	20	9,999816	11,53615
30	9,987832	10,61965	30	9,996269	10,88057	30	9,999851	11,58193
40	9,988133	10,62524	40	9,996433	10,89044	40	9,999882	11,63310
50	9,988430	10,63091	50	9,996594	10,90053	50	9,999910	11,69112
77 0	9,988724	10,63664	83 0	9,996751	10,91086	89 0	9,999934	11,77508
10	9,989014	10,64243	10	9,996904	10,92142	18	9,999954	11,83726
20	9,989299	10,64830	20	9,997053	10,93225	20	9,999971	11,93419
30	9,989582	10,65428	30	9,997199	10,94334	30	9,999983	12,05914
40	9,989860	10,66026	40	9,997341	10,95472	40	9,999993	12,23524
50	9,990134	10,66635	50	9,997480	10,96639	50	9,999998	12,5362
						90 0	10,000000	Infinite.

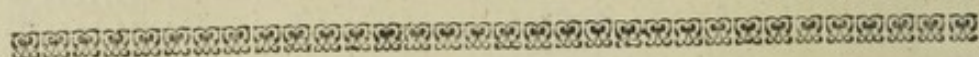
CHAP. II.

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 an Unit, from 1 to 1000.

In the other Columns are placed the *Logarithms* of those absolute Numbers.

By this Table the *Logarithm* of any absolute Number under 1000 may be readily found: Or if any *Logarithm*, 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.

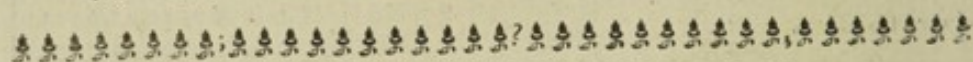


PROP. I.

A Number being given, to find the Logarithm thereof.

LET it be required to find out 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 Logarithm being given, how to find the absolute Number thereunto belonging.

LET 2,731589, be a *Logarithm* given, whose absolute Number you may require. You must first seek this Number in the second Column of the Table, under the word *Logarithm*, against which you shall find 539, which is the absolute Number answering to that *Logarithm*.

¶ 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	105	2,017033
5	0,698970	55	1,740363	106	2,021189
6	0,778151	56	1,748188	104	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	2,063078
14	1,146128	64	1,806180	114	2,056095
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	1,431365	77	1,886491	127	2,103804
28	1,447158	78	1,892095	128	2,107209
29	1,462398	79	1,897267	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	2,164352
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	101	2,303196	251	2,399674
152	2,181844	202	2,305351	252	2,401401
153	2,184691	203	2,307496	253	2,303101
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	1,195899	207	2,315970	257	2,409933
158	2,198657	208	2,318063	258	2,411619
159	2,201397	209	2,210146	249	2,413299
160	2,204119	210	2,322219	260	2,414973
161	2,206826	211	2,324282	251	2,416641
162	2,209515	212	2,326336	262	2,418301
163	1,212187	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	216	2,336459	267	2,426411
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	1,344392	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
175	2,243038	225	2,352183	275	2,449333
176	2,245513	226	2,354108	276	2,440999
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	2,457889
188	1,274158	238	2,376577	288	2,459392
189	2,276462	239	2,378398	289	2,460898
190	2,278754	240	2,380211	290	2,365393
191	2,281083	241	2,382017	291	2,463893
192	2,283301	242	2,383815	292	2,465398
193	2,285557	243	2,385606	293	2,466868
194	2,287802	244	2,387389	294	2,468347
195	2,290035	245	2,389166	205	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	3,396199	289	2,475671
200	2,301029	250	2,397940	300	2,477121

The TABLE of *Logarithms*.

<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>
301	2.478566	351	2.545307	401	2.603144
302	2.480007	352	2.546543	409	2.604226
303	2.481443	353	2.547775	403	2.605305
304	2.482874	354	2.549003	404	2.606381
305	2.484299	355	2.550228	405	2.607455
306	2.485721	356	2.551449	406	2.608526
307	2.487138	357	2.552668	407	2.609594
308	2.488551	358	2.553883	408	2.610660
309	2.489958	359	2.555094	409	2.611723
310	2.491362	360	2.556303	410	2.612784
311	2.492760	361	2.557507	411	2.613842
312	2.494155	362	2.558709	412	2.614897
313	2.495544	363	2.559907	413	2.615950
314	2.496929	364	2.561101	414	2.617000
315	2.498311	365	2.562293	415	2.618048
316	2.499687	366	2.563481	416	2.619093
317	2.501059	367	2.564666	417	2.620136
318	2.502427	368	2.565848	418	2.621176
319	2.503791	369	2.567026	419	2.622214
320	2.505149	370	2.568202	420	2.623249
321	2.506505	361	2.569374	421	2.624282
322	2.507856	372	2.570543	422	2.625312
323	2.509203	373	2.571709	423	2.626340
324	2.510545	374	2.572872	424	2.627366
325	2.511883	375	2.574031	425	2.628389
326	2.513218	376	2.575188	426	2.629409
327	2.514548	377	2.576341	427	2.630428
328	2.515874	378	2.577492	428	2.631444
329	2.517196	379	2.578639	429	2.632457
330	2.518514	380	2.579784	430	2.633468
331	2.519828	381	2.580925	431	2.634477
332	2.521138	382	2.582063	432	2.635484
333	2.522444	383	2.583199	433	2.636488
334	2.523746	384	2.584331	434	2.647489
335	2.525045	365	2.584461	435	2.638488
336	2.526339	386	2.586587	436	2.639486
337	2.527629	387	2.587711	437	2.640481
338	2.528916	388	2.588832	438	2.641475
339	2.530199	380	2.589949	439	2.642465
340	2.531479	390	2.591065	440	2.643453
341	2.532754	391	2.592177	441	2.644439
342	2.534026	392	2.593286	442	2.645422
343	2.535294	393	2.594393	443	2.646404
344	2.536558	394	2.595496	444	2.647383
345	2.537819	395	2.596597	445	2.648360
346	2.539076	396	2.597695	446	2.649335
347	2.540329	397	2.598790	447	2.650308
348	2.541579	398	2.599883	448	2.651278
349	2.542825	390	2.600973	449	2.652246
350	2.544068	400	2.602059	450	2.653213

The TABLE of *Logarithms*.

<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>
451	2,654177	501	2,699838	551	2,741152
452	2,655138	502	2,700704	552	2,741439
453	2,656098	503	2,701568	553	2,742725
454	2,657056	504	2,602430	554	2,743509
455	2,658011	505	2,703291	555	2,744293
456	2,658966	506	2, 04151	556	2,745075
457	1,659916	507	2,705008	557	2,745855
458	2,660865	508	2,705864	558	2,736634
459	2,661813	509	2,706718	559	2,747412
460	2,662758	510	2,707570	560	2,748188
461	2,663701	511	2, 08421	561	2,748963
462	2,664642	512	2,709269	562	2,749736
463	1,665581	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	2,621811	577	2,751176
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	3,764176
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	2,873055
494	2,693727	544	2,735599	594	2,773786
495	2,694605	545	2,736397	595	1,774517
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.*

<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>
601	1.778874	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	705	2.847573
605	2.781755	655	2.816241	706	2.848189
606	1.782473	656	2.816904	704	2.848805
607	2.783189	657	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	2.801514	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	2.828015	723	2.859138
624	1.795185	674	2.828659	724	2.859739
625	2.795880	675	2.829304	725	2.860338
626	2.796574	676	0.829947	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	2.802773	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	2.806858	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	5.812914	700	2.845098	750	2.875061

The TABLE of *Logarithms*.

<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>
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
654	2,877371	804	2,905256	854	2,931458
755	2,877947	805	2,905796	855	2,931966
756	2,878522	206	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	115	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
775	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	2,943000
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	2,919602	881	2,944976
782	2,893207	831	2,920123	882	2,945468
783	2,893762	833	2,920645	883	2,945961
724	2,894316	834	2,921162	884	2,946452
725	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
693	2,899273	843	2,925825	893	2,950851
794	2,899821	844	2,926342	894	2,951338
795	2,900367	845	2,926857	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.*

<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>
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	358	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	2,968011	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				

C H A P. III.

The Use of the Tables of Sines, Tangents, 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 Theorems, as Necessaries thereunto.

1. A *Triangle* is a figure consisting of three sides, and three angles, as CBA (in fig. 1.)

2. Any two sides of a Triangle are called the sides of the angle comprehended by them; as the sides CB and AB are the sides containing the angle CBA.

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 AHE following, the arch CB is the measure of the angle at A; the arch KD is the measure of the angle at the E; and the arch FG 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 thereof.

4. A *Degree* is the 360th part of any Circle: Therefore

5. A *Semi-circle* containeth 180 Degrees: And,

6. A *Quadrant* containeth 90 Degrees.

7. The complement of an Angle less than a Quadrant, is so much as that Angle wanteth of 90 Degrees: As if the Angle HAE should contain 50 Degrees, the Complement thereof would be 40 Degrees; For if you take 50 from 90, there will remain 40.

8. The supplement of an Angle to a Semi-circle, 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 less than a Right-angle.

12. An *Obtuse angle* is greater than a Right-angle.

13. A *Triangle* is either Right-angled or Oblique-angled.

14. A *Right-angled Triangle* is that which hath one right-angle, (or an angle containing just 90 Degrees); as the Triangle (fig. 2.) AHE is right-angled at E, the angle at E being 90 Degrees.

15. In every right-angled Triangle, that side which subtendeth (or lieth opposite to) the right-angle, is called the *Hypotenusal*: And of the other two sides, the one is called *Perpendicular*, and the other the *Base*, at pleasure; but most commonly the shorter is called the *Perpendicular*, and the longer is called the *Base*. So
in

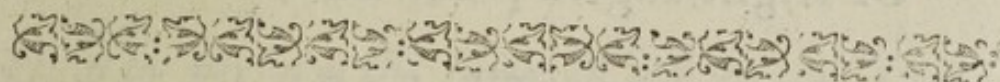
in the former *Triangle*, the side *AH* is the *Hypotenusal*, *HE* the *Base*, and *AE* the *Perpendicular*.

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. And in the *Triangle AHE*, suppose there were given the Angle *AHE* 40 Degrees, then by consequence the Angle *HAE* 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, you have the third angle also given, it being the Supplement of the other two to 80 Degrees.

So in this *Triangle ABC* (*fig. 3.*) if there were given the angle *BAC*, 30 degrees, and the Angle *ACB*, 130 degrees, I say, by consequence, there is also given the third Angle *ABC*, 20 degrees, it being the Supplement of the other two to 80 deg. For, the two given Angles, *A* 30, and *C* 130 degrees, being added together, make 160 deg. which being taken from 180 deg. there remain 20 deg. the quantity of the third Angle *ABC*.

18. In all plain *Triangles* whatsoever, the sides are in proportion one to another, as the Sines of the Angles opposite to those sides. So in the *Triangle ABC*. the Sine of the Angle *ACB*, is in such proportion to the side *AB*, which is opposite to it, as the Sine of the angle *CAB* is to the side *BC*, which is opposite to that angle; or, as the Sine of the Angle *ABC*, is to the opposite side *AC*.



CHAP. IV.

Containing the Doctrine of the Dimension of right-lined Triangles, whether Right angled, or Oblique-angled, and the several Cases therein resolved both by Tables, and also by Lines of Artificial Numbers, Sines, and Tangents.

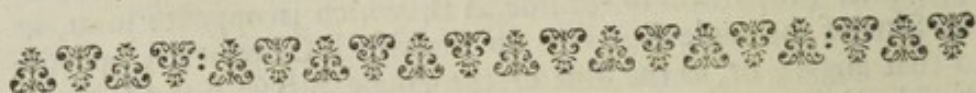
HAVING, in the foregoing Chapters of this Book, explained and shewed the Use of the Tables of *Sines* and *Logarithms*, and also delivered divers necessary Theorems relating to the mensuration of plain *Triangles*, I come now to shew how a plain *Triangle* may be resolved; that is, by having any three of the six parts of a plain *Triangle* given, to find a fourth, both by the Tables of

Sines

Sines and *Logarithms*, and also by the *Lines of Artificial 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, as I before intimated.

¶ 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 three parts being given in any of them, a fourth may be found at pleasure.

The several Cases of a right-angled Triangle will best appear when they are employed 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 CA , in the right-angled Triangle CAB (*fig. 1.*) a Tree, Tower, or Steeple, and that you would know the Height thereof, you must observe with your Instrument, the Angle CBA , and measure the Distance BA ; so have you in the right-angled Triangle ABC , the Base AB , and the angle at the Base CBA : Then may you (by the first Case following) find the side CA , which is the Height of the thing required; namely, the length of the Line CA , be it Tree, Steeple, or other Object.



Of Right-angled plain TRIANGLES.

CASE I.

In a Right-angled plain Triangle, the Base, and the Angle at the Base, being given, to find the Perpendicular.

IN the right-angled Triangle ABC (*fig. 1.*) there is given the Base thereof, BA , 400 Feet, and the Angle at the Base CBA , 30 deg. and it is required to find the Perpendicular CA .

Now, Because the angle CBA is given 30 deg. the angle BCA is also given 60 deg. it being the complement of the other to 90 deg. and therefore the angle BCA is 60 deg. Then to find the Perpendicular CA , the proportion is,

As the Sine of the Angle BCA, 60 degrees, (which is) 9,937531
 is to the Logarithm of the Side BA, 400 Foot, (which is) 2,602059
 So is the Sine of the angle CBA, 30 degrees, (which is) 9,698970

The Sum of the second and third Numbers added---	12,301029
The first Number subtracted from the Sum - - - -	9,937531
To the Logarithm of the side CA, (which is)	2,363498

The nearest absolute Number answering to this Logarithm is 231 fere, and that is the length of the side CA, in Feet, which was the thing required.

A General R U L E.

In all Proportions whatsoever, wrought by Sines Tangents and Logarithms, you must observe this for a general Rule, viz. To add the second and third Numbers together, and from the sum of them to subtract the first Number; so shall the remainder answer the Question demanded; as by the former Work you may perceive, where the Logarithm of the side BA 2,602059 (which is the second Term or Number) is added to the Sine of the Angle CBA 9,698970, (which is the third Term or Number) and from the sum of them (namely, from 12,301029) is subtracted 9,937531, the Sine of the Angle BCA, which is the first Number, and there remaineth 2,363498, which is the Logarithm of 231 almost; and that is the length of the side required in Feet.

The same manner of Work is to be observed in all the Cases following, as will plainly appear.

How to perform the same Work by the Lines of Sines and Numbers.

These kind of Proportions are wrought more easily by help of the Lines of Artificial Numbers, Sines, and Tangents, on the Index of your Table, or any other Scale, and exact enough for any ordinary occasion. But before we shew how to use these Lines, it is convenient to speak of reading or numbering on them; and first on the line of *Numbers*. From the Left-hand to the Right-hand are Divisions of the longer sort numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 1, 2, 3, 4, 5, 6, 7, 8, 9, 1. So that the Beginning, End, and Middle are numbered 1: And whatsoever Value is set on the first 1, the second or middlemost, is 10 times so much; and last 1, an 100 times so

much: And whatsoever Value is set on the $\left\{ \begin{array}{l} \text{first} \\ \text{middle-} \\ \text{most} \end{array} \right\}$ 1, the same Value

Value is set on the numbered Divisions immediately following;

the $\left\{ \begin{array}{l} \text{first} \\ \text{middle-} \\ \text{most} \end{array} \right\} 1$. That is, if the first 1 be called one, then shall

the $\left\{ \begin{array}{l} 2 \\ 3 \\ 4 \\ \text{\&c.} \end{array} \right\}$ immediately following it, be called $\left\{ \begin{array}{l} \text{two,} \\ \text{three} \\ \text{four,} \\ \text{\&c.} \end{array} \right\}$ And if the

first 1 be called 10, then the $\left\{ \begin{array}{l} 2 \\ 3 \\ 4 \\ \text{\&c.} \end{array} \right\}$ immediately following it, shall

be called $\left\{ \begin{array}{l} \text{twenty,} \\ \text{thirty,} \\ \text{forty,} \\ \text{\&c.} \end{array} \right\}$ And so if the first 1 be called 100, then the $\left\{ \begin{array}{l} 2 \\ 3 \\ 4 \\ \text{\&c.} \end{array} \right\}$

immediately following it, shall be called $\left\{ \begin{array}{l} 200 \\ 300 \\ 400 \\ \text{\&c.} \end{array} \right\}$ and so on. And

in like manner, if the middlemost 1, be called ten, (which is when

the first 1 is called one) then the $\left\{ \begin{array}{l} 2 \\ 3 \\ 4 \\ \text{\&c.} \end{array} \right\}$ immediately following the

middlemost 1, is called, $\left\{ \begin{array}{l} \text{twenty,} \\ \text{thirty,} \\ \text{forty,} \\ \text{\&c.} \end{array} \right\}$ And if the middlemost 1

is called 100 (which is when the first 1 is called ten) then the

$\left\{ \begin{array}{l} 2 \\ 3 \\ 4 \\ \text{\&c.} \end{array} \right\}$ immediately following the middlemost 1, is called $\left\{ \begin{array}{l} 200 \\ 300 \\ 400 \\ \text{\&c.} \end{array} \right\}$

Secondly, Between every two of these figured Divisions are 10, (shorter than the primary or figur'd ones) and called *Secondary Divisions*. And the Value of any *Secondary*, is just $\frac{1}{10}$ th part of that primary one which immediately preceeds it: So if a primary

Division be valued $\left\{ \begin{array}{l} \text{hundreds,} \\ \text{tens,} \\ \text{units,} \end{array} \right\}$ the secondary ones immediately

following it, are $\left\{ \begin{array}{l} \text{tens,} \\ \text{units,} \\ \text{10th parts.} \end{array} \right\}$ So if the primary Divisions were

hundreds,

{ hundreds, }
 { tens, } then the fifth or longest Division between 3 and 4,
 { units, }
 signifies { 350 }
 { 35 }
 { $3\frac{5}{10}$ }.

Lastly, Between these *Secondary Divisions* are other shorter ones, called *Tertiary*; in some Places 10 between two *secondary* ones (as those immediately following the middle Figures); and in this Place the Value of the *tertiary* ones are each $\frac{1}{10}$ th of the Value of the preceeding *secondary*; and in some places 5 between every *secondary* (as those immediately following the latter Figure of 2): And here the Value of the *tertiary* ones are $\frac{2}{10}$ ths of the Values of the preceeding *secondary*: And so if we imagine one single Division between each of these last *tertiary* ones, every one of them will be $\frac{1}{10}$ th of their *secondary* ones. In some Places between the *secondary* is only one *tertiary*, whose Value is $\frac{1}{10}$ ths of its preceeding *secondary*; the other *tertiary* ones here, are to be supplied in the Imagination, as before.

Therefore to find upon the Line 143, make the first 1 ten, and the middlemost one 100; then of the 90 on towards 2, count till you come to the 4th *secondary* Division, which gives the Number 140. Lastly, Count forwards three *tertiary* Divisions, and there will be the place of the Number 143. In like manner, to find the Number 247; call the middlemost 1 an hundred, and so the 2 following it 200; then go on four of the *secondary*, which will give the place of 240: Lastly, Go still onwards to 3 and $\frac{1}{2}$ of the *tertiary*, and you will have the place of 247.

And here note, That the Divisions following the middlemost one, are best to signify three places of Figures; but those that immediately follow the first 1, to signify a Number of one or two places; especially to a Learner.

And now for the line of *Sines*: We are to observe they begin a little below one Degree, and run with 2,3,4,5,6,7,8,9,10,20,30,40,50,60,70,80,90. And that the Values are not changeable, as on the Numbers, but fix'd by the Figures annex'd.

The *secondary Divisions* on the Left-hand of 10, denote the parts

of a Degree; and where there are { 12 }
 { 6 } each signifies { 5 }
 { 4 } { 10 }
 { 3 } { 15 } Min.
 { 2 } { 20 }
 { 2 } { 30 }

of a Degree. The *secondary* Divisions from 10 upwards (where they are in Number 10 between their *primary*) signify whole Degrees; and the *tertiary* ones between them, denote parts of a Degree.

Where

Where there are but five *secondary* Divisions (as sometimes there are no more between 70 and 80) each Division denotes two Degrees.

Between 80 and 90, there generally is only one Division, which is the 85th Degree.

The Line of *Tangents* begins as the Line of Sines doth, and goes on to 45 Degrees; the Degrees above 45 are supplied by those below 45, and usually numbered backwards. The Places here are fix'd, as on the *Sines*, and have not changeable Values, as on the Number:

For, as in the preceeding Example, the proportion was

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 *feré*.

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 almost 231 in the line of Numbers, which is the length of the side A C, which was required.

Or rather thus: Extend the Compasses from the Sine of 60 degrees, to the Sine of 30 degrees in the line of Sines; the same extent will also reach from 400, in the line of Numbers, to almost 231, as before.

And thus, by these Artificial Lines, the Work is much abbreviated, there being need neither of Pen, Ink, Paper, or Tables, but only of your Compasses.---- And for the working by these Artificial Lines, this is

A General R U L E.

If you set one foot of the Compasses in the first term of the Proportion, and extend the other to the second term, the same extent shall reach the same way, either upwards or downwards; from the third term in the Proportion, to the fourth proportional Number sought.

Or,

If you set one foot in the first term, and extend the other to the third term, the same extent shall reach from the second term to the fourth also.

And here we are to observe not to cross the Lines, as in the first Example was required, if it might be conveniently avoided.

The

The Base, and the Angle at the Base being given, to find the Hypotenusal.

IN the same Triangle ABC, (*fig. 1.*) let there be given (as before) the Base AB, 400 Feet, and the angle ABC, 30 degrees, and let it be required to find the Hypotenusal BC.

Now, because the Angle CBA is given, the other Angle BCA is also given, and the Proportion is,

As the Sine of the angle BCA 60 degrees,	9,937531
is to the Logarithm of the side BA, 400 Feet,	2,602059
So is the Side of the angle CAB, 90 degrees,	10,000000
(the sum of the second and third Numbers added)	12,602959
(the first Number subtracted from the sum,)	9,937531
to the Logarithm of the side BC, which is	2,664528

The nearest absolute Number answering to this Logarithm, is 462, and so many Feet is the Hypotenusal BC.

This Work may be somewhat abbreviated, and so may all others of this kind, where the [*Radius*] or Sine of 90 degrees is ingredient; for, the Sine of 90 degrees consisting of 10, and certain Cyphers, neither increaseth by Addition, nor decreaseth by Subtraction, more than by the Unit. Wherefore, when the *Radius* or the Sine of 90 is to be set down, you may add the Unit only to the number next it, as I have here done, and then will the Work of this second Case stand thus;

As the Sine of the angle BCA 60 degrees,	9,937531
is to the Logarithm of the side BC 400,	12,602059
So is the Sine of the angle CAB 90 deg.	
To the Logarithm of the side BC, which is---	2,664528

exactly agreeing with the former. And here you see, that in the first manner of working there are six lines of Figures used, and in this but three: but it is my Custom to render things plain at first, and use Abbreviations afterwards.

By the Lines of Sines and Numbers.

The manner of work is altogether the same with that of the former Case: For the proportion being,

Y

As

As the sine of the angle BCA 60 degrees
 is to the length of the side BA 400 foot,
 So is the Sine of the angle CAB 90 degrees
 to the length of the side CB 462; therefore

Extend the Compasses from the Sine of 60 degrees to the Sine of 90 degrees, the same extent will also reach from 40 to 462, as before.

C A S E. III.

The Hypotenusal and Angle at the Base being given, to find the Perpendicular.

IN the same Triangle, (*fig. 1.*) let there be given the Hypotenusal BC 462 Feet, and the angle at the Base CBA 30 degrees, to find the Perpendicular CA .

The angle CAB is a right-angle, or 90 degrees; and therefore the Proportion is,

As the Sine of the angle CAB 90 degrees,	10,00000
is to the Logarithm of the side BC 462,	2,664642
So is the Sine of the angle CBA 30 degrees,	
	12,335358
to the Logarithm of the side CA ,	2,363612

The number answering this Logarithm is 231 *ere*, and that is the length of the side CA in Feet.

Here the Work is somewhat abbreviated, for the angle CAB 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 Logarithm of the number sought.

By the lines of Sines and Numbers.

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 CA .

The

C A S E IV.

The Hypotenusal and Angle at the Base being given, to find the Base.

LET there be given in the former Triangle, (*fig. 1.*) the Hypotenusal BC 462, and the angle at the Base CBA 30 deg; then by consequence the angle BCA must be 60 deg. the complement of the other to 90. How to find the side BA, the proportion is,

As the Sine of the angle CAB 90 degrees,	10,000000
is to the Hypotenusal BC 462	2,664642
So is the the Sine of the angle BCA 60 degrees	9,937531
to the Logarithm of the Base BA,	*2,602173

The nearest number answering to 2,602173, is the Logarithm of 400; and so long is the Base BA.

By the lines of Sines and Numbers.

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 BA.

C A S E V.

The Perpendicular and Angle at the Base being given, to find the Hypotenusal.

IF the Perpendicular CA (*fig. 1.*) be given 231, and the angle at the Base CBA 30 degrees, the Hypotenusal BC may be found thus: For,

As the Sine of the angle CBA, 30 degrees,	9,698970
is to the Logar. of the Perpendicular CA 231,	12,363612
So is the Sine of the angle CAB 90 degrees,	10,000000
to the Logarithm of the Hypotenusal BC,	2,664642

¶ Here, because the angle CAB is a right angle, or 90 deg. and comes in the third place, I therefore only put an unite before the second term, and from that second term subtract the first term, and the remainder is 2,664642: The absolute number answering thereunto is 462, the side BC.

By

By the lines of Sines and Numbers.

The distance between the Sine of 30 degrees and 90 degrees will be equal to the distance between 231 and 462; which giveth the side required.

C A S E VI.

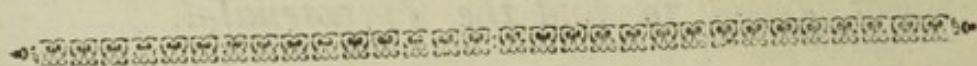
The Hypotenusal and Perpendicular being given, to find the Angle at the Base.

IN the foregoing Triangle (*fig. 1.*) there is given the Hypotenusal BC 462 Feet, and the Perpendicular CA 231 Feet, and it is required to find the angle CBA : the proportion is,

As the Logarithm of the Hypotenusal BC 462,	2,664642
is the right-angle BAC 90 degrees,	10,000000
So is to the Logarithm of the Perpendicular CA 231,	12,363612
to the Sine of the Angle CBA 30 deg.	9,698970

By the Lines and Sines of Numbers.

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 CBA .



Of the Oblique-angled plain Triangles.

C A S E VII.

Having two Angles and a Side opposite to one of them given, to find the side opposite to the other.

IN the Triangle QRS , (*fig. 4.*) there is given the angle QSR , 24 deg. 20 min. and the angle QRS 45 deg. 10 min. and the side QS 303 Feet, and it is requir'd to find the side QR .

¶ 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

As the Sine of the angle Q R S 45 deg. 10 min.	9,850745
is the Logarithm of the side Q S 303 Feet,	2,481443
So is the Sine of the angle Q S R 24 deg 20 min.	9,614944
(the sum of the second and third terms)-----	12,096387
(the first term subtracted) - - - - -	9,850745

To the Logarithm of the side Q R, 2,245642

The nearest 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 before. For,

If you extend the Compasses from the Sine of 45 deg. 10 min. to 24 deg. 20 min. 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 deg. 30 min. and the angle Q R S, 45 deg. 10 min. and the side Q S, 303 Feet, had been given, the side R S required, the manner of Work had been the same. For,

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 R Q S 110 deg. 30 min. (or 69 deg. 30 min. which is the complement of 110 deg. 30 min. to 180 deg.)	9,971588
the sum of the second and third terms)	12,453031
(the first term subtracted) - - - - -	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 than 90 degrees; you must therefore take the complement thereof to 180 degrees; so 110 deg. 30 min being taken from 180 degrees, there remains 69 deg. 30 min. whose Sine is the same with the Sine of 110 deg 30 min. and being used instead thereof, will effect the thing required. And the like is to be done as oft as you have an angle greater than 90 degrees.

By the lines of Sines and Numbers.

The Compasses being opened to the Distance between the Sine of 45 deg. 10 min. and 60 deg. the same Distance will reach from 303 to 400, as before.

C A S E VIII.

Two Sines and an Angle opposite to one of them being given, to find the Angle opposite to the other.

IN the same Triangle (*fig. 4.*) let there be given the side Q S 303, and Q R 176, together with the angle Q S R, 24 deg. 20 min. and let it be required to find the angle Q R S, the Proportion is,

As the Logarithm of the side Q R 176,	2,245513
is to the Sine of the Angle Q S R, 24 deg. 20 min.	9,614944
So is the Logarithm of the side Q S 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 Q R S,	9,850374

The nearest Degree in these small Tables answering to the Sine is 45 deg. 10 min. which is the quantity of the angle Q R S required.

By the lines of Sines and Numbers.

The Distance between 176 and 303 will be equal to the distance between 24 deg. 10 min. and 45 deg. 10 min.

When the side opposite to the sought angle is less than the side opposite to the given one; the sought angle is doubtful, and may be either that found in the Tables, or its Supplement to 180 degrees; both of them being possible.

C A S E IX.

Having two Sides and the Angle contained by them given, to find either of the other Angles

THIS Case and the former will seldom come in use in Surveying, because the thing required is an angle, which are most com-

commonly given, they being observed by Instrument, and therefore in this Place might be omitted: However I will shew how they may be resolved by the Tables, and also by the proportional Lines, which is as followeth.

For performance of this Problem: Suppose there were given the side QS 303 (*fig. 4.*) and the side RQ 176, and the Angle comprehended by them, namely the angle RQS 110 deg. 30 min. and it were requir'd 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 17th Theor. of Chap. 3.*) therefore the angle RQS being 110 deg. 30 min. if you subtract this angle from 180 deg. 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 QS	303
The side RQ	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 Log. of the difference of the sides, 127,	2,103804
So is the Tangent of the half-sum of the two unknown angles 34 deg. 45 min.	{ -9,841187
(the sum of the second and third Numbers)	11,944991
(the first Number subtracted)	2,680335
to the Tangent of 10 deg. 25 min.	9,264656

These 10 deg. 25 min, being added to the half-sum of the two unknown angles, namely, to 34 deg. 45 min. the sum will be 45 deg. 10 min. the Quantity of the angle QRS , which is the greater angle of the two. Also, these 10 deg. 25 min being subtracted from the same half-sum, there remain 24 deg. 20 min. for the angle QSR , which is the lesser of the unknown angles: The greater angle being always that which is opposite to the greater side. And thus are both the angles found which were sought.

By the lines of Tangents and Numbers.

Extend the Compasses from the sum of the sides 479 to the differences of the sides 127; the same extent upon the line of Tangents, will reach from the Tangent of 34 deg. 45 min. (which is the

the half-sum of the two unknown angles) to the Tangent of 10 deg. 25 min. and these 10 deg. 25 min added to, and subtracted from the half-sum, as before is shewed, will give the Quantity of either of the two unknown angles.

When on the Tangents the Distance reaches beyond 45; then as much as it reaches beyond, must be laid from 45 backwards.

C A S E X.

The three sides of a right-lined plain Triangle being given, how to find the Area, or the superficial Content thereof.

First, Add the three sides together, and from the half-sum subtract each side severally, to the end you may have the difference betwixt that half-sum and each side: This done, add the Logarithms of the said half-sum and of those differences together: And lastly, Dividing the sum of those Logarithms by 2, you have the Logarithm of the superficial Content, or Area of the Triangle.

E X A M P L E.

Let the Triangle given be A B C, (*fig. 3.*) the sides thereof being 20, 13, 11, how much is the superficial content thereof?

The sum of the sides is 44, the half-sum 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
	2	0,301030
The differences,	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 always 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.

Other Cases might be added, but in this place at present let these suffice. And now I shall proceed to shew you the farther Use of these Tables and Lines, in the solution of divers Problems, which are of frequent Use in the Practice of Surveying.

TRIGO.



OF TRIGONOMETRY.

The Second PART.



HE Table of Logarithms, or Line of Numbers, are of singular Use in casting up the Content of any *Superficies*, and for *Land-measuring* particularly. Mr. Gunter hath several Propositions, like unto which I will here insert divers others, which will be of special Use in the Practice of *Surveying*; shewing you how they may be wrought both by the *Table of Logarithms*, and also by the *Line of Numbers*, on the edge of your Index.

PROBLEM. I.

The length and breadth of a Right-angled Parallelogram being given in Perches, to find the Content thereof in Perches.

IN the *Parallelogram* ABCD, (fig. 5.) let the length AB be 25 Perches and the breadth AC 12, 8, that is, 12 Perches, and 8 tenth parts of a Perch, and the content in Perches is required. The proportion is,

As 1 Perch is to 12, 8, (the breadth in Perches)

So is 25 Perches (the length in Perches)

to 320, (the Content in Perches.)

A a

By

By the Logarithms.

The Logarithm of 12,8 is	— — —	1,107209
The Logarithm of 25 is	— — —	1,397940
Their sum	- - -	2,505149

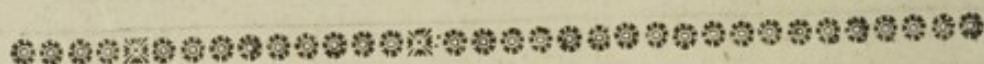
which is the Logarithm of 320; and so many square Perches are contained in the Parallelogram A B C D.

By the line of Numbers.

Extend the Compasses from 1 to 12,8, the same extent will reach (the same way) from 25 to 320, the content in Perches, as before.

Or,

Extend from 1 to 25, it will reach from 12,8 to 320.



P R O B. II.

The length and breadth of a Parallelogram being given in Perches, to find the Content in Acres.

SO in the same Parallelogram A B being 25 Perches, and A C 12,8 Perches, the proportion is,

As 160 (the Perches contained in one Acre)
is to 12,8, (the breadth in Perches,)

So is 25 (the length in Perches)
to 2 (the content in Acres.)

By the Logarithms.

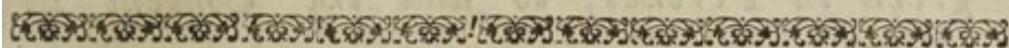
The Logarithm of 160 is	— — —	2,204119
The Logarithm of 12,8	— — —	1,107209
The Logarithm of 25	— — —	1,397940
Their sum	- - -	2,505269
The Log. of 160 being subtracted, there remains		0,301150

which

which is the Logarithm of 2; so that in the Parallelogram ABCD there is contained just 2 Acres.

By the line of Numbers.

Extend the Compasses from 160 (downwards) to 12,8, the same Extent will reach from 25 (downwards) to 2, the content in Acres.



P R O B. III.

The length and breadth of a Parallelogram being given in Chains, to find the Content in Acres.

IN the Parallelogram ABCD, let the length thereof CD be 6 Chains, 25 Links, and the breadth thereof BD 3 Chains, 20 Links, to find the content thereof in Acres. The proportion is,

As 10 is to 3, 20 Links (the breadth)
So is 6 Chains 25 Links (the length)
to 2 (to the content in Acres.)

By the Logarithms.

The Logarithm of 10 is	1,000000
The Logarithm of 3, 20 is	0,505149
The Logarithm of, 6,25 is	0,795881
Their sum is —	1,301030

From which 1,000000 being subtracted, there remains 0,301030, which is the Logarithm of 2; and so many Acres are contained in the Parallelogram ABCD.

In this Operation, and all others of the same Kind, where we use Chains and Links, we are to seek the Log of Chains and Links as tho' all were Links, and to lessen the left-hand Figure (cut off by the Comma) by 2; that is, instead of 3 Chains, 20 Links, seek the Log of 320, which is 2,505149; and then lessening the left-hand place by 2, it is, 0,505149. Or else using the Logarithms without lessening them, in their sum, lessen the left-hand place by 4.

Or

Or, Lastly, cut off towards the right-hand, of the Number answering to the sum, 4 places, and those to the left are Acres.

•••••

P R O B. IV.

The Base and Perpendicular of a Triangle being given in Perches, to find the Content in Acres.

IN the Triangle ECD (*fig. 6.*) let the Perpendicular EF be 38 Perches, and 4 tenth parts of a Perch and the Base CD 75 Perches; to find the content in Acres, this is the proportion,

As 320 is to 38, 4, (the Perpendicular)
So is 75 (the Base)
to 9 (the content in Acres.)

By the Logarithms.

The Logarithm of 320 is - - - - - 2,505149

The Logarithm of 38, 4 is - - - - - 1,584331

The Logarithm of 75 is - - - - - 1,875061

Their sum is 3,459392

From which 2,505149 being subtracted, }
there remains 0,954243

which is the Logarithm of 9; and so many Acres are contained in the Triangle ECD.

By the line of Numbers.

Extend the Compasses from 320 (downwards) to 38, 4, the same extent will reach (downwards) from 75 to 9, the quantity of Acres in the Triangle contained.

PROB.

P R O B. V.

The Base and Perpendicular of a Triangle being given in Chains, to find the Content thereof in Acres.

SO in the former *Triangle*, the Perpendicular EF being 9 Chains, 60 Links, and the Base CD 18 Chains, 75 Links; to find the Content in Acres: The proportion is,

As 20 is to 9, 60, (the perpendicular,)
So is 18, 75 (the Base) to 9 (the Content.)

By the Logarithms.

The Logarithm of 20 is	- - - -	1,301030
The Logarithm of 9, 60 is	- - - -	0,982271
The Logarithm of 18, 75 is	- - - -	1,273001
Their sum is		2,255272

From which 1,301030 (the Logar. of 20) being subtracted, there will remain 0,954242, which is the Logarithm of 9, the content of the Triangle in Acres.

¶ *Note*, Your Table of Logarithms in this Book going but to 1000, you cannot therein find the Logarithm of 18, 75, which is 1,273001: wherefore, if (instead thereof) you take the Logarithm of 18, 7, (omitting the 5) which is 1,271842, the Work will be near the same; for the Logarithm thereby produced, will be 0,953083, which is the nearest logarithm in your Table to 9, and so will produce the same Effect, as if you had had the Logarithm of 18, 75. And thus may you do if your Numbers were greater: As if the Base of a Triangle were 27 Chains, 81 Links, and the Perpendicular 12 Chains, 94 Links, the Area of that Triangle will be found to be 12 Acres, as by the Example, here wrought, may appear.

The Logarithm of 20 is 1,301030

The Log. of 27, 81, is 1,444201 } instead of which } 27,8---1,444045

The Log. of 12, 94 is - 1,111934 $\left. \begin{array}{l} \text{of which} \\ \text{I take the} \\ \text{Logar. of} \end{array} \right\} 12,9 \text{---} 1,110589$

The Log. of 12, 94 is - 1,111934 Logar. of } 12,9---1,110589

Their sum is---2,556135 Their sum is 2,554634

From both which sub-
tract the Log. of 20, } 1,255105 - - - - Or - - - 1,253604
and there remains

tract the Log. of 20,
and there remains

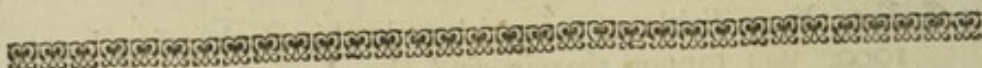
and there remains

Either of which, in your Table, will be found to be the Logarithm of 18: And so many Acres are contained in such a Triangle: Nevertheless it is much better to use a larger Table, such as *Sherwyn's*.

By the line of Numbers.

For the first Triangle, --- Extend the Compasses from 20 (downwards) to 9,60: The same Extent will reach from 18,75 (downwards) to 9, the content of the Triangle in Acres.

For the second Triangle, --- Extend the Compasses from 20 (downwards) to 12, 94: The same Extent will reach from 27, 81 (downwards) to 18, the content of that Triangle in Acres.



PROP. VI.

Having the length of the Furlong given, in Perches, to find the breadth of the Acre.

SO if a Furlong should be 50 Perches long, and you would know what breadth it must be to make an Acre, this is the Rule.

As 50 (the length of the Furlong in Perches)
is to 160 Perches, constantly

So is 1 Acre

to 3, 2, (the breadth of the Acre in Perches)

By

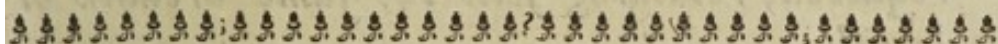
By the Logarithms.

The Logarithm of 50 is - - - - -	1,698970
The Logarithm of 160 is - - - - -	2,204119
The Logarithm of 1 is - - - - -	0,000000
The sum - - -	2,204119
Subtract 1,698970, and there remains - - -	0,505149

which is the Logarithm of 3,2 that is, 3 Perches, and 2 tenth parts of a Perch: and so broad must the Furlong be to make it just an Acre.

By the line of Numbers.

Extend the Compasses from 50 to 160, the same extent will reach the same way, from 1 to 3,20, the breadth of the Acre.



P R O B. VII.

The length of the Furlong being given in Chains, to find the breadth of the Acre in Chain-measure.

SO if the Furlong be 6 Chains 56 Links long, or, 656 Links, how broad must it be to make an Acre? To perform which, this is the Rule,

As 656, (the length of the Furlong in Links)
is to 100000, a constant Number,
So is 1 Acre
to 153 Links, or 1 Chain 53 Links, (the breadth of
the Acre in Chain-measure.)

By the Logarithms.

The Logarithm of 656 is - - - - -	2,816904
The Logarithm of the constant Numb. 100000, is	5,000000
The Logarithm of 1 is - - - - -	0,000000
Their sum	5,000000
From which subtract 2,816904, there rests, —	2,183096

which

which is the Logarithm of 153, that is, 1 Chain, 53 Links; and so broad must the Furlong be to make it an Acre.

By the Line of Numbers.

Extend the Compasses from 6, 56 (upwards) to 10; the same Extent will reach, the same way, from 1 to 1, 53 the breadth of the Acre in Chain-measure.

P R O B. VIII.

The length or breadth of any piece of Ground being given either in Perches, or Chains and Links, how to lay out any Quantity of Acres required, retaining still the same breadth or length.

SUPPOSE H I K L (*fig. 7.*) were a piece of Land, the Side whereof from H to K were 9 Chains, 75 Links, and from that side I would lay out a Parcel which should contain 7 Acres; how much breadth must be set off from H and K, towards I and L? To perform this, this is the Proportion;

As 9, 75 (the length or breath given)
is to 1,00000, (or 1 Acre)

So is 7, (the Number of the Acres required to be laid out)
to 7 Chains, 18 Links (the breadth.)

By the Logarithms.

The Logarithm of 9, 75 is - - - - - 0,989005

The Logar. of 1,00000 (or 1 Acre) is - - - - - 0,000000

The Logarithm of 7 is - - - - - 0,845098

Their sum the same--- 0,845098

0,989005 being subtracted, there rests - - 0,856093

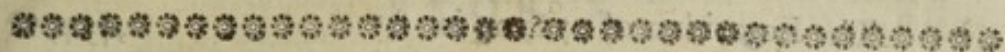
which is the Logarithm of 7, 18, that is, of 7 Chains 18 Links: and so much being set off, or staked out from H to M, and from K to N, and a Hedge, Pale, or Wall, made from M to N, it shall inclose the piece of Land H M N K, containing just 7 Acres, as was required.

Hereof expect more in laying out Lands.

By

By the line of Numbers.

Extend the Compasses from 9, 75 (the length or breadth given) to 7, (the quantity of Acres to be set out) the same Extent will reach from 1 Acre to 7, 18; that is, to 7 Chains, 18 Links: And so much being set from H and K towards I and L, as at M and N, the Hedge M N shall inclose a piece containing 7 Acres.



P R O B. IX.

The Area, or superficial Content of any piece of Land being given, according to one kind of Perch, to find how much the same piece of Land would contain, if it were measured with a Pole or Perch of another length, differing from the former.

LIKE Plains are in proportion one to another, as are the Quadrats (or Squares) of their homologal Sides: And therefore,

As the square of the Perch, by which the Land is to be measured,
is to the square of the Perch, by which it was measured,
So is the Area given
to the Area required.

Thus; Suppose B (*fig. 8.*) be a piece of Land, (suppose a Wood) which being measured by a Chain of 18 Foot (which is the Wood-land Perch) should contain 61 Acres, and 3 tenth parts of an Acre; and it were required to find how many Acres the same Land would contain, if it had been measured by a Chain of 16 Foot and an half to the Perch, (which is a Statute Perch) for several Countries have their respective Customs; but this Rule is general: To work it, this is the Proportion.

As the Square of $16\frac{1}{2}$, (the Perch by which the Land is to be measured) which is 272, 25,

is to the Square of 18, (the Perch by which the Land was measured) and is 324,

So is 61 $\frac{3}{10}$, (the Quantity as measured by the 18 Foot Perch)
to 73 (the Quantity, when measured by the Statute Perch
of $16\frac{1}{2}$).

By the Logarithms.

The Logarithm of 272, 25 you cannot find in your Table: Wherefore (because it is the Square of 16, 5) double the Logarithm of 16, 5, which is 1,217484, and it makes 2,434968, which is equal to the Logarithm of 272, 25; and so must you do in other the like Cases. Now to proceed,

The Logarithm of 272, 25 is	2,434968
-----------------------------	----------

The Logarithm of 324 is	2,510545
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The Logarithm of 61, 3, is	1,787460
----------------------------	----------

• Their sum	4,298005
-------------	----------

The first Number subtracted, there remains	1,863037
--	----------

which is the Logarithm of 73: And so many Acres would the piece of Land have contained if it had been measured with a Chain of 16½ Foot in the Perch.

On the contrary, If this Piece being measured by a Chain of 16½ in the Perch, should have contained 73 Acres, and it had been required to know how many Acres it would have contained, had it been measured by the Chain of 18 Foot in a Perch, the Operation would have been as followeth.

The Logarithm of 324 is	2,510545
-------------------------	----------

The Logarithm of 16, 5 is	1,217484
---------------------------	----------

The same again	1,217484
----------------	----------

The Logarithm of 73 is	1,863323
------------------------	----------

• Their sum	4,298291
-------------	----------

The first Number subtracted, there remains	1,787746
--	----------

which is the Logarithm of 61,3, which is 61 Acres and 3 tenth parts on an Acre: And so much doth the Land contain, if measured with an 18 Foot Pole.

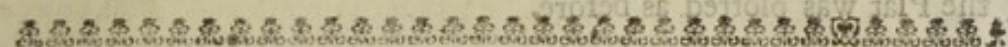
By the line of Numbers.

This Work (by the Line of Numbers) is done more easily, for here is no need of squaring of the Feet in the Perches, but do thus;

For the first Example, ---- Extend the Compasses from 16, 5 to 18, the same extent will reach the same way from 61, 3 to another Number upon the Line; and from that other Number forward to 73; which is the Content, when measured by a Statute Perch.

For

For the second Example, - - - Extend the Compasses from 18 (downwards) to 16, 5; the same extent will reach from 73 (downwards) to a fourth Number; and from that fourth Number, to 61, 3; and that is the Quantity, if it be measured by a customary Perch of 18 Foot.



PROB. X.

The Area or Content of any Plat of Land being given, (and the Scale lost or concealed) to find the Scale by which the same Plat was plotted.

LET the Figure B. (in the last Problem) be a Piece of Land said to contain 8 Acres, and you desire to know by what Scale it was plotted.

First, Take any Scale, (as suppose that of 12 in the Inch) and cast up the content of the Plat thereby, (as is hereafter taught in the Fourth Book;) and so doing, suppose you find the same Plat to contain 11 Acres, and 50 hundredth parts of an Acre, (that is, half an Acre) which should by the Assertion be 12 Acres: Now, to find the true Scale by which it was plotted, this is the proportion;

As the quantity of Acres found (*viz.* 11, 5 Acres)
is to the Square of 12, the Scale by which you measured,
(*viz.* 144,)

So is the Content given (*viz.* 8 Acres)
to 100, the Square of the Scale by which it was plotted,
(*viz.* 10)

By the Logarithms.

The Logarithm of 11, 5 is	1,060698
The Logarithm of 144 is	2,158362
The Logarithm of 8 is	0,903090
Their sum	3,061452
The first Logar. subtracted, there remains	2,000754

which is the Logarithm of 100, the Square Root whereof is 10; and that is the Scale by which the Plat was plotted. --- Or, when you have found the Logarithm 2,000754, you may take the half thereof, which is 1,000377, which will be the Logarithm of 10 also for the Scale required.

By

By the Line of Numbers.

Extend the Compasses from 11, 5 (downwards) to 8, the same extent will reach from 144 (downwards) to 10, the Scale by which the Plat was plotted as before.

Divers Problems of this Kind might be added, but these being most necessary, I shall trouble the Reader with no more at this time.

The Invention of Logarithms, is one of the greatest Improvements in Mathematicks: But because this Table is short, tho' sufficient for a Surveyors Trigonometry; and, because their full Use in casting up Land, requires more Directions than I have Room here to give; also, because Operations of this Kind are easily enough calculated by the Pen, I refer you to the Doctrine hereafter laid down.

The End of the Third Book.



Book 3.

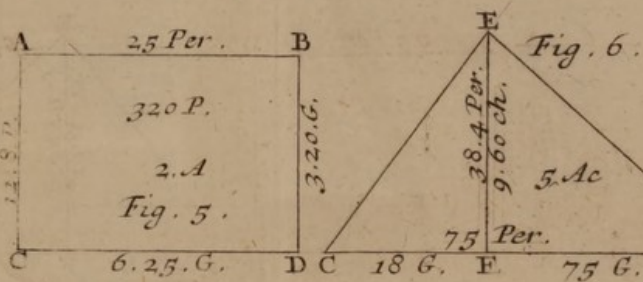
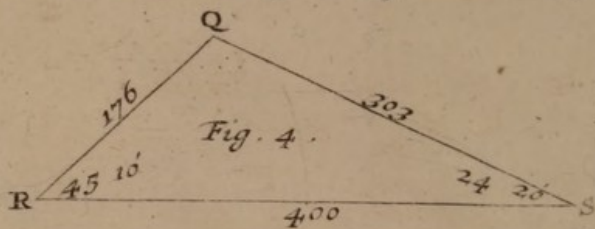
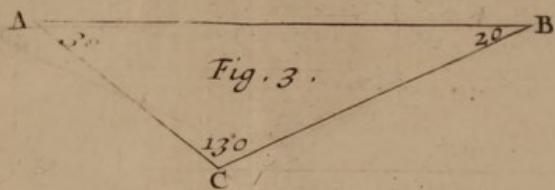
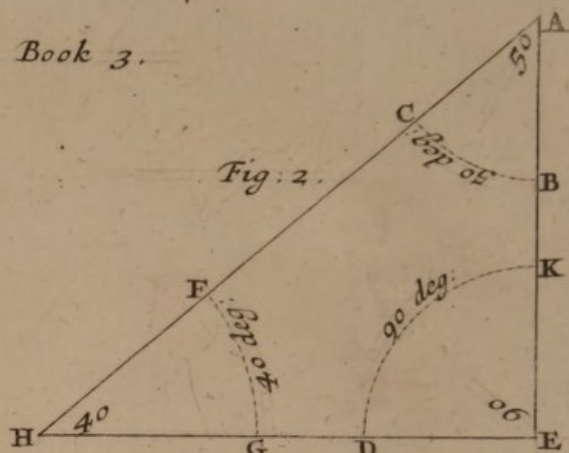
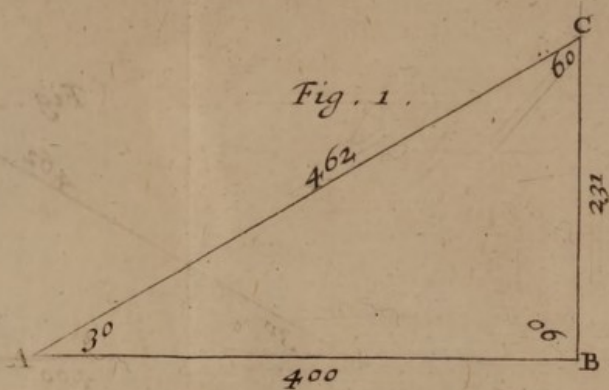
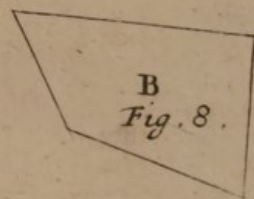
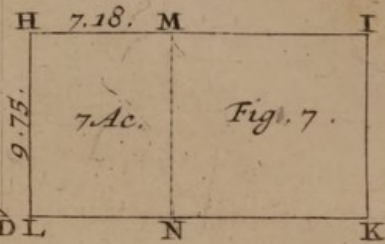


Fig. 6.





THE COMPLEAT SURVEYOR.

The Fourth BOOK. In Two PARTS.

THE ARGUMENT.



I hath hitherto been our business 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, we come now to apply these Instruments, and other things before learned, to Practice, and that several ways: First, in taking of Heights and Distances, whether accessible or inaccessible; and then, in Surveying of Land. In this Book every kind of Work is perform'd Three several ways, by Three several Instruments, viz. the Plain Table, the Theodolite, and Circumferentor;

A a

by

by which the Congruity and Harmony of the several Instruments may easily be discerned. and the Truth of every Example may the better appear. Here are 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. In the First Part of this Fourth Book you are also Taught how to Survey by the Theodolite, or Circumferentor, by way of Traverse, (as they do keep their account at Sea) whereby, when you have gone over your Work, you may (by examining your Field-Book only) know whether you have wrought right or not, before you begin to Protract; and if you find your Work erroneous, you may amend it before you go out of the Field. And there are also added in this Edition other manner of ways of Surveying, both exact and compendious. Here is also shewn how to take the Plot of a whole Mannor, to find the content or quantity thereof, and to keep your account in your Field-Book, after the best and most easie manner: With divers Rules, Cautions, and Directions necessary to be observed in that Work. You have also in this Book the manner how to lay out several Furlongs in Common Fields, and to inclose a Lordship lying in Common, and to give a particular of all the Arable Leys and Meadow-Grounds in the same Lordship: Also how to Plot Mountainous and uneven Ground; with divers other matters and things pertinent to Surveying, which would be too tedious here to enumerate.

The



The First PART.

The Application and Use of the several INSTRUMENTS (before describ'd) in the Practice of SURVEYING.

CHAP. I.

The Use of the Scale.

HAVING before described the several 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 down of Lines; for which purpose the several Scales of equal Parts are there divided, some into greater and some into lesser Quantities, but all of them into 10 Divisions apiece; the use of all of them being the same. For each Line is divided into certain equal Parts representing 8 Chains. And these grand Divisions are numbered with Arithmetical Figures by 1, 2, 3, &c. to the end of the Ruler, upon which the Scales are described: And the uppermost large Division is again divided into 10 other smaller Parts, every Part containing 10 Links of your Chain: Each of which smaller Parts, you may suppose to be again divided into 10 other lesser Parts representing single Links of your Chain.

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

Suppose, that measuring along a Hedge, or the distance between any two marks or places, with your Chain, you find 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,

B

C

D

E

A

First, draw a Line, as A B: Then place one Foot of your Compasses upon your Scale at the Figure 5, for your five Chains, and extend the the other Foot to six of the small Divisions, (which represent 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, which Scale hath 10 at the top thereof in large Figures.

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 Inch, 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 find the extent of the Compasses to reach from five of the great Divisions, to six of the lesser Divisions: 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.

¶ But here you must remember, that in laying down of the lengths of Lines by your Scales, whatsoever Scale you begin your Work with, with the same Scale you must continue it to the end, not laying down one Line by one Scale, and another by another. But if you would have a large Work in a little room, then use a small Scale, as of 24 or 30 in an Inch: But on the contrary, if you would express every small particular, then you were best to use a larger Scale, as of 10 or 12 in an Inch.

There is another kind of Scale called a *Diagonal*, consisting of 11 Parallel Lines, one of which is divided and Numbred as the preceding Scales; with this Addition, viz. the same Divisions which represent the tens of Links, or, 10th Parts of the Chain, are Numbred 2, 4, 6, 8; and the use of this Line is in all respects the same with those before mentioned; so that 5 Chains 60 Links are taken from the grand Division, Numb. 5, to the small Division Numb. 6.

The

The other 10 Lines are to give the Length when there are any odd Links besides the Tens, and every other of these Lines are Number'd at the Ends 2, 4, 6, 8; and those between them are only conceived to be Numb. 1, 3, 5, 7, 9, for want of Room.

If by this Scale you would take 5 Chains 64 Links, take from the long Line markt 4 at the End, the Distance from the grand Division markt 5, to the lesser Division markt 6, and that will represent 5 Chains 64 Links; and if you would have 7 Chains 59 Links, on the long Line markt 9 at the End, take the Distance from the grand Division markt 7, to the lesser Division markt 5, you will have the Representative of 7 Chains and 59 Links.

And every of these Diagonals are double, one End being a Scale twice as great as the other: But here we may observe, That a Diagonal Scale generally fills up one side of a Ruler, and can give us but 2 Sizes of Scales, and therefore, though it be very exact, yet is not so general as the preceeding.

There is yet one kind of Scale, which for Neatness, Ease and Dispatch, exceeds all those mentioned; its Description and Use will be in the Appendix.

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 at pleasure, as AB, (*Fig. 16*) and from the point A, let it be required to protract or lay down an angle of 40 deg. 20 min.

First, extend your Compasses upon the line of Chords, from the beginning thereof, to 60 degrees always, and with this distance; setting one foot upon the point A, with the other describe the arch BC: Then with your Compasses take 40 degrees 20 minutes (which is the quantity of the angle which is to be laid down) 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 AC, so the angle CAB shall contain 40 degrees 20 minutes.

4. *Any Angle being given, to find what number of degrees and minutes it containeth.*

Suppose CAB (*Fig. 16*) were an Angle given, and that it were required to find 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 CB : Then take in your Compasses the distance CB , and measuring that extent upon the line of Chords, from the beginning thereof, you shall find 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, or dividing the Angle into any two parts equal unto it, as if the Angle were 159 Degrees; take 80 and 79 deg. or 90 and 69 deg. &c. or rather by taking 60 or twice 60 (if the Angle be so much) and then the Remainder.

C H A P. 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 Paper upon which you protract your Plot) the *Protractor* is far more convenient; the Use whereof is,

I. *To lay down upon Paper an Angle of any quantity, suppose 50 Degrees.*

First, draw a right Line at length, as AB : (*Fig. 17*) 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 or Diameter of the *Protractor* (noted in the Description thereof with EF) lie directly on this line AB , the Semicircle of the *Protractor* lying upwards, (or from you:) then holding with your Left-hand the *Protractor* fast there, with your Protracting-pin close to the edge of the Semicircle of the *Protractor*, at the division of 50 Degrees, mark the point D with your Protracting-pin, and draw the line CD . So shall the Angle DCA contain 50 Degrees.

Here we may observe, that the *Protractor* here spoken of, is numbred from A towards B , according to the motion of the Sun, and agreeing to the Numbring on the *Theodolite*; and therefore, as in this Example, it lays down an Angle, whose Angular-point is to-

wards

wards the Right-hand. But if the line CB were given, and it were required to draw some line towards DC, contrary to (the motion of the Sun) and the numbring of the *Protractor*, that shall make an Angle with CB at C of any assigned Number of Degrees, suppose 130; lay the Center on C, and turn the *Protractor* about 'till 130 fall on CB, and then with your *Protracting-pin* make the mark D at the beginning of the Divisions, and draw DC. So shall the Angle DCB be 130 Degrees.

Or rather thus: Subtract 130 from 180, and of the Remainder 50 Degrees make an Angle AGD, and then will DCB be 130, because both will always make 180.

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

Suppose DCB (*Fig. 17*) were an Angle given, and that it were required to find the quantity thereof by the *Protractor*. First, you must apply the Center of the *Protractor* to the point C, and the Meridian line or Diameter thereof directly upon the line DC; then shall you find the line CB to lie directly under 130 Degrees of the *Protractor*, and such is the quantity of the Angle DCB required; but here we are to Observe, that the line DC must be produced till it reach both ways to the Arch of the *Protractor*, in order to guide the laying the Diameter exactly on it.

C H A P. III.

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

WHen you would make your Table fit for Use in 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 binds both the Paper to the Boards, and the Boards one to another. 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 Staff, and there screw it: Also put the Sights upon the Index, and lay the Index upon 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

I shall think most convenient for the bringing on of the Work 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 Wire which goes through a small hole of Brass fastned 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 Staff, with a brass Screw-pin fitted for that purpose ; so that the Staff 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 Label upon the farther Sight : And thus are you exactly fitted for all occasions.

C H A P. 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 all Observations of Angles that are taken upon the Table in the Field, do agree exactly in Proportion with those of the Field it self, but are not denominated by their quantities, but by their Symmetry or Proportion.

Secondly, when I mention the *Theodolite*, or work by that 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 several 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.

How

How to observe an Angle in the Field by the Plain Table, Theodolite and Circumferentor.

I. By the Plain Table.

SUPPOSE EK and KG (*Fig. 18*) to be Hedges, or two sides of a Field, including the angle EKG, and that it were required to draw upon your Table an angle equal thereunto. *First*, place your Instrument as near the angular point K as conveniency 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 Compass point, assign 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 near E, but as far from EK as the Instrument near K is from EK; and then with your Protracting-pin, or Compass 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 GK as your Instrument is placed from KG, 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 EK and KG; and those lines shall include an Angle equal to the Angle EKG. And although you know not the quantity of this Angle, yet you may (by the 1. or 2. *Chapters* of this *Book*) find the quantity thereof, if there were any need: For in working by this Instrument, it is sufficient only to give the symmetry 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.

Here Note, That when I say plant your Instrument at any Angle, I mean, as near that Angle as you can conveniently come; and when I say direct to any Mark in any other Angle, I mean, a Mark set up near the Angle equidistant from the Hedge with the Instrument.

II. By the Theodolite.

LET it be required to find the Quantity of the Angle EKG by the *Theodolite*. Place your Instrument at K, laying the Index on the Diameter thereof; then turn the whole Instrument about,

bout, (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 find to be 114 Degrees, and that is the Quantity of the Angle E K G.

One thing is to be Observed, That when you look on the Divisions of *Theodolite*, which are on the nearest edge to you; in some the Numbers encrease towards the left hand, in others towards the right: And this is the first thing to be observed, if you meet with an Instrument you never saw before.

And then standing at the Instrument to take your Observation, if the Degrees encrease towards the left hand, the first Sights shall be directed along E K the left hand Hedge, if otherwise the contrary.

III. By the Circumferentor.

IF it were required to find the Quantity of the former Angle E K G (Fig. 18) 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 upon 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 (always) subtract 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 subtract 79, the Remainder is 246. But because this Remainder 246 is greater than 180, you must therefore subtract 246, the Remainder from 360, and there will remain 114, the true Quantity of the inquired Angle. And thus you must always do, when the Remainder exceedeth 180 Degrees.

¶ This adding and subtracting for the finding of Angles, may seem tedious to some; but here the Reader may take 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: But 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 per-

ceive

ceive what Congruity and Harmony there is in all the three Instruments.

And here we are to Observe, That the *Circumferentor* is the only Instrument proper to the Mapping of Harbours, and drawing the true Positions of Rocks, Lands, Shoals, Soundings, &c. nor is it scarcely possible to be done by any other Instrument; but such as have a Needle and divided Card. But of this more in the Appendix.

IV. *How to set the Index and Label 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 Wire, you must hang a Line and Plumbet upon that Pin, and then put on the Label; then move the Index up and down, 'till the Thread and Plumbet 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.

V. *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 Mountainous and uneven Grounds.

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

Suppose CA (*Fig. 19*) to be a Tree, Tower or Hill, whose Height is required. Your Instrument being placed at B, exactly level, direct the Sights thereof towards CA, and there fix it, hanging the Label on the farthest Sight, on 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 espie 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 CBA.

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 ways, with divers other necessary conclusions incident to Surveying.

C H A P. 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 ways, 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 Triangle, and 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, (*Fig. 20*) and that at S were some eminent Mark, (as a Tree, Church, House, or such like) and that it were required to find the Distance between R and S.

First, place your Table at R, and thereon assign 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 Staff or other Mark be erected, and the Table remaining as before, turn the Index about upon the Point R, '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 QRS. 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 R 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, where your Instrument stood, 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 upon the point Q, 'till through the Sights you espie

espie the mark at S; then draw a line by the side of the Index which will cut the line R S (first drawn) 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, and apply that distance to the same Scale from whence 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 may the distance between any two places be measured, although they be so Situated, that by reason of Water or other Impediments you cannot approach near unto them. And here Note, That when you take your second Station, you take it so large if the Ground will permit, that the angle S may approach to 90 Degrees; for the nearer S is to 90 Degrees, the more directly will the point of Intersection be found.

CHAP. VI.

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

IN the former Diagram, let R and Q (*Fig. 20*) be two Stations, from either of which it is required to find 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 Q, and there screw it fast; then turn the Index about upon the Center, 'till through the Sights you espie the Mark at S, noting the Degrees cut by the Index, which suppose 45 degrees 10 minutes; then remove your Instrument to Q, 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 deg. 30 min. This done, measure the distance of your two Stations Q R, which let be 176 Feet: So in the Oblique-angled Triangle Q S R you have given, (1) the angle S R Q, 45 deg. 10 min. the angle observed at your first Station; (2) the angle R Q S, 110 deg. 30 min. which was the angle observed at your second Station; and (3) you have given the measured side R Q S 176 Foot, which is the distance of your two Stations, and you are to find the two other sides R S, and Q S, which you may find by the 7 *Case* of the 4 *Chapter* of the 3 *Book*, in this manner. For,

D d

Having

Having two angles SRQ and RQS given, you have also the third angle RSQ given, 24 degrees 20 minutes, it being the complement of the other two to 180 degrees, (by the 17 Chap. of the 3 Lib.) Then to find the other two sides, the proportion is,

I. For the side QS ;

As the sine of the angle RSQ , 24 degrees 20 minutes,
is to the Logarithm of the side RQ , 176 foot,
So is the sine of the angle QRS , 45 degrees 10 minutes,
to the Logarithm of the side QS , 303 foot, *fere.*

II. For the side RS ;

As the sine of the angle QRS , 45 degrees 10 minutes,
is to the Logarithm of the side QS , 303 foot,
So is the sine of the angle RSQ , 24 deg. 20 min. (or
69 deg. 30 min.) to the Logarithm of the side RS ,
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 Chapter 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 inaccessible distance at two stations by the Circumferentor.

LET it be required to find the distance from R or Q to S . (Fig. 20.) 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 deg. 30 min. then turning the Instrument about, direct the Sights to Q , observing what degrees the Needle there cutteth, which let be 270 deg. 20 min.; therefore from 315 deg. 30 min. subtract 270 deg. 20 min. and there will remain 45 deg. 10 min. which is the quantity of the angle SRQ .

Then remove the Instrument to Q , and direct the Sights to R , the Needle cutting 90 deg. 20 min.; also direct the Sights to S , the Needle cutting 339 deg. 50 min. Now if you subtract 90 deg. 20 min. from 339 deg. 50 min. the remainder is 249 deg. 30 minutes, which (because it exceedeth 180 deg.) subtract from 360 deg. and there remains 110 deg. 30 min. the true quantity of the angle RQS .

Having

Having thus obtained the two angles RQS and SRQ , you must measure the Stationary distance QR 176 foot; so have you given in the Triangle QRS , (1) the angle RQS , 110 deg. 30 minutes; (2) the angle QRS , 45 deg. 10 min. (3) the angle QSR 24 deg. 20 min the complement of the other two to 180 deg. and (4) the Stationary distance QR 176 foot, whereby you may find the other sides QS and RS , according to the Doctrine delivered in the foregoing Chapter.

	deg. min.
First Station at R, degrees cut are	315 30
	270 20
The quantity of the Angle QRS	45 10
Second Station at Q, degrees cut are	339 50
	90 20
Subtract	249 30
from	360 00
The quantity of the Angle RQS	110 30
The Stationary distance	176 Foot.

Having these things given, if you resolve the Triangle QRS , you shall find the side RS to contain 400 Foot, and the side QS 303 Foot *ferè*, as in the last Chapter.

CHAP. VIII.

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

HAVING made 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 Pastboard the true Symmetry or Proportion of the distance taken in the last Chapter.

First, Upon your Paper draw a Line at length, as RQ , (Fig. 20) then, upon one end thereof, as at R , place the Center of your *Protractor*, and lay the Meridian line EF of the *Protractor* directly upon the Line QR ; then (because the angle QRS is 45 degrees 10 minutes,

10 minutes,) therefore 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 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 deg. 30 min.) 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 number found in the last Chapter.

C H A P. 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 farther use thereof, in the taking of Heights, either Accessible or Inaccessible.

Suppose therefore that the Line *C A* (*Fig. 19*) were a Tree, Tower, 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 Sight of the Label by the Pin, 'till you espie the top of the Altitude at *C*, note what degrees of the Tangent Line are 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 (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 find 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 angle *C B A* 30 degrees,
to the Logarithm of the side *C A*.

This

This Proportion being wrought according to the former directions, the side CA will be found to contain almost 231 Foot; and that is the Height of CA required.

C H A P. X.

How to Protract or lay down upon Paper the Observation made in the last Chapter.

HAVING drawn a Line upon your Paper, as AB, 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 BA lies just under 30 Degrees; then (with your *Protracting-pin*) make a mark by the edge of your *Protractor* against 00 degrees, and draw the Line BC, so shall the angle CBA contain 30 degrees. Then, (because the measured distance BL 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 contain almost 231 Foot: And so much is the Altitude CA, as before.

C H A P. 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 BC (*Fig. 21*) 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 BAC. 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 BDC, 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 ABC must be 40 degrees, the Complement of the former to 90 degrees: Again, the angle BDC being 64 degrees, the angle DBC must be the Complement thereof, namely 26 degrees.

grees. Then if you subtract the angle DBC , 26 degrees from the whole angle ABC , 40 degrees, there will remain 14 degrees for the angle ABD , by the knowledge whereof you may attain to the Altitude BC ; for in the Triangle ABD you have given,

- 1 The Angle BAD , 50 degrees;
- 2 The Angle ABD , 14 degrees;
- 3 The Distance AD , 200 foot.

which (by the former Directions) will help you to find the length of the side DB , either by the Tables in the third 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 ABD , 14 degrees,
is to the Logarithm of the side AD , 200 foot,
So is the Sine of the Angle BAD , 50 degrees,
to the Logarithm of the side DB :

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 BCD , in which you have given,

- 1 The Angle BDC , 64 degrees;
- 2 The Angle DBC , 26 degrees;
- 3 The side DB , 633 Foot.

And you are to find the side of BC , the Altitude required: Wherefore say again,

As the Sine of the Angle BCD , 90 degrees,
is to the Logarithm of the side DB , 633 foot,
So is the Sine of the Angle BDC , 64 degrees,
to the Logarithm of the Altitude BC :

which, according to the former Doctrine, will be found to be 569 Foot, the Altitude required.

C H A P. XII.

How to Protract the Observation taken in the last Chapter.

HAVING made observation as in the last Chapter, and noted down in a Book, or otherwise, that the degrees cut at your first Station at A (*Fig. 21*) were 50, and the degrees cut at the second Station at D were 64, and that your Stationary distance AD was 200 foot, you may immediately find the Altitude BC by Protraction, thus:

First, draw a Line, as AC, in which line let A represent your first Station, whereon lay the Center of your *Protractor*; and make the angle BAC to contain 50 deg. (as hath been several times before shewn) and draw the line AB. Then upon the line AC 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 BDC, and draw the line DB: Then where these two lines AB and DB intersect or meet, which is in the point B, from that point let fall the Perpendicular BC, the length whereof being measured upon the same Scale from whence you took the distance AD, will give you 569 foot; and that is the Altitude of AB, which was required.

C H A P. XIII.

*How to take the Distance of divers places one from another, according to their true Situation, and to make a Map thereof.*I. *By the Plain Table.*

Fig. 1. **T**HIS 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 ABCDEFG be certain eminent places situate in some Town or City, and let it be required to describe all those places upon Paper, by which the Distance of any of them one from another may be readily found.

At some convenient distance from the City or Town, make choice of two convenient places, as K and L, from either of which you may plainly discern all the places which you intend to describe in your Map. Then at one of these places (as at K) place your Table, and near one of the sides thereof draw a Line parallel to the edge of the Table. In this Line assign any point, as K, for your

your first Station; and laying the Index upon the Line, turn the Table about, 'till through the Sights you espie the other place which you intend for your second Station; which found, scrow 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 AK: *Secondly*, turn the Index to the second mark at B, and draw the Line BK: *Thirdly*, direct your Sights to C, and draw the Line CK: *Fourthly*, direct your Sights to D, and draw the Line DK: *Fifthly*, direct the Sights to E, and draw the Line EK: *Sixthly*, direct the Sights to F, and draw the Line FK: *Lastly*, direct the Sights to G, and draw the line GK. So have you finished your work at your first Station.

This done, with your Chain measure the Distance of your two Stations K and L, (in which you must be very exact) which suppose to contain 800 Foot; and removing your Table to L, lay the Index upon the Line KL, turning the Table about, 'till through the Sight, you see your first Station at K, and there scrow 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 AL, CL, BL, FL, DL, EL, and GL. So is your work finished at your second Station also.

Having thus done, first observe where the Line KA crosseth the Line LA, 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 KB crosseth the Line LB, which is at B, at which point write the name of the place as before. *Thirdly*, observe where the Lines KC and LC interfect, which is at C, at which point also note the place. *Fourthly*, at the intersection of KD and LD, 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 interfection, 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 Stationary distance KL was laid down, and it will there shew you the distance required.

And by this means may you make a true and accurate Map of any City, Town or Village, from two Towers, or like places, from whence all Churches, Towers, and other eminent Places may be seen, as the Bending of Rivers, Wind-mills, &c.

II. By the Theodolite.

Fig. I. **A**S in the last Chapter, make choice of two places, from either of which you may conveniently see all those places 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 back 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 deg. 50 minutes; at B, 97 deg. 55 minutes; at C, 114 deg. 10 minutes; at D, 123 deg. 40 minutes; at E, 134 deg. 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 fore 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 Stationary 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 Stationary Distance 800 Foot.

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

By the help of this Table of your Observations, you may at any time Protract the same upon Paper; and making a Scale of
 F f equal

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.

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

Fig. I. **Y**our Paper or Parchment being provided, draw thereupon a Line at length, and therein assign 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 thereof (which is noted with E F) directly upon the line KL. 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 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 KA, KB, KC, KD, &c.

Then remove your *Protractor* to L, which signifies your second Station, laying the Meridian Line thereof upon the Line KL; 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 intersect 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, that your Stationary Distance KL may contain 800 of them. Your Scale being

ing 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 exactness attain the true Distance and Situation of any Mark or Marks far remote, without approaching near 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: "Such are the greatest part of those "vast Woods in *Carolina*, this Year sold to the *Quakers*.

"For, if two Scaffolds be erected at a sufficient Distance from "one another, higher than the tops of the Trees, and in such places "that we can plot their Distance, as hereafter taught: Then let "Pikes with Flags be erected at the most remarkable bounds of the "Land then to be Plotted, and let Signals by Waving, and Colours "distinguish them from one another, at the two different Stations. "I say, having thus prepared things, a Surveyor may Survey and "Plott ten thousand Acres of Land in one Day. And after he hath "Plotted these Observations, he may use any two of these to raise "his Scaffolds at, and so proceed through the whole Country. Of "this see more in the Appendix.

¶ 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 Distances; or, part of a Distance or Altitude being given, to find the whole, with infinite others of that nature: But seeing that these are but Parts or Branches of what is here already delivered, and are rather Problems of Curiosity then Use, I will therefore pass them over, and the rather, because these being rightly understood, the performance of any other will be very easie. But remember always, in taking of inaccessible Heights and Distances, as also in the Plotting of unpassable Grounds, that you take always your Stationary distance as large as may be. And if at any time you be required to take the Altitude of a Castle, Church or Tree, standing on a Hill, 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: And then subtracting 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 always add to the Height found, the Height of your Instrument from the Ground.

C H A P. XIV.

How to take the true Plot of a Field at one Station taken within the same Field, from whence you may see all the Angles: By the Plain Table, Theodolite and Circumferentor.

I. *By the Plain Table.*

Fig. II. **H**AVING entred upon any Field to Survey thus, your first work must be to set up some visible Mark at each Angle thereof, [*not near but in the very Angle;*] or let one go continually before you to every Angle, holding up a white Cloath, 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, cover'd with a sheet of Paper, the Needle hanging directly over the Meridian-line of the Card; (which you must always have regard unto, especially when you are to Survey many Fields together.) Then make a Mark about the middle of your Paper, which shall represent that part of the Field where your Table standeth; and laying the Index upon this Point, direct your Sights to the several 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 Compass-point, at the end of every of them: Then with 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 choice 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

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 the Line 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 directing 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 applied to your Table from L to C, shall give you the point C, representing your third Mark.

In this manner you must deal with the rest of the marks at D, E and F, and more, if the Field had consisted of more Sides and 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, always representeth the Meridian-line.

II. *By the Theodolite.*

Fig. II. 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 Columns of your Field-book, as hath been directed in the Description thereof, and as is done in this Chapter.

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 LC 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, after the Index hath passed 180 degrees, which is at the line NS, (representing always the Meridian-line) you must then count the degrees backward, according as they are numbred on the Frame of the Table, from 190 to 360.)

—then measure the Distance LD, which let be 8 Chains 53 Links. The 212 degrees must be noted in the first Column 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 LE 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 LF 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

III. By the Circumferentor.

Fig. II. 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-

Flower-de-luce of the Card being always 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 find 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 cutting 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 find the South-end of the Needle always 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.

IV. *How to Protract any Observation taken according to the former Directions.*

Fig. II. First, draw upon your Paper or Parchment a Line at length, which shall represent the Meridian-line N S in the Figure: Then make choice of some Point or other in that Line, which shall represent your Station or Place of standing in the Field, as L: 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, and 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 mark upon your Paper.

2. Seeing the degrees cut at your second Observation were 99 degrees 15 minutes, you must against 99 degrees 15 minutes of your *Protractor* make a Mark upon your Paper.

3. The degrees cut at your third Observation were 165 degrees 15 minutes, therefore against 165 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: And so you must always do when the Angle you are to Protract exceedeth 180 degrees.)

—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 degrees 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 degrees of your several Observations, take away your *Protractor*, and laying a Ruler to the point L, draw obscure Lines from L through those Points; which Lines will be LA, LB, LC, LD, LE, and LF.

This done, you must observe by your Field-book the length of every Line.

As the line LA at your first Observation being 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 them upon your Paper from L to B.

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

And thus must you deal with all the rest of the Lines, as LD, LE, and LF.

Lastly, draw the lines AB, BC, CD, DE, EF, and FA, 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 seldom or never used in Surveying of divers Parcels, but for one particular Field whose sides are straight it is as good as any, but cannot always be used; sometimes for spoiling of Grass or Corn upon the Ground, sometimes for Water, or when the sides are crooked, and other the like Impediments. But divers other Varieties will appear in the following Chapters.

C H A P. XV.

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, Theodolite and Circumferentor.

I. *By the Plain Table.*

Fig. 3. Place your Table in some convenient Angle [*in the Angle not near it*] 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 NS; in which Line assign 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 HA, and measure the distance HA, (as was directed before in *Chap. 14.*) Then direct the Sights to B, your second Mark, and there likewise draw a Line HB, measuring the distance HB, as was taught in the fore-mentioned Chapter.

In like manner direct the Sights to CDEF 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 several Angles of the Field, A, B, C, D, E, F and G: Which distances being taken in your Compasses, from any Scale, set them upon your Table from H, upon the several lines HA, HB, HC, HD, HE, HF and HG; so shall you have upon your Table the Points A, B, C, D, E, F and G: By which Marks draw the lines HA, AB, BC, CD, DE, EF, FG and GH; which lines will include the exact Figure of the Field upon your Table.

This way of Measuring is also liable to the inconvenience of that in the last Chapter, and therefore but in some cases to be used.

II. *By the Theodolite.*

Fig. 3. IN the same Figure, 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

H h

Columns

Columns of your Field-book, according to the former Directions.

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 HB, 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 66 degrees 30 minutes, and the distance HC, 16 Chains 64 Links: Note these also in your Field-book, as before.

And in this manner must you deal 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	5	22
G	162	00	7	73

III. By the Circumferentor.

Fig. 3. 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 degrees 15 minutes, and the distance HA containing 8 Chains 46 Links; which agrees exactly with the first Observation in the last Chapter. These degrees and minutes, together with the measur'd distance HA, must be noted down in the several Columns of your Field-book. And if you make Observations 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 find 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 equal: And if you make a Table of your Observations, you shall find it the same with that in the last Chapter.

IV. How to Protract any Observation taken, according to the foregoing Doctrine.

Fig. 3. First, draw the Meridian-line NS, and make choice of a Point therein representing your Stationary Angle, as at H, to which Point apply the Center of your Protractor, the Semi-circle upwards. Then laying your Field-book before you, you may perceive

perceive that at your first Observation (which was at A) the Index of the *Theodolite*, or the Needle of the *Circumferentor*, cut 22 degrees 15 minutes; therefore make a Mark against 22 degrees 15 minutes, and draw the line H A.

2. The degrees cut at your second Observation, at B, being 42 degrees 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 degrees 30 minutes, make a Mark against 66 degrees 30 minutes, 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 Lineal; namely, to the length of your Lines, noted in the third and fourth Columns of your Field-book.

1. Seeing that the length 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 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 the 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 Points, A B C D F F G and H, you draw the Lines 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 Geometrical Protraction so exactly to agree. And if at any time you make several Observations of any one piece of Ground, according to the directions of the foregoing Chapter, or the like; if you find them not exactly to agree, you may be sure you have failed in one or other of your Observations, and therefore, before you proceed farther, it is best to reform your first Error.

C H A P. XVI.

How to take the Plot of a Field at two (or more) Stations taken in any parts thereof, by measuring from either of the Stations to the visible Angles: By the Plain Table, Theodolite and Circumferentor.

I. *By the Plain Table.*

Fig. 4. **T**HIS manner of work is chiefly 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 *Chap. 14.* only the Instrument, in this, must be placed in two or three several 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, representing in this Figure by the line NOS. 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 O B, 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 08 Links.

Having thus made Observation of these Angles, which are all that can conveniently be seen from your first Station at O, and drawn the several Lines, O A, O B, O C, O D, O E, O K, O L, and O M; and upon them set the several lengths as you found them by measuring

ſuring, 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 OQ: Then meaſure the Diſtance from O to Q, which let contain 8 Chains 89 Links.

Then remove your Inſtrument to Q, and lay the Index upon the line OQ, 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 ſituated in the ſame Poſition as before; ſo that you may now deal 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 QE, containing 5 Chains 10 Links:
- (2) to F, and drawing the Line QF, containing 7 Chains 64 Links:
- (3) to G, and drawing the Line QG, containing 6 Chains 40 Links:
- (4) to H, and drawing the Line QH, containing 5 Chains 33 Links:
- (5) to I, and drawing the Line QI, containing 6 Chains 95 Links:
- (6) to K, and drawing the Line QK, containing 7 Chains 61 Links:

Theſe Angles being Obſerved, and the lines meaſured as the former were, you ſhall find the ſeveral points, E, F, G, H, I, and K; on this ſide of the Field alſo: So that you may draw the lines AB, BC, CD, DE, EF, FG, GH, HI, IK, KL, LM, and MA; which ſhall repreſent upon your Table the exact Figure of the Field to be meaſured.

¶ 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; that when you have meaſured your Stationary diſtance OQ, and removed your Inſtrument to Q, and there fixed it; when you direct the Sights to E or K, and meaſure the diſtance QE, QK, and ſet it off from Q, you ſhall find 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 require: Or, if two or three ſmall Cloſes ſhould lie together, by this means they may be Plotted upon one ſheet of Paper by this Artifice; and ſo in this Figure IV. you may imagine the part A, B, C, D, E, K, L, M, to be one Field; and E, F, G, H, I, K, to be another.

II. By the Theodolite.

Fig. IV. **Y**Our Station 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
I i Sights

Sights to A, the Index cutting 19 degrees 10 minutes, and the line OA 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 OB 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 Sights to your second Station at Q, the Index cutting 18 degrees 15 minutes; which note down in your Field-book by it self. Also measure the Stationary distance OQ, 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, turn it about, till through the Sights you espie your first Station at O; then will the Needle hang over the Meridian-line, and the Instrument will be truly situate.

Then direct the Sights to E, the Index cutting 52 degrees 15 minutes, and the line QE containing 5 Chains 10 Links; which must be noted in your Field-book in all respects as formerly. In this manner make Observation of all the other lines and 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	The First Station at O.
B	53	30	7	18	
C	95	15	7	21	
D	132	00	6	33	
E	166	30	5	57	
K	251	30	7	83	
L	282	00	9	95	
M	304	30	8	05	

The Stationary Distance OQ is 8 Chains 89 Links; and the Angle OQN, 18 degrees 15 minutes, the inclination or difference of Meridians.

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

III. *By the Circumferentor.*

Fig. IV. **T**HE 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. 16*. And the work of this Chapter differeth nothing therefrom, 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 find the degrees cut by the Needle to be the same with those collected in your Field-book at your first Station at O, taken with the *Theodolite*. Also, your Instrument being removed to Q, and Observation made of the several 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 kind of Practices hitherto treated of, and not the *Circumferentor*: I only have hinted the Use thereof, that the agreement of the several Instruments might be taken notice of; the *Circumferentor* serving chiefly for large Champain Plains, Wood-Lands, Sea-Coasts, Harbours, &c.

IV. *How to Protract any Observations taken according to the directions of this Chapter.*

Fig. IV. **D**RAW upon your Paper the Meridian-line NOS, the Point O representing your first Station: Upon this Point O place the Center of your *Protractor*, laying the line EF thereof directly upon the Meridian-line NS: Then laying your Field-book before you, observe the degrees there noted, namely,

- (1) at A, 19 degrees 10 minutes, the Line OA containing 7 Chains 46 Links;
- (2) at B, 53 degrees 30 minutes, the Line OB containing 7 Chains 18 Links;
- (3) at C, 95 degrees 15 minutes, the Line OC containing 7 Chains 21 Links;

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 OA, OB, OC, OD, OE, OK, OL, OM; and upon those lines set off the several lengths from O, as you find them collected in your Field-book.

Having

Having thus Protracted the Observation of your first Station, (before you move your *Protractor*) make a Mark against 18 degrees 15 minutes, and draw the line O Q, setting off 8 Chains 89 Links, the length thereof, being the Stationary Distance from O to Q: Then upon the point Q, place the Center of the *Protractor*, as before, moving it up and down, 'till the line O Q 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 several degrees and minutes, as by your Instrument you observed them, together with the lengths of the lines as they were measured, drawing lines through those Points also, as the lines Q E, Q F, Q G, Q H, Q I and Q 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.

C H A P. XVII.

How to take the Plot of a Field at two Stations taken about the middle thereof, from either of which all the Angles in the Field may be seen, by measuring of one Line only.

I. By the Plain Table.

Fig. V. **N**ecessity may sometimes require the Plotting of a Field according to the directions which I shall deliver in this Chapter; yet I would have as little use made thereof as possibly can be, in regard of the acuteness of the Angles, or rather, of the oblique Intersections, which (in some places) the lines at either Station will make one with another: Which is more liable to Errour than any of the ways 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 H.

This

This done, direct the Sights to your second Station at Q, and draw the line OQ upon your Table: Then (with your Chain) measure out your Stationary Distance OQ, which is 7 Chains, and lay it from O to Q; and removing your Instrument to Q, lay the Index upon the line OQ; and looking through the Sights, turn the Table about, 'till you see a Mark set up at your former Station at O, and there fix the Table: And when you have so fixed it, (if you have truly taken your Back-sight, the Needle will hang directly over the Meridian-line of the Card as before) make Observation at Q, as you did before at O. As,

- (1) direct the Sights to A, and draw the Line QA;
- (2) direct the Sights to B, and draw the Line QB;
- (3) direct the Sights to C, and draw the Line QC;
- (4) direct the Sights to D, and draw the Line QD;
- (5) direct the Sights to E, and draw the Line QE;
- (6) direct the Sights to F, and draw the Line QF;
- (7) direct the Sights to G, and draw the Line QG;
- (8) direct the Sights to H, and draw the Line QH.

Now you may plainly perceive by the Figure, where the correspondent Lines at each Station intersect or cross each other. As,

- (1) the Lines OA and QA intersect each other at A:
- (2) the Lines OB and QB intersect each other at B:
- (3) the Lines OC and QC intersect each other at C:
- (4) the Lines OD and QD intersect each other at D:
- (5) the Lines OE and QE intersect each other at E:
- (6) the Lines OF and QF intersect each other at F:
- (7) the Lines OG and QG intersect each other at G:
- (8) the Lines OH and QH 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 Symmetry or Proportion of your Field; as namely, the lines AB, BC, CD, DE, &c.

In this kind of Plotting you cannot but perceive a wonderful quick dispatch, you being to measure nothing but the Distance between your Stations: But by reason of the acuteness of the Angles (without exact and curious drawing of your Lines, and observing well the precise Points of Intersection) you may run into gross absurdities and mistakes.

II. By the Theodolite or Circumferentor.

Fig. V. YOU may perceive by what hath been said in the foregoing Chapter, that the manner of work is the same both with the *Theodolite* and *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 minutes:
- (8) direct the Sights to *H*, the Index or Needle cutting 328 degrees 30 minutes.

This done, measure your Stationary Distance *O Q*, which suppose to contain 7 Chains; and remove your Instrument to *Q*, turning it about, 'till the Needle hang directly over the Meridian line, 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:
- (3) direct the Sights to *C*, the Index or Needle cutting 79 degrees 45 minutes:
- (4) direct the Sights to *D*, the Index or Needle cutting 153 degrees 15 minutes:
- (5) direct the Sights to *E*, the Index or Needle cutting 224 degrees 30 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

(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 put 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.

III. *How to Protract any Observations taken according to the foregoing Directions.*

Fig. V. First draw the Meridian-line N S; upon which line assign 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 look 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 Lines 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 find 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 this Fourth Book, I shall therefore in this place pass it over as superfluous.

C H A P. XVIII.

How to take the Plot of a Wood, Park, or other large Champain Plain, by measuring round about the same, and making Observation at every Angle.

I. *By the Plain Table.*

Fig. VI. **H**itherto we have shewed how the Plot of any Plain and even ground, or any small Enclosure, may be taken several ways, as being the easiest for a Practitioner to try experience upon: I now come to shew how the Plot of any Champain Plain or over-grown Wood may be measured; for in such kind of grounds the former directions will be of little validity, for the largeness of the Plain, or the thickness of the Wood, may many times hinder both your Sights and measuring: Therefore the best way to measure these kinds of Lands is, to go about them, and make Observation at every Angle.

Suppose the following Figure *A B C D E F G* to be a large Wood, or other Champain 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 *B*: Then turn your Index about, and direct the Sights to *G*, the angle on the other side of *A*, and draw the line *A G* upon the Table: But at present you need not to measure the Distance.

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

the Sights to D, and draw upon your Table the line CD: 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 DC, 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 DE: Then with your Chain measure the Distance DE 13 Chains 4 Links, and set 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 DE, 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 EF: Then measure the Distance EF 7 Chains 70 Links, which take from your Scale, and set it on your Table from E to F.

6. Remove your Instrument to F, (placing a Mark at E where it last stood) and lay the Index upon the line EF, 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 FG upon your Table; which line FG will cut the line AG in the Point G: Then measure the Distance FG 5 Chains 67 Links, and set that off upon your Table from F to G.

7. Remove your Instrument to G, (setting up a Mark at F where it last stood) and lay the Index upon the line FG, turning the whole 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 GA, which (if you have truly wrought) will pass directly through the Point A where you first began.

In this manner may you take the Plot of any Champain Plain, be it never so large. And here Note, That many times Hedges are of such a thickness, that you cannot come near 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 self.

Note also, That in thus going about a Field, you may much help your self by the Needle: For look 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 find the Needle to cut the same degree again, which will give you no small satisfaction in the prosecution of your work. And though there be 100 sides or more, your Needle will still cut the same degree at all of them, except you have committed some former Errour; therefore at every Station have an Eye to your Needle as well as to your Back-sight.

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 thereof is as followeth.

Example.

Suppose in going about to take the Plot of the Field A B C D E F G, *Fig. 22.* as in this Chapter is taught, That, you having 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, 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 contain: Then near 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 fairest point that you can bring upon your Table.

¶ And here Note, That the equal parts upon the Frame of your Table are purposely made for the easie and true drawing of these parallel lines.

This being done, mark 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 23d. 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 the best advantage, as at the point O, in the 23d. 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.

Having thus done, proceed with your Work upon your new Sheet, beginning at the point O, *Fig. 23.* 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 from G to A, (by this direction) shifting your Paper as often as you shall have occasion.

H. *By the Theodolite.*

Fig. VI. 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, and laying the Index on the Diameter, 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 deg. 30 min. 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 fifth angle at E; and there fixing it, 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*, 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

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 find 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

III. How to Protract or lay down any Observations taken according to the Doctrine last delivered.

Fig. VI. Consider which way your Plot will extend, and accordingly upon the Paper where you would have the Plot of your Field described, draw a Line at pleasure, as the line G A. 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 A G lie directly under 130 degrees; and then at the beginning of the *Protractor* (which is at 00 degrees, noted in the Figure thereof with the letter E) make a Mark, and through it draw the line A B, 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 A B lies directly under 120 degrees 30 minutes; and then at the beginning of the degrees make a Mark, and through it draw the line B C, 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 B C 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 C D, 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 C D lies directly under 120 degrees 30 minutes; and then making a Mark at the beginning of the *Protractor*, through it draw the line D E, and upon it set 13 Chains 4 Links from D to E.

In this manner must you deal with all the rest of the Angles; and when you come to Protract the angle at F, which is the last angle, and

and have drawn the line *FG*, you shall find 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, practice 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 otherwise, 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 placing the Center of your *Protractor* on the point *F*, and the Meridian-line thereof upon the line *FG*, make 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 *FE*, setting 7 Chains 70 Links thereupon from *F* to *E*.

An in this manner must you proceed with the rest of the lines and angles; and at last you shall find 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 the last Chapter) you should meet with any angle that bendeth inwards in the Field, you must reckon that angle 'by those rank of Figures which begin at 180, and go on 'to 190, 200, 210, &c. and therefore such an angle will always exceed 180 degrees.

IV. *How to know whether you have taken the Angles of a Field truly.*

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 former part of this Chapter, collect the quantity of all the angles found at your several Observations into one Sum, and multiply 180 degrees by a number less by two than the number of angles in the Field: And if the product of this Multiplication be equal to the total Sum of your angles, then is your Work true, otherwise not.

Example.

deg.	min.	In the Work of this Chapter the angles
130	00	found were as in the Margin, the Sum of them
120	30	being 900 degrees 00 minutes. Now, be-
137	30	cause the Field consisted of 7 angles, you
120	30	must therefore multiply 180 degrees by 5,
121	30	(which is a number less by two than the num-
126	30	ber of angles in the Field) and the Product
143	30	will be 900; which exactly agreeing with the
		Sum of all the angles in the Field as you found
900	00	them by Observation, you may conclude that
		your Work is exactly performed.

‘ This Rule is general, provided that we use the Numbers greater than 180, when we have an inward angle.

V. By the Circumferentor.

Fig. VII. HAVING shewn before the Use of the *Circumferentor* in taking the Plot of any small Inclosure several ways, yet for those kind of practices, the *Circumferentor* being 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 *Circumferentor* is a most absolute Instrument for the Surveying of any large and spacious business, as a Park, Wood, or other large Common, Field, or Champain Plain; the Use thereof differing from all that hath hitherto been delivered.

Suppose then that ABCDEFGHK 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 your Sights to B, the South end of the Needle cutting 191 degrees, and the Ditch, Wall, or Hedge AB containing 10 Chains 75 Links: The degrees cut, and the line measured, must be noted down in your Field-book, as in the foregoing Example.

2. Place your Instrument at B, and direct the Sights to C, the South-end of the Needle cutting 279 degrees, and the line BC 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 CD 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 6 Chains 96 Links.

5. Place the Instrument at E, and direct the Sights to F, the Needle cutting 12 degrees 30 minutes, and the line EF containing 9 Chains 71 Links.

6. Place

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 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 Instrument 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 gone round the Field in this manner, and collected the degrees cut, and the lines measured, in the several Columns of your Field-book, according to former Directions, you shall find 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	324	30	7	54
G	98	30	7	54
H	71	00	7	78
K	161	30	8	22

In going about a Field in this manner, you may perceive a wonderful quick dispatch; for you are only to take notice of the degrees cut once at every angle, and not to use any Back-sights, as in the foregoing 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 degrees as before; which ought to be done, and may be without much loss of time.

So the Instrument being placed at A, if you direct the Sights to B, you shall find 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 exactness, (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 care be taken) much labour will be saved. For whereas (by the directions here given) 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. Placing the Instrument at C, and directing the Sights 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 C, and there place your Instrument; and directing your Sights backwards to B, you shall find the Needle to cut 279 degrees, which are the same degrees as were before cut when the Instrument was placed at B; so that the labour of placing the Instrument at B is wholly saved. Then (the Instrument 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 from G to K, and so to every second angle, be there never so many. And here you see that half the labour is clearly saved, and the Work the same as if the Instrument had been placed at either angle.

VI. *How to Protract the foregoing Observations taken by the Circumferentor.*

THE manner of Protracting of any Observations taken by the *Circumferentor*, differeth from that of the *Theodolite*; wherefore according to the largeness of your Plot provide a Sheet of Paper, or skin of Parchment, or writing Vellom rather, as LMNO; upon which draw the line LM, and parallel thereto draw divers other lines quite through the whole Paper or Parchment, as the pricked lines in the Figure drawn between LM and NO: And let the Distance of each of these Parallels one from another be somewhat less than the breadth of the Scale of your *Protractor*. These parallel lines thus drawn do represent Meridians, and are hereafter so called:

Upon

Upon one or other of these lines (or parallel to one of them) the Meridian-line of your *Protractor* (noted in the Figure thereof, with EF) must always be laid, when you Protract any Observations taken by the *Circumferentor*, as in the Chapter before going.

Your Paper or Parchment being thus prepared, assign 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 look in your Field-book what degrees the Needle cut at A, which were 191 degrees: Now, because the degrees were more than 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 AB, 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. 297, therefore the Semicircle must lie downwards; and so holding it, make a Mark against 279 degrees, and through it draw the Line BC, 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 CD, 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 325; 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 DE, making it to contain 6 Chains 96 Links.

5. Remove your *Protractor* to E, laying the Meridian-line thereof upon (or parallel to) one of the Meridians drawn upon your Paper: And because the degrees cut by the Needle at this angle were less than 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 EF, 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 FG, which contains 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: Always observing this for a general 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 less 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.

C H A P. XIX.

How to take the Plot of a Field, or other Enclosure, by going about the same, and measuring only of one Line the Plain Table.

I. By the Plain Table.

Fig. X. **L**ET ABCDEFG be a Field, or other Enclosure to be Plotted. *First*, make choice of some convenient place about the middle of the Field, from whence you may conveniently see all the angles thereof, as at M; where place your Table, turning it about, 'till the Needle hang directly over the Meridian-line in the Card, and there screw fast the Instrument. Then assuming any Point about the middle of your Table, representing the place of your standing in the Field, as M, to this Point apply the side of your Index, and directing the Sights thereof to the first angle at A, by the side of the Index draw the Line MA: Then direct the Sights to the angle at B, and by the side of the Index draw the line MB: Again, direct the Sights to C, and draw the line MC. Do thus 'till you have directed the Sights to all the other angles, as to D, E, F and G, and draw the lines MD, ME, MF and MG.

This done, measure the distance from M, the place of your standing, to any of the angles of the Field, as to A, and let the distance from M to A be 5 Chains 80 Links: Take 5 Chains 80 links from any Scale, and set that distance upon the line MA, from M to A, and mark the Point or Angle A.

Secondly, remove your Instrument from M to A, and there place it, laying the Index upon the line AM, turning the Table about, 'till through the Sights you see a mark set up at M, (the place where your Instrument last stood) and there fix your Instrument: Then apply your Index to the point A, and upon that point turn it about, 'till through the Sights you see the next angle at B: And then by the side of the Index, draw a line which will cut the
line

line MB (before drawn) in the point B; and the line AB will represent the Hedge or Wall AB, and be of equal length therewith.

Thirdly, remove your Instrument to B, laying the Index upon the line MB, and turn the Table about, 'till through the Sights you espie the Mark set up at M, and then fix it.

(¶ And here Note by the way, that when your Table is thus fixed at B, if you lay the Index upon the line AB, and look through the Sights, you shall then see the Angle at A, or place where your Instrument last stood.)

Then lay the Index upon the point B, turning it about, 'till thro' the Sights you see the angle at C, and draw the line by the side thereof, 'till it cut the line MC, which it will do in the Point C; and the line BC shall represent the Hedge BC in the Field.

Fourthly, place the Instrument at C, laying the Index upon the line MC, turning the Table about, 'till through the Sights you see your first mark at M, and there fix it; and laying the Index upon C, direct the Sights to D, and draw the line CD, cutting MD in D: CD doth represent the Hedge CD.

Fifthly, remove the Table to D, laying the Index upon the line MD, and turn the Table about, 'till you espie your Mark at M, and then fix it; and laying the Index upon D, direct the Sights to E, and draw the line DE, cutting ME in E.

Sixthly, place the Table at E, and lay the Index on ME, turning the Table about, 'till you espie the Mark at M; and fixing the Table there, remove the Index to E, and direct the Sights to the angle at F, and by the side thereof draw a line cutting the line MF, formerly drawn in F, which shall represent the Hedge EF.

Sevently, remove the Instrument to F, and lay the Index on MF, turning the Table about, 'till through the Sights you espie the Mark at M; and fixing it there, lay the Index upon F, directing the Sights to the angle at G, and by the side thereof draw a line FG, cutting MG in G.

Lastly, place the Table at G, and lay the Index upon MG, turning it about, 'till through the Sights you see the Mark at M, and there fix it: Then upon G lay the Index, and direct the Sights to your first angle at A; and (if you have committed no former Error) the Index will then fall just upon the point A, in the line AM first drawn. And so is your Plot exactly closed, and your Field finished.

And by this way of Plotting you cannot but perceive wonderful expedition, almost all manner of Measuring being wholly omitted, and only Angular Observations made use of. And this way being well and carefully performed, is not much inferiour to any of the preceeding.

II. By the Theodolite.

Fig. X. HAVING made choice of a place in the middle of the Field, as M, place there your *Theodolite*, turning it about, 'till the Needle hang directly over the Meridian-line of the Card; and there fixing it, direct the Sights to every respective angle of the Field, noting what degrees the Index did cut upon the Frame of the Table, which suppose to be these following.

		Deg.	Min.
The Sights being directed to	{ A }	{ 14 }	{ 30 }
	{ B }	{ 45 }	{ 30 }
	{ C }	{ 95 }	{ 00 }
	{ D }	{ 129 }	{ 00 }
	{ E }	{ 151 }	{ 30 }
	{ F }	{ 212 }	{ 30 }
	{ G }	{ 277 }	{ 30 }

the Index did cut upon the Frame of the Table

Having made Observation of what degrees the Index cut at every angle, and noted them down in your Field-book or Table, as you see done above, then measure the Distance from M to any angle, as to A, and you will find it to be 5 Chains 80 Links; which note down in your Field-book also in this manner,

From Station to the next Angle from the
North-Eastward, 5 Chains 80 Links.

Then placing your Instrument at A, lay the Index on the Diameter of the Table, and turn it about, 'till through the Sights you see the Mark set up at M; and there fixing the Instrument, turn the Index about, 'till through the Sights you see the angle at B; and note the degrees then cut by the Index, which let be 112 degrees 30 minutes.

Then remove the Instrument to B, the Index lying on the Diameter, turning it about, 'till through the Sights you espie the Mark at M, and there fix it; turning the Index about 'till you see the angle at C, the degrees there cutting 114 degrees 00 minutes, and the rest as in the Table following.

		deg. min.	
The Instrument being placed at	{ A }	{ B }	{ 112 30 }
	{ B }	{ C }	{ 114 00 }
	{ C }	{ D }	{ 141 30 }
	{ D }	{ E }	{ 70 00 }
	{ E }	{ F }	{ 120 00 }
	{ F }	{ G }	{ 136 00 }
	{ G }	{ A }	{ 132 00 }

and directed to M, the Index being turned about to the angle will cut

ing. **How to Protract or lay down the Observations taken according to this Doctrine.**

Fig. IX. **U**Pon your Paper or Parchment draw a Right line N S, representing your Meridian, or Line of North and South: About the middle thereof, as at M, assume a Point for your Station in the middle of the Field; upon which Point place the Center of your *Protractor*, the Meridian-line thereof lying exactly upon the line N S. Then having recourse to your Field-book, and finding that directing your Sights to your first angle at A, the Index cut 14 degrees 30 minutes, make a Mark against 14 degrees 30 minutes: also,

Directing the Sights to B, the Index cut 45 degrees 30 min.

Directing the Sights to C, the Index cut 95 degrees 00 min.

Directing the Sights to D, the Index cut 124 degrees 00 min.

Directing the Sights to E, the Index cut 151 degrees 30 min.

Directing the Sights to F, the Index cut 212 degrees 30 min.

Directing the Sights to G, the Index cut 277 degrees 30 min.

Against all which numbers of degrees and minutes make Marks with your Protracting-pin, close to the edge of the degrees of your *Protractor*: [Remembring, that when your degrees exceed 180, as they do at the angle F, you turn the Semicircle of your *Protractor* downwards:] And then through these several Points draw right lines from the Center-Point at M, as the lines M A, M B, M C, M D, M E, M F and M G.

Then, because your measured line from M to the angle A was 5 Chains 80 Links, out of any Scale take 5 Chains 80 Links, and set it upon that line from M to A.

Again, having recourse to your Field-book, see there what degrees and minutes were cut by the Index when the Instrument was placed at the several angles A, B, C, D, &c. and finding that at the angle A, the degrees there cut were 112 degrees 30 minutes, apply the Center of your *Protractor* to the Point A, laying the Meridian-line thereof upon the line A M, and against 112 degrees 30 minutes make a Mark, through which, and the Point A, draw a line, 'till it cut the line M B in B. Then place the Center of the *Protractor* upon the point B, and the Meridian-line thereof upon the line M B, and (because the degrees cut at B were 114 degrees) make a Mark against 114 degrees, and draw the line B C. Do the like for the degrees cut by the Index at the angles at C, D, E, F and G; so shall you have a perfect Draught of your Field. And this way of Surveying is both speedy and exact, if carefully managed.

C H A P. XX.

How to take the Plot of a large Champain, or other Enclosure, upon the Plain Table, upon one Sheet of Paper.

FOrasmuch as the way of Shifting of Paper, taught in the 18 Chapter of this Book, may seem tedious and troublesome, in respect that you may be forced to alter or shift many Sheets for one Field, (especially if you use a large Scale;) I shall therefore here shew you how you may take a large Enclosure upon one Sheet of Paper, which is thus:

Let *ABCDEF G H K*, *Fig. VII.* be a large Champain to be Surveyed, and you would effect it by the *Plain Table*, and bring all your Field-work upon one Sheet of Paper.

First, About the middle of your Table assign a Point at pleasure, as at *O*; and upon that Point, as a Center, describe two Concentrick Circles at about an Inch distance, and the outermost to be within half an Inch of the edge of your Paper, as are the two prick'd Circles in the Figure.

Secondly, Consider where to begin your Work, which suppose at the angle *A*; and there placing your Table, and fixing it, turn the Index about upon the Center *O*, and direct the Sights to *K*, and by the side thereof draw a line from *O*, to the edge of the outermost Circle, and somewhat beyond it; and just without the Circle set a Cypher *o*: Then measuring from *A* to *K*, and finding it to contain 8 Chains 22 Links, set that number upon the Line *O o* between the two Circles: And before you move your Table, lay the Index to the Center *O*, and direct the Sights to *B*, and draw a Line from *O* to the outermost Circle, setting the Figure 1 to the end thereof: And the length *AB* being 10 Chains 75 Links, set that length upon the line *O*, 1 between the two Circles. So shall the angle *o O, 1* upon your Table be equal to the angle *KAB* in the Field.

Thirdly, Remove your Instrument to the angle *B*, laying the Index upon the line *O 1*, and turn the Table about, 'till through the Sights you see the angle at *A*: Then fix the Table, and upon *O* turn the Index, 'till you see the angle *C*; and draw a line from *O* to the outermost Circle, setting to the end thereof the Figure 2; and the length of *BC* being 6 Chains 83 Links, set that length upon the line *O 2* between the Circles. So shall the angle *1, O 2* upon the Table be equal to the angle *ABC* in the Field.

Fourthly, Remove the Table to *C*, laying the Index upon the line *O 2*; turn it about, and direct the Sights to *B*; then fix it, and direct the Sights to *D*, and draw a line from *O* to the outermost Circle,

Circle, setting to the end thereof the Figure 3; and the length CD being 7 Chains 82 Links, set that number upon the line O 3 between the Circles, and (because the angle in the Field at C is an Exteriour or Elbow angle) make a * or other mark upon the line O 3 within the innermost Circle, as is done in the Figure. So shall the angle 2 O 3 be equal to the angle B C D.

Fifthly, Place the Table at D, laying the Index upon the line O 3, and turn the Table about, 'till you see the angle at C, and then fix it: Then direct the Sights to E, and draw a line from O to the outermost Circle, setting 4 at the end of it, and 6 Chains 96 Links upon it, between the Circles. And so is the angle 3 O 4 equal to the angle C D E.

Do thus by removing the Table to the respective angles in the Field, namely to E, F, G, H and K; still remembring to make the point O to represent always the place of your standing. And when you have gone about the Field, 'till you return to the angle A where you first began, you shall find the several Angles to be as in the Figure, namely,

The respective angle	$\left\{ \begin{array}{l} 0 O 1 \\ 1 O 2 \\ 2 O 3 \\ 3 O 4 \\ 4 O 5 \\ 5 O 6 \\ 6 O 7 \\ 7 O 8 \\ 8 O 9 \end{array} \right\}$	$\left\{ \begin{array}{l} \text{on the Table} \\ \text{to be equal} \\ \text{to the angle} \end{array} \right\}$	$\left\{ \begin{array}{l} K A B \\ A B C \\ B C D^* \\ C D E \\ D E F \\ E F G^* \\ F G H \\ G H K^* \\ H K A \end{array} \right\}$	$\left\{ \begin{array}{l} \text{in the Field.} \end{array} \right\}$

And having gone round the Field, and made Observation at every angle as is here delivered, noting the Exteriour (or Elbow) angles D, G and K, with Marks, as * or the like, you may Protract the same at leisure, according to the Directions given in the next Chapter.

How to Protract the Observations taken by the Directions of the last Chapter.

HAVING made Observation at every angle, *Fig. VII.* and drawn lines from the Center O to the outermost Circle, and marked them at the ends with Arithmetical Figures, and noted the Exteriour (or Elbow) angle as is there directed; then (according to the Largeness of your Plot you intended) provide a Skin of Vellum or Sheet of Paper, and considering which way your Work will extend, accordingly make choice of a Point representing your first angle, as the Point A: Then repair to your Circular Scheme, and finding that your first line marked with the Cipher 0 contained

8 Chains

8 Chains 22 Links, lay down a line of that length, as the line A K: Then in regard that the first angle in your Circular Scheme $\circ O 1$ was equal to the angle K A B in the Field, you must therefore upon the Point A

[Either by the 4 *Problem* of the *First Book*, or by the *Directions* given in the *First* and *Second Chapters* of this *Fourth Book*]

Protract an angle equal to $\circ O 1$, which will be the angle K A B; and setting off from A 7 Chains 75 Links (the length of the line $\circ O 1$) it shall give you the Point B.

Then upon the Point B protract an angle equal to the angle $1 O 2$, equal to A B C, and upon it set 6 Chains 83 Links; so shall you have the Point C.

Again, upon the Point C Protract an angle equal to the angle $2 O 3$, taking out of your Scale 7 Chains 82 Links, the number belonging to the line $O 3$: Against which lines you find this mark*; which shews, that this angle at C must be Protracted outwards, or from the Field, as is the angle B C D, equal thereto.

In like manner deal with the angles D, E, F, G, H and K: And when you have come to the angle H, you shall (if you have truly wrought) find that the line H K would cut the line A K in its true point K, whether you had set off 8 Chains 22 Links thereupon or not.

C H A P. XXI.

How to take the true Plot of a Forest, Chase, Wood, Park, or other large Inclosure, by the Circumferentor or Theodolite, by a different way from the former; and to know (before you begin to Protract) whether your Plot will close or not.

THIS way of Surveying is the most exact and absolute of all others for the Surveying of Counties, and all other large and capacious Works, as of Islands, Plantations, &c. For the performing of this Work, the Card of the *Circumferentor* must be divided into four Quadrants or Quarters, each containing 90 degrees, and numbred by 10, 20, 30, &c. to 90, beginning at the Meridian, and so reckoning to the East and West Points; as is expressed in the Figure of the Card mentioned in the Tenth Chapter of the *Second Book*, Fig. IV.

Your Instrument being provided with such a Card as I just now mentioned, you may proceed to take the Plot of the ground you intend in manner following. But first provide your Field-book, which
(in

(in this case) must be ruled with Red-ink into six Columns. The first of which must be so broad as to contain the number of degrees, and the quarter of the Compass 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 containeth. 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 Work, and discover whether your Plot will close or not, before you proceed to Protract it.

I. *The manner of Working.*

Fig. XI. **L**et ABCDEFGHK be a Field to be measured. Having placed marks at every angle thereof; *first*, place your Instrument at A, (the Flower-de-luce 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 SW 54 degrees 0 min. representing South-west 54 degrees 0 min. 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 BC containing 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 CD containing 3 Chains 35 Links.

Fourthly, place your Instrument at D, and direct the Sights to E, the Needle cutting North-east 31 degrees, and the line DE containing 4 Chains 55 Links.

Fifthly, place your Instrument at E, and direct the Sights to F, the Needle cutting North east 56 degrees, and the line EF containing 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 FG containing 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 GH containing 2 Chains 95 Links.

Eighthly, place your Instrument at H, and direct the Sights to K, the Needle cutting South-east 34 degrees, and the line HK containing 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 KA containing 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 find them to stand as followeth.

The Figure of your Field-book.

		deg. m.	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				

II. How to Examine your Work, whether you have truly wrought or not.

YOur Work being finished, the degrees cut by the Needle, and the length 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 may by help of the lines of Sines and Numbers, or by the Table of Sines and Logarithms in the *Third Book*, very speedily make trial, and discover wherein you have erred, and amend that Errour before you proceed farther. 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 Sine of 90 degrees,
is to the length of the side of the Field in Chains and Links,

So

So is the Sine of the Complement of the deg. 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 Degrees cut by the Needle to the length in the Parallel.

‘But when the length is near 10 Chains, this extending will be not so convenient, unless the Sines and Numbers are back to back, as hinted at in *Chap. 4. Book 2.* But if your Compasses are long enough to reach from the Radius to the middle 9, the work will do very well: But if not, extend the Compasses from the first Term in the Proportion to the Third, and that extent will reach from the Second to the Fourth.

¶ 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 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.

E X A M P L E.

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 degrees 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 deg. to 5 Chains 12 Links in the 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 Compass 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

being 2 Chains 89 Links, if you extend the Compasses from the Sine of 90 degrees to 2 Chains 89 Links 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 Compass was North-west) set 2 Chains 4 Links (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 CD being 3 Chains 35 Links, if you extend the Compasses from the Sine of 90 degrees to 3 Chains 35 Links in the line of Numbers, that extent will reach from the Sine of 76, which were the degree 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 of 14 degrees, which is the Complement of the degree 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 the quarter of the Compass was North-west) let 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 DE 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 Compass 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 EF 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

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 Compass 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 degrees, and the length of the line FG 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 Compass 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 degrees, and the length of the line GH 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 Compass 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 Column of South; and so have you done with your seventh Station at G.

Eighthly, The degrees cut by the Needle, when the Instrument was placed at H, being S E 34 degrees, and the length of the line HK 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

fore (because the quarter of the Compass 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 Column 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 SW 4 degrees, and the length of the line KA 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 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 (because the quarter of the Compass 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 Column 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 find them to stand in the Field Book, as followeth.

The Figure of your Field-book.

		deg. m.	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, add all the Figures in the *North* Column together, and you shall find that they make 10 Chains 40 Links; also add the *South* Column, and they make 10 Chains 40 Links: Then add the *East* Column, and they make 9 Chains 49 Links; *lastly*, add the *West* Column, and they also make 9 Chains 49 Links.

Now

Now because 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 are equal, you may be assured that your Work is true: But if the Sums of the *North* and *South* Columns had differ'd, your Angles or Sides had been falsly observed; and also if the Sums of the *East* and *West* Columns had differ'd, it had discovered an errour: But being they agree, you may be assured your Work is true, and therefore may with confidence proceed to Protraction, according to the Directions following.

How to Protract any Observations taken according to the Directions of the last Chapter.

Fig. XI. **U**PON a Sheet of Paper or Parchment draw first a line, as SN, representing the Meridian, and at right angles here to another line EW, representing the Parallel: Then laying your Field-book before you, you shall find in the *South* Column 2. 97; wherefore take in your Compasses 2 Chains 97 Links, and place it upon the Meridian from A to 1.

Secondly, In the *North* Column you find 2. 04: Take 2 Chains 4 Links in your Compasses, and set that Distance upon the Meridian from 1 to 2. And because you change your Column from *South* to *North*, you must set your 2 Chains 4 Links from 1 to 2 downwards towards the N.

Thirdly, In the *North* Column you shall find 0. 93: Take 0 Chains 93 Links in your Compasses, and set that Distance upon the Meridian from 2 to 3.

Fourthly, In the *North* Column you shall find 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 find 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 find 1. 83: Take 1 Chain 83 Links in your Compasses, and set that Distance upon the Meridian from 6 to 7. And here again, because you change your Column from *North* to *South*, you must set your 1 Chain 83 Links from 6 to 7 upwards towards the *South*.

Eighthly, In the *South* Column you shall find 2. 68: Take 2 Chains 68 Links in your Compasses, and set that Distance upon the Meridian from 7 to 8.

Ninthly,

Ninthly, In the *South* Column you shall find 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 wrought.

Thus have you found the Points 1. 2. 3. 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-book, where in the *West* Column you shall find 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 find 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 find 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 find 2. 35: Take 2 Chains 35 Links in your Compasses, and set that Distance upon the Parallel from 3 to 4. And here, because you change your Column from *West* to *East*, you must set your 2 Chains 35 Links from 3 to 4 backward towards A.

Fifthly, In the *East* you shall find 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 find 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 find 2. 30: Take 2 Chains 30 Links in your Compasses, and set that Distance upon the Parallel from 6 to 7.

Eighthly, In the *East* you shall find 1. 82: Take 1 Chain 82 Links in your Compasses, and set that Distance upon the Parallel from 7 to 8.

Ninthly, In the *West* you shall find 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 and 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

This done, you shall find 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 cross 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 find it to contain 5 Chains 12 Links.

Likewise the Lines 2 C and 2 C cross one another in the Point C.
Likewise the Lines 3 D and 3 D cross one another in the Point D.
Likewise the Lines 4 E and 4 E cross one another in the Point E.
Likewise the Lines 5 F and 5 F cross one another in the Point F.
Likewise the Lines 6 G and 6 G cross one another in the Point G.
Likewise the Lines 7 H and 7 H cross one another in the Point H.
Likewise the Lines 8 K and 8 K cross 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 Survey'd. And this way for exactness exceedeth any other that I know of.

C H A P. XXII.

How to take the true Plot of a Wood, or other Enclosure, into which you cannot come to fix your Instrument, or to Measure your Distances.

I. *By the Plain Table.*

LET ABCDEF (*Fig. XXIV.*) be a Wood, first assign a place to begin at, without the Wood, which let be at the angle at A: From whence, measure to a Mark set up at the next angle at B, which Distance let be 2 Chains 05 Links.

Secondly, Place your Instrument at B, and assign some convenient point upon your Table to represent the same, and draw a line thereupon, set upon it your Measures distance from B to A.

Thirdly, Lay your Ruler and Sights upon this line, and move the Table about 'till you see your Mark at A, and there fix the Table: Then,

Fourthly, Lay your Ruler to the point B, and direct your Sights to a Mark set up at C, and by the edge of it draw a line, and Measure the distance from B to C, which suppose to be 1 Chain 48 Links, which distance set from B to C.

Fifthly, Remove your Table to C, laying the Ruler upon the line C B, and turn it about 'till you see your Mark at B, and then fix it;

R r

and

and turn the Ruler about upon the point C, 'till you see a Mark set up at D, and by the side thereof draw a line, and Measure the distance C D, which suppose to be 2 Chains 06 Links, which distance set upon the line from C to D.

Sixthly, Remove your Table to D, laying the Ruler upon D C, and turn the Table about, 'till you see your Mark C, and there fix it, turning the Index about upon D, 'till you see a Mark set up at E, drawing a line by the side of it: Then measure the distance from D to E, which let be 4 Chains 75 Links, which set upon the line from D to E.

Seventhly, Remove your Table to E, laying the Index upon the line E D, and turn the Table about, 'till you see the mark at D, and there fix it, turning the Index about upon the point E, 'till you see a Mark set up at F, drawing a line by the side of it. Then measuring the distance from E to F, suppose 2 Chains 15 Links, set that distance upon the line from E to F.

Lastly, Remove your Table to F, laying the Index upon the line F E, and turn the Table about, 'till through the Sights you see the Mark at E, and then fix the Table, and turning the Index upon the point F, direct your Sights to your Mark first set up at A, and measure the distance F A, which will be 2 Chains 62 Links. And so is your Wood inclosed.

II. By the Theodolite.

HAVING assigned an angle without the Wood whereat to begin, as at A, (*Fig. 24.*) set your Instrument at the next angle at B; then measure the distance from A to B, which suppose 2 Chains 05 Links, which set down: Then turn the Instrument about, 'till through the fixt Sights, you see your next Mark at C, and then fix it, and turn the Index about 'till you see your last Mark at A, and note what Degrees are cut, which we will suppose to be 93 degrees, which set down in your Book.

Then measure the Distance from B to C, suppose to be 1 Chain 48 Links, which set down: Then set up your Instrument at C, turning it about upon the Staff, 'till through the fixt Sights you see your next Mark D, and then fix it, turning the Index about, 'till through the Sights you see your Mark at B, where we suppose it will cut 257 degrees. And working in this manner at every of the other angles, and measuring the several distances, you will find them to be as in this Table.

		C. L.			Deg.		
From	A	to	B	is	ABC		
	B		C		BCD		
	C		D		CDE		
	D		E		DEF		
	E		F		EFA		
	F		A		FAB		
					and the Angle		
					is		
					93		
					257		
					44		
					79		
					145		
					97		

III. How

III. *How to Protract according to these Observations.*

‘I Need say nothing concerning the Protraction hereof, it being performed in the same manner as the Protraction in *Chap. 18.*
 ‘But the very sight of *Fig. X.* will be better Direction, than a whole Chapter of Information, and therefore to it I refer it.

C H A P. XXIII.

How to take the Plot of a whole Mannor, or of divers parcels of Land lying together, whether Wood-lands or Champain Plains.

I. *By the Plain Table.*

Fig. XIII. **A**Lthough practice, in the performance hereof, be better than 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 Mannor, 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 *13 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 Mannor, 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, Mills, High-ways, 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 Mannor, 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) assign any point at pleasure, as *A*; unto which point lay the Index,
 and

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 LA, 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 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 ML, 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 find 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 espie 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 NM, 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 espie the next angle at P, and draw a line by the side thereof: Then measure the distance NP 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 Mannor, making Observation at every angle thereof, as at PQSTYXGH 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 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 as is taught in the 18 Chapter of this Book.

Having

Having thus drawn the true Plot of the outward bounds or Periphery of the whole Mannor 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 A L before drawn, and turn it about 'till through the Sights you espie 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 espie a Mark set up at the angle B, and by the side of the Index draw the line A B, 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, and 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 O C, 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 espie 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 espie the angle at S; and there fixing it, turn the Index about upon the point T, 'till through the Sights you espie the next angle at V, and by the side of the Index draw the line T V, 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 V G, 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 espie the angle at R, and by the side of the Index draw the line QR, containing 10 Chains 75 Links, which set from Q to R.

Lastly, Bring your Table to R, and laying the Index on the line QR, 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 espie the angle at D, and draw the line RD, 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 Mannor, or of several Inclosures; in the performance whereof I have been something 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 abbreviated, and the same thing effected with almost half the measuring.

1. 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 espie the next angle at L: Then draw the line AL, 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 K, and by the side of the Index draw the Lines AB, and AK; but you need not measure the lengths of them.

2. Then go forward with your Work as in the former part of this Chapter, placing your Table at the angles LM and N; and when you come to N, and have drawn the line NP, you may (before you move your Table) draw the line NO, but not measure it.

3. Also when you come to the angle Q, and have drawn the line QS, you may draw the line QR also, at once placing of the Table.

4. When you come to observe at the angle T, and have drawn the line TY, you may at the same time also draw the line TV, but need not measure it.

5. When you come to the angle G, and have drawn the line GH, you may also draw the line GV, which will cut the line TV in the point V; and at the same time also you may draw the line GF, containing 6 Chains 68 Links.

Having thus gone round the whole Mannor, and made a Plot of the outward part or Periphery thereof, and also drawn the lines AB, NO, QR, TV, GV and GF, as you went along the bounder, the remainder of the Work will (by this means) be much abbreviated, for you have no more to do, but

I. To

1. To place your Table at F, laying the Index upon the line FG, and to turn it about 'till through the Sights you espie the angle at G: And fixing it there, direct the Sights to E, and draw the line EF, containing 5 Chains 50 Links.

2. Place the Table at E, and lay the Index on the line EF, 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 espie the angle at C, and by the side of the Index draw the line EDC, which containeth 10 Chains 22 Links. Then, because from C to D there are 4 Chains, set 4 Chains from C to D, and draw the line DR, which will cut the line QR in the point R, leaving the line DR to contain 5 Chains 3 Links.

Lastly, Place the Table at C, laying the Index on the line CE, 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 CB and CO. And thus have you upon your Table an exact Plot of your Mannor 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 Mannor 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 find that those Plots (if your work be true) will justly fill the Plot of the whole, leaving no vacuity.

II. *By the Theodolite or Circumferentor.*

Fig. XIII. **BY** what hath been hitherto delivered concerning the Harmony between the *Theodolite* and *Circumferentor*, 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 ALMNPQRSTVXG HK represented part of a Mannor. Then having provided your Field-book ready Ruled, you must at the head of one of the leaves thereof write the Title of the Mannor, the County in which it is, and who is Lord thereof, As,

*The Mannor 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 Tenant's name, the name of the Close, and the tenure by which he holds the same. So for the first Close,

Henry Grey, Cosbye 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 and fourth Columns.

2. Remove your Instrument to L, and direct the Sights to M, the Needle cutting 181 degrees 30 minutes, and the line L M 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 Hedge or bounder A L M N, adjoining to *Wisby Common*, (which appertaineth to another Mannor, 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 degrees 40 minutes, 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 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 you 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 Hedge 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 withal 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, and then it is not material:) Wherefore 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 $\odot$ or the like Mark, and write the Title for your second Close thus:

Samuel White, Bay Wood, by Lease,
begin at $\odot$.

By this means you shall readily know, when you come to protraction, where to begin with this parcel, and in the margin 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 do-

ing you shall find that at your first Observation from C to E, you went partly by the Hedge 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 & Church-Field*, there drawing a line: Then at your two next Observations at E and F, you went along the Hedge or Bounder

The Mannor of Elsmore in the

County of S. for the Honourable

R. B. Lord thereof.

(1) *Henry Grey, Cosby Close, Pasture, Free.*

160	45	8	68	
181	30	6	55	<i>Wisby Common.</i>
233	00	7	27	
355	40	4	45	$\times$ <i>Banton Plain.</i>
309	30	6	64	
54	00	8	5	$\odot$ <i>Bay Wood.</i>
19	30	6	43	

Bounder of *Church-Field*; and at the three last Observations at G H and K, you went against the Hedge or Bounder of *Wisby Common*, there finishing your second parcel: Wherefore draw a double line quite thro' 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 the 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, and 4 Chains 45 Links, make this $\times$ or some other mark for a remembrance when you come to Protraction. Then for the next parcel write in your Field-Book,

(2) *Samuel White, Bay Wood*, by Leate, begin at $\odot$.

220	00	10	22	<i>Banton Plain, and Church-Field-</i>
15	10	5	50	
227	45	6	68	<i>Church Field.</i>
87	30	6	84	
113	30	6	73	<i>Wisby Common.</i>
153	30	6	69	

(3) *George Burton, Banton Plain*, for two Lives, begin at $\times$.

220	20	9	32	<i>Wisby Common.</i>
299	30	10	50	<i>the Forrest.</i>
15	40	10	75	$\times$
52	30	5	3	<i>Church Field.</i>

(4) *Thomas King, Church-Field*, by Leate, begin at $\times$.

316	20	13	12	<i>the Forrest</i>
17	15	10	83	<i>Church-lane.</i>
56	00	6	15	
24	10	6	28	<i>Odcumb Close.</i>

(5) *John Nichols, Odcumb Close*, Free, begin at—

334	30	7	3	
48	30	6	25	<i>Church Lane.</i>
101	30	6	18	

George Burton, Banton Plain, for two Lives, begin at $\times$.

This being done, place your Instrument at N, and direct the sights to P, the Needle cutting 220 degrees 20 minutes, and the line NP 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

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*, which were 15 degrees 40 minutes, and 10 Chains 75 Links; against which in your Field-book, make this x 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 x.

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 (remembering the premisses) to draw a Plot thereof at any time; remembering always, that those numbers in the margent of your Book ought to be placed severally in your Plot in those Closes they represent.

These Instructions given being sufficient for the application and use of the Field-Book, I shall desire every Practitioner to make frequent Trial and Practice thereof, and compare the Book with the Plot; and protracting the same according to the directions hereafter given, you will find 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 and Protracting: But by small practice this and divers other Abbreviations 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 work of this Chapter, with the several Lines, Angles and Bounders, as you observed them in your Survey.

C H A P. XXIV.

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.

Fig. XIV. **P**ROvide a Skin of Vellum, or Parchment, or divers Sheets of Paper neatly fastned together with mouth-glue 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; upon 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; and staying the Protractor there, look in your Field-book what deg. and minutes the Needle cut at your first Observation at A, which 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 AL, 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 LM, 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 MN, containing 7 Chains 25 Links.

Then place the Center of the Protractor upon the point N, the degrees cut being 355 degrees 40 minutes, the line NO containing 4 Chains 45 Links; and because against these 355 degrees 40 minutes you find in your Field-book this mark x 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 find 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

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 $\odot$, 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 mind 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. 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.

C H A P. XXV.

By way of Conclusion to this Fourth Book, and clearing of some doubts that may arise therein.

WHereas throughout this *Book* almost in every *Chapter* you meet with these or the like words, *Place your Instruments at the Angle A, or B, &c.* it is not there supposed you should set your Instrument in the very angular point, for that is impossible to be done but at some competent distance from it, for *Banks, Bushes, Trees,* or the like Obstacles (almost in every Field) will prevent you. You must therefore set your Instrument as near as conveniently you can, and measure from your Instrument to those small returns which you shall find almost at every eminent turning. Neither when I say, *Measure the length of the Line AB or CD,* do I mean that you should go on the top of the Bank among the Bushes, or in the Ditch, but at a competent distance from all these Obstacles: but yet you ought to measure parallel to the Hedge or Bank, and give it its due Length. And whereas in other places I say, *Place your Instrument at every Angle,* I do not by those words mean at every small bowing, which returns again to a straight Line suddenly, or at every small Crook of a River or Rill; but I mean at every grand or eminent Angle, that varies the Coast 3, 4, or 5 Points of the Compass, and so goes on for a considerable Length together: for the fewer times you remove your Instrument, the more exactly shall you perform your Work. For I have Surveyed a Field that hath had above 20 sides and as many Angles in it, and yet placed my Instrument but in 3 Places in going round about the Field; and in my measuring from Station to Station I have taken in all my smaller Angles and Out-lets, with Gates, Stiles, Trees standing alone, and the like. For those ways taught of Measuring of Fields at *One, Two,*

or *Three Stations* taken in the Middle thereof, or at any one *Angle*, will in the Survey of very large Enclosures stand you in as much stead as in Measuring of small Grounds: and what Instrument soever you use, the Reason is the same in all, although the manner of Work do differ.

In casting up the Content of Plots when they are taken, I say, *You must divide your Field into Trapezias and Triangles*. It is true, so you must: but when you have a large thing plotted, and you are to give the Content thereof in Gross, then draw the greatest *Trapezia* that possibly you can in the Middle of the Plot, and then you will have only the small Out-lets to measure by *Triangles*, which being but small can make little or no variation or difference in your Content. But the principal care will be to measure the Diagonal and Perpendiculars of the middle large *Trapezia*; for missing in taking of the Lengths of either of them will occasion a great Errour, and therefore it ought to be very circumspectly performed.

‘ I have in this place given a slight Caution concerning these Matters; but you will find ways following in this Book, whereby they will be all easily prevented.

The End of the first Part of the Fourth Book.



THE



THE FOURTH BOOK.

The Second Part.

C H A P. I.

How to find 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 contain. In the performance hereof you must consider, that the Original of the mensuration of all superficial Figures, such as *Land, Board, Glass*, 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 *Trapezoid*, 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,

I. Of

I. Of the Geometrical Square.

A *Geometrical Square* is a Figure consisting of four equal sides; and as many equal Angles; as is the Square ABCD, (*Fig. 25.*) whose sides are all equal, which containeth six equal parts, which may be attributed either to *Inches, Feet, Yards, Perches, Chains,* or any other measure whatsoever.

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, (*Fig. 25.*) to be a piece of Land, and the side thereof to contain 6 Perches, therefore multiply 6 in it self, that is, multiply 6 by 6, and the product will be 36; and so many Perches doth the Square piece of Land contain.

And here observe, that if the linear Measure had been Feet, the Content had been superficial Feet; or if the Length had been taken in Yards, the Content had been superficial Yards, &c.

II. Of the Long Square or Parallelogram.

A *Long Square or Parallelogram*, is a Figure consisting of four sides, as ABCD, (*Fig. 26.*) the two opposite sides whereof are equal, as the sides AB and CD, and likewise AC and BD; each of the shorter sides containing 7 Perches, and the longer sides 13 Perches.

To find the superficial content of this *Long Square or Parallelogram*, you must multiply one of the longer sides by one of the shorter, that is, multiply 7 by 13, and the product will shew the superficial Content thereof.

Example. The longer side of the Square contains 13 Perches, and the shorter 7 Perches; now if you multiply 13 by 7, the product will be 91, and that is the Content of the Square in Perches. If the Numbers 13 and 7 had represented linear Feet, the Product 91 had been Superficial Feet.

There are two other 4 sided Figures, which may be said to have some regularity, and often fall out in Buildings, *viz.* a Parallelogram (as ABCD, see *Fig. 27.*) having its opposite sides both ways parallel, or such a Figure as hath only two sides parallel as GHJK, (see *Fig. 28.*) For the first multiply one of the sides AB by AE the Perpendicular distance of AB from its opposite CD (produced if need require it) and the Product is the Content. That is,

	Feet.
AB	9
AE	11

99 the Content.

For

For the latter Figure, multiply half the sum of the parallel sides GH and KI by their distance LM, and you have the Content, that is,

	Feet.
KI ———	14
GH ———	10
$\frac{1}{2}$ of ———	24
is ———	12
LM ———	7
	84 the Content.

1. Half the length of the Base, being multiplied by the length of the Perpendicular, shall be equal to the *Area* of the Triangle.

Or, 2. Half the length of the Perpendicular, being multiplied by the whole Base, will be the content of the Triangle.

Again, 3. The whole length of the Perpendicular, being multiplied by the whole length of the Base, half the product shall be the Content of the Triangle.

EXAMPLE.

Suppose you were to find the *Area* or content of the Triangle A B F (*Fig. 29.*) 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 the 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 1392, the half whereof is 696, the *Area* or content of the Triangle as before. And of these three Methods, the fittest for Surveying is this last, the other two for Building.

And here Note, That though the Perpendicular B E had fallen without the Triangle on the Base produced (as in *Fig. 31.*) yet still the Product made by multiplying the whole length of the Base A F by the Perpendicular, had been double the content of the Triangle, as before; and all the three preceeding Rules would hold good.

Lastly, if through the middle of the Perpendicular or Sides, in either Example, be drawn a line parallel to the Base, as G H; then G H (in the first Example) $26 \frac{1}{2}$ multiplied by the Perpendicular, gives the content. And this is common in measuring Buildings.

IV. Of the Trapezia.

A *Trapezia* is a Figure consisting of four unequal sides, and as many unequal angles, as is *ABCD*, *Fig. 30*.

To measure this *Trapezia*, you must first draw the Diagonal line *BD*, for by this means the Figure is reduced into two Triangles, as *ADB*, and *CDB*: Then if you let fall the Perpendiculars from the points *A* and *C*, you may measure them by the last Example as two Triangles, the sums whereof being added together will be the *Area* or content of the whole *Trapezia*.

EXAMPLE.

Having drawn the line *BD*, and so reduced the *Trapezia* into two Triangles, and let fall the Perpendiculars *AE* and *CF* upon the line *BD*, which is the common Base to both the Triangles, you may find the *Area* of the whole *Trapezia*, thus:

Suppose the Perpendicular *CF*, were 102 Perches, the Perpendicular *AE*, 118 Perches, and the Base *BD*, (which is common to both Triangles) 300 Perches.

Now if according to former directions, you multiply 300, the Base, by 59, half the Perpendicular *AE*, the product will be 17700, for the content of the Triangle *ABD*.

In like manner, if you multiply 300, the Base, by 51, half the Perpendicular *FC*, the product will be 15300, for the content of the Triangle *BCD*.

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 ABCD*.

But this Work may be performed with more Brevity, for there are as many varieties of measuring of *Trapezia*'s, as there were of Triangles, namely three.

In respect the Base *BD* is common to both the Triangles, you may therefore add the two Perpendiculars together; the half of which being multiplied 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 sum 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,

2. You may multiply 220, the sum of the Perpendiculars, by 150, half the length of the Base, and the Product will be 33000, as before.

Or,

3. You

3. You may multiply the sum of the Perpendiculars, 220, by the Base, 300, and that product will be 66000; the half whereof is 33000, as before. And this last Method is fittest for a Surveyor.

And these Rules are also true, though one or both of the Perpendiculars should fall without (as in *Fig. 31*;) for then the sum of the Perpendiculars BE and CD, multiplied by the Diagonal AF, produces the double content.

V. Of Irregular Figures, how to reduce them into Triangles or Trapezia's, and to cast up the Content thereof.

Let ABCDEFGH (*Fig. 32.*) 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 Square, 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 another, as the lines AD, DB, AF, and FH; then will the whole Figure be reduced into six Triangles, as

- | | | |
|----------------------|---|----------------------|
| 1. The Triangle BCD, | } | 4. The Triangle AEF, |
| 2. The Triangle ADB, | | 5. The Triangle AFH, |
| 3. The Triangle ADE, | | 6. The Triangle FGH. |

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	}	should contain	{	72	}	Perches.
		A D B						
		A D E						
		A E F						
		A F H						
		F G H						
						84		
						110		
						121		
						165		
						66		

The Sum 618.

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 abbreviation of this Work, you need not to find the *Area* of every Triangle, but of every Trapezia, as is before taught; for the Figure is as well divided into Trapezia's as Triangles, namely, into the Trapezia's ABCD, ADEF, AFGH.

By this means you need but to find the *Area* or content of these three Trapezia's, which will abbreviate nigh half of the Arithmetical

cal Work: For if you measure the three *Trapezia's* severally, as hath been taught in this Chapter, you shall find

$$\text{the Trapezia } \left\{ \begin{array}{l} A B C D \\ A D E F \\ A F G H \end{array} \right\} \text{ to contain } \left\{ \begin{array}{l} 156 \\ 231 \\ 231 \end{array} \right\} \text{ Perches.}$$

The Sum 618.

These three Numbers being added together produce 618, exactly agreeing with the former.

Or rather thus, add the double content of all the *Trapezia* and *Triangles* together, and then half the sum will be the content sought, *e. g.* (See *Fig. 33.*)

Perpend. {	BH— 9	Perpend.— 9	DN
	KD— 6	Base, — 10	FE
	—		—
	15	double Content	90
Diagonal AC	23		
	—		
	45	Perpend. {	LD 10
	30		GM 7
	—		—
double Content	345	Diagonal AF	17
			19
			—
			153
			17
			—
		double Content	323

$$\left. \begin{array}{r} 345 \\ 90 \\ 323 \end{array} \right\} \text{double Content.}$$

the $\frac{1}{2}$ of 758 is 379 double the Content of the whole.
is 379 the true Content.

Or the Contents of any Field may be readily cast up thus: Take every Base and every Perpendicular of every Triangle, and every Diagonal of every *Trapezia*, in Links, esteeming every Chain one 100; in every *Trapezia*, multiply the sum of the Perpendiculars by the Diagonal; and in every single Triangle, the base by the Perpendicular; then add the several Products together: Then from the right hand make a Dash between the fourth and fifth places, and another between the fifth and sixth; then halve the Figures to the left hand of the Dashes, and so will this half be Acres. If an Unite remain, that Unite is an half Acre or two Roods; and if the Figure between the Dashes be five or more, take five from it, and account it

it another Rood: Lastly, Multiply the remaining Figure between the Dashes by 8, and to product, add the Tens to be carried from the fourth Figure, and you have the Perches. If any Person is so curious, as to esteem the Decimal parts of the Perches, they will be the Product made by multiplying the Figures to the Right-hand of the Dash by 8. So in Figure 36 the Operation will be thus.

$\begin{array}{r} 313 = AC \\ 612 = DE \\ \hline 925 \\ 725 = BR \\ \hline 4625 \\ 1850 \\ \hline 6475 \\ \hline 670625 \end{array}$	$\begin{array}{r} 214 = KL \\ 396 = HI \\ \hline 610 \\ 500 = FM \\ \hline 305000 \end{array}$	$\begin{array}{r} FG = 418 \\ AH = 900 \\ \hline 376200 \end{array}$
--	--	--

	$\begin{array}{r} 670625 \\ 305000 \\ 376200 \\ \hline 13 5 1825 \\ A. R. P. \\ \text{Answer, } 6 . 3 . 1 \end{array}$
--	--

Here half 13 gives 6 the Acres, and one remaining is 2 Roods; then the 5 between the Dashes gives another Rood; and so the whole is 6 Acres and 3 Roods; and because there is but one Ten to be carryed from the fourth place, and that after the 5 is taken out of the fifth, there remains nothing, there is but one Perch.

In like Manner if the whole Sum of all the

	$\left. \begin{array}{l} 17 4 5364 \\ 11 9 2765 \\ 10 5 4321 \\ 8 4 3764 \end{array} \right\} \text{Products be}$	the Content is	$\begin{array}{r} A. R. P. \\ 8 . 2 . 36 \\ 5 . 3 . 34 \\ 5 . 1 . 03 \\ 4 . 0 . 35 \end{array}$
--	---	-------------------------	---

So if the sum of the Products be 41|7|6354. the Content is A. R. P. 20 . 3 . 21|0832. But this Method must be only used when the Figure is reduced to Triangles and Trapezias.

2. To find the Area or Superficial Content of a Circle.

TO find the Area or Content of any Circle, you must multiply the Diameter thereof in it self, and multiply that Sum by 11, which Product being divided by 14, shall give you the Area of the Circle.

E X A M P L E.

In this Circle ABCD, (*Fig. 34.*) let the Diameter thereof DB be 28, which multiplied in it self giveth 784, this number multiplied by 11 giveth 8624, which being divided by 14, the Quotient will be 616; and that is the *Area* of the Circle.

Or thus: Half the Diameter multiplied by it self, and the Product again by 3 and $\frac{1}{7}$ gives the Content.

Thus $\frac{1}{2}$ the Diameter

$$\begin{array}{r}
 14 \\
 14 \\
 \hline
 56 \\
 14 \\
 \hline
 196 \\
 3 \frac{1}{7} \\
 \hline
 588 \\
 28 \\
 \hline
 \end{array}$$

616 the Content.

Or thus: From the Product made by multiplying the Circumference by it self subtracted $\frac{1}{7}$ part of the Product, and divide the Remainder by 11.

The Circumference

$$\begin{array}{r}
 88 \\
 88 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 704 \\
 704 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 8) 7744 \\
 968 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 11) 6776 \\
 616 \\
 \hline
 \end{array}$$

The Content 616

3. To find the Area or Content of a Semicircle, Quadrant, or other Sector of a Circle.

ALL these Portions of Circles are measured by this one general Rule, *viz.*

Half the length of the Arch-Line, being multiplied by the *Radius*, or half the Diameter, shall give the content of that Semicircle, Quadrant, or Sector.

E X A M-

1 *E X A M P L E.*

For the Semicircle ABC (*Fig. 34.*) half the Arch-Line thereof is 22, and half the Diameter OC or OA is 14, which multiplied together make 308 for the content of the Semicircle ABC.

2 *E X A M P L E.*

For the Quadrant OAB, the half Arch-Line AB is 11, which multiplied by 14, the Semidiameter OA, giveth 154 for the *Area* of the Quadrant OAB.

3 *E X A M P L E.*

For the Sector OBE, whose Arch-Line is 8, the half thereof is 4, which multiplied in the Semidiameter OC or OE, 14, giveth 56 for the *Area* or content of the Sector OBE.

Again, for the other Sector OEC, whose Arch-Line is 14, the content thereof will be found to be 98, which with the other Sector 56 make 154, equal to the whole Quadrant.

The length of the Arch may be found thus; Let GH bisect AE perpendicularly and draw GA. Then from 8 times AG take AE, and divide the Remainder by 3, and you will have the length of the Arch AGE very near.

4. *To find the Area of a Segment of a Circle.*

THIS Problem is something difficult to perform exactly, however I will give you a Rule whereby you shall come very near the truth.

Example. Let it be required to find the Content or *Area* of the Segment AEG. First draw the Chord-Line AE, and measure the length thereof, which suppose to be 25 $\frac{1}{2}$; then measure the Perpendicular GH, which suppose to be 7. Now I say, if you multiply the Perpendicular 7 by two thirds parts of the Chord-Line AGE, you shall have the near *Area* of the Segment AGE.

Example. Two third parts of 25 and a half is 17, which multiplied by 7, the Perpendicular GH, produceth 119, which is the near *Area* of the Segment: Which we will thus prove.

First, the *Area* of the whole Sector AOE may be found as before is taught: For the Arch-Line AB being a Quadrant is 22, and the Arch-Line BE is 8, which together make 30, the half whereof, 15, multiplied by the Semidiameter OB, 14, giveth 210, for the *Area* of the whole Sector AOE. Now the whole Sector, which contains 210, consisteth of these two parts, namely, the Segment AGE, and the Triangle AOE: wherefore find the *Area* of the Triangle AOE, the Base AE is 25 and a half, the Perpendicular 7; (it being the remainder of GH taken from OG

OG 14;) wherefore multiply 25 and a half by 3 and a half, and the Product will be 90 and a quarter, for the *Area* of the Triangle. Now it follows,

The whole *Area* of the Sector OAE is ——— 210

The *Area* of the Segment AGE is ——— 119

The *Area* of the Triangle AOE is ——— 90 $\frac{1}{4}$

The Sum—209 $\frac{1}{4}$

Which is equal to the whole Sector, within less than an Unit.

Or easier thus, draw AG; then to $\frac{2}{3}$ of AG add AH; and multiply the Sum by $\frac{4}{3}$ AD. Or nearer thus; Find I the middle of GH and draw AI; then add AG to 4 times AI and $\frac{1}{3}$ of the Sum multiplied by $\frac{4}{3}$ AD gives the Content of the Segment (tho' it be almost as great as the Semicircle it self) as near, as the Proportion of *Archimedes* gives the whole Circle.

When AE (*Fig. 35.*) is assigned for the length of an Ellipse and, FG for its breadth; make FB and FD equal to AC or CE; then is the Length AE called the Tranverse Diameter, FG its Conjugative Diameter, C the Center, B and D the Foci.

To find the Periphery of the Ellipse, add once and $\frac{1}{4}$, the conjugative Diameter, to twice the Tranverse, and the Sum is the Periphery nearly.

Or nearer thus, draw FA; and then to FA add its 9th part, and the Sum multiplied by 4, gives the thing required.

Or (for the sake of the Curious) make, as the fourth power of AF, to the fourth Power of BC, so AG to a fourth proportional, which taken from 10 times DC, and the Remainder multiplied by 4, gives a Product, which divided by 9, is the Periphery of the Ellipse, as near as the Periphery of the Circle is given by *Archimedes*.

But if the Diameter of a Circle had been given to find the Circumference, the Work had been thus, To thrice the Diameter, add $\frac{1}{4}$ of the Diameter. Let 28 be the Diameter, and then

$$\begin{array}{r}
 28 \\
 3 \\
 \hline
 \text{thrice the Diameter} \text{ — } 84 \\
 \frac{1}{4} \text{ part of the Diameter} \text{ — } 4 \\
 \hline
 88 \text{ gives the Circumference.}
 \end{array}$$

Or as 113 to 355, so the Diameter to the Circumference.

Or as 1 to 3,14159, so the Diameter to the Circumference.

C H A P. II.

Of the manner of casting up the content of any piece of Land in Acres, Roods and Perches.

IN the Fifth Chapter of the Second Book you have a description of Chains in general, and more particularly of Mr. Rathborn's and Mr. Gunter's. In the measuring of Land by Master Rathborn's Chain, you call every Pole or Perch thereof (which is divided into 100 Links) an *Unite*, and every ten of those Links you call a *Prime*, and every single Link you call a *Second*.

Now because there are divers that fancy this Chain rather than any other, because it giveth the content of any Superficies measured therewith in its smallest denomination, namely, in Perches and parts of a Perch, so that when any Superficies is cast up and brought to Perches, it may easily be reduced into Roods and Acres; therefore (for their sakes that affect this Chain) I will shew the Use thereof, and afterwards of Master Gunter's Chain, leaving every man to take his choice, and use that which liketh him best.

Suppose that ABCD (Fig. 24.) were a piece of Land lying in a long square, which being measured by Mr. Rathborn's Chain should contain in length 16 *Unites*, 2 *Primes*, and in breadth 1 *Unite*, 3 *Primes*, 2 *Seconds*, and that it were required to find the *Area* or content thereof in Perches; to effect this, 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 5 Chapter of the 2 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 multiplier, there are three fractions, namely, one in your multiplicand, and two in your multiplier, you must therefore (with a dash of your Pen) cut of the three last figures of the Product towards your Right-hand, and then will your Product stand thus; the three last Figures whereof are the Numerator of a Fraction, whose Denominator is 1000, and the other two Figures toward 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 than a third part of a Perch.

Z z

But

But to express the exact quantity of these Fractions in a business of this nature were superfluous; only observe this one Rule for all, namely, that if the Figures cut off come near to a Unite, that is, when the Figures cut off are near 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 farther practice take another Example, which let be a piece of Land containing in breadth 5 *Units*, 6 *Primes*, 3 *Seconds*, and in length 15 *Unites*, 4 *Primes*, and 2 *Seconds*; which place as before.

$ \begin{array}{r} 1542 \\ 563 \\ \hline 4626 \\ 9252 \\ 7710 \\ \hline 868146 \end{array} $	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 <i>Perches</i>, and $\frac{8146}{10000}$ parts of a <i>Perch</i>: Now because 8146 is near to 10000, I add 1 to 86, making it 87 <i>Perches</i>, disregarding the excess as immaterial.
---	--

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 fractions in your numbers multiplied, and there will remain 21 *Perches*, and $\frac{384}{1000}$ parts of a *Perch*, which being but of small value you may reject.

C H A P. III.

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 exceeded 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*.

EXAM.

E X A M P L E I.

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, and the Quotient will be 3, and 27 remaining: So that 5267 Perches, being reduced into Acres, produce

Acres	Roods	Perches.
32	3	27

Or thus, Divide the Perches by 40, and the Remainder 27 are Perches, and the Quotient 131, divided by 4, leaves 3, which are Roods, and the Quotient 32 are Acres, as before.

E X A M P L E II.

Let 5496 Perches be given to be reduced into Acres, Roods and Perches. 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 Perches reduced will be

Acres	Roods	Perches
34	1	16

E X A M P L E III.

Let 12169 Perches be given to be reduced into Acres, Roods and Perches, 12169 divided by 160 give in the Quotient 76, and 9 remaining; which 9, being less than 40, is only 9 Perches: So that the Reducement is,

Acres	Roods	Perches
76	0	9

The Arithmetical Work of these Three Examples.

(I)	(II)	(III)
160) 5267 (32 Acres 160)	160) 5496 (34 Acres 160)	160) 12169 (76 Acres
480	480	1120
467	696	969
320	640	
40) 147 (3 Roods	40) 56 (1 Rood	
120	40	
27 (Perches	16 (Perches	960
		9 (Perches

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 I.

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.

$$\begin{array}{r} 5120 \\ 120 \\ 27 \\ \hline 5267 \end{array}$$

EXAMPLE II.

Let 34 Acres, 1 Rood and 16 Perches be given to be reduced into Perches. *First*, multiply 34 by 160, the product will be 5440; then multiply the 1 Rood by 40, the product will be 40; to which add the 16 Perches, and the product will be 5496: So that in 34 Acres, 1 Rood and 16 Perches, there are contained 5496 Perches.

$$\begin{array}{r} 5440 \\ 40 \\ 16 \\ \hline 5496 \end{array}$$

EXAMPLE III.

Let 76 Acres and 9 Perches be given to be reduced into Perches. *First*, multiply 76 by 160, the product will be 12160; to which add the 9 Perches, and the sum will be 12169: So that in 76 Acres and 9 Perches there are contained 12169 Perches.

$$\begin{array}{r} 12160 \\ 9 \\ \hline 12169 \end{array}$$

The Arithmetical Work of these Three Examples.

(I)	(II)	(III)
32	34	76
<u>160</u>	<u>160</u>	<u>160</u>
1920	2040	4560
<u>32</u>	<u>34</u>	<u>76</u>
5120	5440	12160
40	40	9
<u>3</u>	<u>1</u>	<u>1</u>
120	40	9
27	16	
<u>1</u>	<u>1</u>	
27	16	

Or Acres, Roods and Perches may be reduced to Perches thus: (See *Example I.*) multiply 32 Acres by 4, and to the Product add the Roods 3, and so will the Result be 131 Roods; multiply these by 40, and to the Product add the Perches 27, and the Result 5267 are Perches as required. See the Operation.

A.	R.	P.
32	3	27
4		
131		
40		
5267		

CHAP. III.

How to cast up the Content of any piece of Land in Acres, Roods and Perches, measured by Mr. Gunter's Chain.

IN measuring by Mr. Gunter's Chain, you are in your account only to take notice of Chains and Links, as was before intimated in the Description thereof, *Chap. 7 Lib. 2.* Suppose then that ABCD (*Fig. 26.*) were a piece of Land lying in a long Square, and that, being measured by Mr. Gunter's Chain, it should contain in length 9 Chains 50 links, and in breadth 6 Chains 25 links.

Set your numbers down as before is taught, and as in this Example, drawing a line under them: Then multiplying them together, you shall find 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 multiplied by 4, the number of Roods in one Acre, the Product will be 375000. From which Product cutting off five Figure towards the right hand as before, it will stand thus, 3|75000: So is the 3 towards the left hand compleat Roods, and the 75000 hundred thousand parts of a Rood; which being multiplied by 40, the number of Perches in a Rood, the Product will be 3000000; from which cutting off 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, 3 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.

A a a

For

950
625
4750
1900
1700
5 93750
4
3 75000
40
30 00000

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

For if you look for 90000 under the Title *Links*, (which is the first Figure with Cyphers added,) you shall find against it 3 *Roods*, 24 *Perches*; then look for 3750, and against it you shall see 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 *Perches*.

A.	R.	P.
5	00	00
	3	24
		6
5	03	30

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 multiplied one in the other, will produce the *Area* or content of the whole Triangle.

16,56	Set your numbers down as in the margin is done;
4,32	and multiply one by the other, so will the Product be
3312	715392: From which cutting of the five last Figures
4968	towards the right hand, there will be left before the
6624	line of partition 7, which is 7 compleat Acres, and
715392	behind the line there will be 15392, which are hun-
it not, but the nearest thereto is 5625, against which there standeth	9 Perches: All these numbers being added together
A. R. P.	will produce 7 Acres, 00 Roods, 25 Perches, which
7 00 00	is the <i>Area</i> of the Triangle.
	Thus may you find the <i>Area</i> of any Triangle or Pa-
16	rallelogram very easily by one Multiplication and Ad-
9	dition, which is much easier then the way of casting
7 00 25	up by Mr. Rathborn's 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 Chain 42 Links, and 1 Chain 36 Links, the *Area* or content will be found to be 1 Acre, 2 Roods, 10 Perches. Also, the length and breadth being 12 Chains 86 Links, and 5 Chains

5 Chains 25 Links, the *Area* will be found to be 6 Acres, 3 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 (in stead 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 numbring 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, 16, 20, &c. to 40. The Scale of square Links proceedeth gradually from 1 to 25000, and is also sub-divided, and numbred 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 multiplied together produce 715392, and the five last Figures being cut off, there are 7 Acres and 15392 remaining. Now to find how many Roods and Perches this is, look in the Scale of square Links for 15392, and against it, in the Scale of square Perches, you shall find 24 Perches, and above half a Perch.

Another EXAMPLE.

Let us take the first Example before going, where the numbers multiplied were 9. 50, and 6. 25; these being multiplied one by another produce 59350, 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 1 Rood or 40 Perches, as appeareth by the Scale it self, and also by the Table; then is 50000 equal to 2 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 2 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 are 3 Roods contained therein; which I set to the 5 Acres, and subtract 75000 from 93750, the remainder being 18750: This number 18750 I seek in the Scale of Square

A.	R.	P.
5	3	30
		Links,

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 *Acre* or content required.

Thus you see with what celerity and exactness the Scale effecteth your desires; 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 honoured Friend Mr. S. F. deceased.

C H A P. IV.

How to reduce one kind of measure into another, as Statute measure to Customary measure, and the contrary.

BY the Precepts delivered in the Second *Part* of the Third *Book*, you may perform this work by the Tables of Logarithms and Lines 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 Pearch of 16 foot and a half, but in many places of this Nation (through long custom) there have been received other quantities called Customary, as namely, of 18, 20, 24, and 28 foot to the Pole or Perch: And in some place in the *West* of *England*, as about *Dorchester*, *Blandford*, &c. they account but 15 Foot and 8 Inches to the Pole, Perch or Roods; 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 Numbers in Proportion, as 18 foot to 16 foot and a half, which to perform do thus: Because 16 and a 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 $\frac{36}{11}$: Which abbreviated by 3, by saying, How many times 3 in 36? the Quotient will be 12: And again, How many times 3 in 33? the Quotient will be 11. So will the least integer Numbers which are in Proportion, as 46 and a half to 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 consider 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

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.

But on the contrary, suppose it had been required to reduce Statute measure into Customary measure, then you must have multiplied 900 Perches (your given quantity) by 121 the lesser Square, (because the lesser measure is to be reduced into the greater,) and the product will be 108900; which divided by the greater Square 144, the quotient will be 756 $\frac{1}{4}$ Perches; which reduced into Acres is 4 Acres, 2 Roods, 36 Perches and a quarter.

The same manner of work is to be observed in the reducing of any Customary quantity whatsoever.

And now, before I leave this Chapter, I will insert a Paper containing a few Examples of this kind. It was lately sent to me out of *Ireland*, with a desire to have it inserted into my Book, which I have accordingly done; it being a most excellent and compendious way of performing operations of this nature.

Land was formerly measured with a Pole or Perch containing by Statute measure feet 16, 5; and 160 of such square Poles or Perches is an Acre of Statute measure, which is the usual measure for all sorts of Land. But it is a custom in some parts to measure Wood-land with a Perch or Pole of 18 foot long, and to accompt 160 of those Poles or Perches for an Acre of Wood-land measure. And in *Ireland* the usual Perch is feet 21, and 160 of those Perches are accompted to an *Irish* Acre. Wherefore

Having the breadth and length of an Oblong Rectangle Superficies given in Perches, to find the Content in Perches,

Multiply (L) the length by (B) the breadth, and the product will be the (C) content in Perches of that measure your Pole was; and may be reduced into Acres, Roods and Perches, by dividing the same by 40 $\times$ 4.

E X A M P L E.

I desire to know how many Acres, Roods and Perches are contained in Perches 25678.

First, set down the Perches given, and then cut off the figure next unto the right hand with a line, as in the Margin; so have you divided the number given by 10; Then divided 2567 by 4, the quotient will be 641 $\frac{3}{4}$; write 641 before the separating line, and the 3 that was remaining set after the separating line, as in the Mar-

B b b

$$\begin{array}{r} 40) \ 25678 \\ 4) \ 6413 \\ \hline 1601 \end{array}$$

gin:

gin: Then again divide 641 by 4, the quotient will be 160, and 1 remaining; which being set down as in the Example in the Margin, you shall find 160 Acres, 1 Rood, 38 Perches, to be contained in the number of 25678 Perches, which were proposed to be reduced. Also,

Having the Base and Perpendicular of a Triangle given in Perches, to find the Content in Perches.

Multiply the Perpendicular by half the Base, or else multiply the Base by half the Perpendicular, or otherwise multiply the Base by the Perpendicular, and divide that product by 2, and so shall you have the content of the Triangle in Perches; which you may reduce into Acres, Roods and Perches, as before taught.

E X A M P L E.

A Triangle whose Base is Perches 183, and Perpendicular 30, the content will be found 17 A.—0 R.—25 P. For,

$$1 \cdot 30 :: 91,5 \cdot 2745. \quad \text{Or } 1 \cdot 183 :: 15 \cdot 2745.$$

Otherwise, $1 \cdot 183 :: 30 \cdot 5490$, which divided by 2, the quotient will be Perches 2745, agreeing with the former.

But because the measuring of quantities with single Poles or Perches of such lengths was very tedious, it is now become a custom to use a Chain made of strong Wire, whereof those of 4 Pole long, divided into 100 Links, are best for ease and expedition for Statute Acres; because 1 Chain in breadth, and 10 Chains in length, is a Statute Acre. Wherefore,

If an Oblong Rectangle superficies or Square be measured with such a Chain, and the breadth multiplied by the length, and the product divided by 10, the quotient will shew the content in Acres and Decimal parts.

E X A M P L E.

An Oblong Rectangle piece of Land being in breadth Chains 8, 2, and in length Chains 16, 75, what is the content in Acres and Decimal parts?

Multiply 16, 75 by 8, 2, the product will be 137, 35; which being divided by 10, (by removing the separating line one place towards the left hand,) the quotient will be Acres 13, 735, the content of that piece proposed.

But if the Base and Perpendicular of a Triangle be measured with such a Chain, you may either multiply half the Base by the whole Perpendicular, or else the whole Base by half the Perpendicular, and then

then dividing that product by 10, the quotient will shew the content in Acres and decimals parts. Or otherwise you may multiply the Base and Perpendicular together, and then divide that product by 20, so the quotient will shew what Acres and decimal parts are contained in that Triangle.

E X A M P L E.

If a Triangle have its Base Chains 16, 75, and its Perpendicular Chains 8, 2; how much is the content thereof in Acres and decimal parts?

Multiply 8, 375 by 8, 2, or else multiply 16, 75, by 4, 1, and the product will be 68, 675; which divided by 10, the quotient will be Acres 6, 8675.

Or otherwise, 16, 75 being multiplied by 8, 2, the product will be 137, 35; which being divided by 20, the quotient will be Acres 6, 8675, agreeing with the precedent. And hereby it appeareth, that a Triangle is but half a Parallelogram having the same Base and height.

Decimal parts of an Acre are readily reduced into Roods, Perches, and decimal parts of a Perch, by multiplying the decimal parts given by $4 \times 4 \times 10$.

As for Example, let it be required to reduce Acres 13, 735 into Acres, Roods, Perches, and decimal parts.

First, set down the number given, as in the Margin; then multiply 735 by 4, the product will be Roods 2,94; then 94 multiplied by 4, the product will be 3,76; which multiply by 10, the product will be Perches 37,6, which sheweth that 13,735 are equal unto 13 A.—2 R.—37,6 P. And contrary,

Roods, Perches, and their decimal parts, are reduced into decimal parts of an Acre, by dividing them by $10 \times 4 \times 4$.

E X A M P L E.

Let it be required to reduce 13 A.—2 R.—37,6 P. into decimal parts of an Acre.

Set down your Acres, Roods, Perches, and their decimal parts, accordingly as is done in this Example, in the Margin: For by so placing your numbers, you have divided your

Perches by 10, which you must also again divide by 4, saying, 4 is in 37 9 times, remains 1; then, 4 is in 16 4 times, remains nothing: So Perches 37,6 are reduced unto 0,94 of a Rood. Then Roods 2,94 being divided by 4, the quotient will be 0,735, being the decimal parts of an Acre, and are to be written after 13 Ac. according to the Example. So 13 A.—2 R.—37,6 P. will be reduced unto Acres 13,735.

So

$$10 \times 4) 1,88$$

$$4) 3,47$$

$$6,8675$$

So likewise 6 A.—3 R.—18,8 P. will be reduced unto Acres 6,8675.

To reduce Statute Acres of 16,5 foot in a Perch, into Woodland Acres of 18 foot in a Perch;

Say, $144 \cdot 121 :: \text{Statute Acres} \cdot \text{Woodland Acre}.$

E X A M P L E.

How many Acres of Woodland measure are contained in 18 A.—3 R.—09,5 P. of Statute measure?

First, reduce 18 A.—3 R.—09,5 P. into Acres and decimal parts, by the precedent Rule, according as you see it done in the Margin, it will be Acres 18,809375; which multiplied by 121, the product will be 2275,934375; which divided by 144, the quotient will be Acres 15,805: And so many Acres of Woodland measure are contained in 18 A.—3 R.—09,5 P. of Statute measure.

For, $144 \cdot 121 :: 18,809375 \cdot 15,805.$

And contrary, *To reduce Woodland Acres into Statute Acres;*

Say, $121 \cdot 144 :: \text{Woodland Acre} \cdot \text{Statute Acre}.$

Or if you plot by a Scale of 12, and cast up the content by a Scale of 11, you will find the content in Woodland measure. And contrary,

Having the length of an Acre of Land given in Chains, to find the breadth;

Divide 10 by the length given, the quotient will shew the breadth.

E X A M P L E.

Let the length given be Chains 12,25, I demand the breadth of an Acre.

Divide 10 by 12,25, the quotient will be 0,8, the breadth sought.

And likewise, if the breadth given be 0,8, divide 10 by 0,8, the breadth given, the quotient will shew Chains 12,25, the length sought.

If the want of Decimal Arithmetick shall make these Examples seem difficult, (which are very plain, brief and easie,) they may repair to my Book of Arithmetick, where they may, as well as in Vulgar Arithmetick, find ample satisfaction in this of Decimals; to which Book I refer the Reader.

C H A P. V.

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 3 Columns; in the first whereof towards the left hand is to be written the Tenant's Name, and the tenure by which he holds the same Land: The two next Columns are to contain the length of every man's Furlong in Chains and Links; in the two next Columns is expressed the breadth of every man's 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 Tenant's Furlong in Acres, Roods and Perches.

In the laying out of several parcels in this kind, you will have use only 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 Tenant's Name, and the tenure by which he holds the same, from what place you begin to measure, and upon what point of the Compass you pass 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 express the same in your Book under the title of Length. As for the expressing of the several breadths, you need but to cross over the whole Furlong, taking every man's breadth by the middle thereof, and entering the same as you pass 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 in proportion between them a 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 shall you have the quantity of every parcel by its 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 tenure.	Length.	Breadth.	Content.		
	C. L.	C. L.	A. R. P.		
Abel Johnson, 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
James Norden, at Will.	25 11	12 35	31	0	2

C H A P. VI.

How a Lordship lying in Common Field is to be inclosed.

IT most commonly happeneth, when a Lordship is to be improved wherein are many Free-holders, that their ground (consisting of different Qualities) lies for the most part disperfed, and intermixt one amongst another in all parts and quarters of the Field. Therefore to find the just Quantity of every Man's Ground, both Arable, Ley-ground and Meadow, 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 Pencil, and one greater Column towards the left hand, which shall contain the butting, bounding and number of every Man's particular Lands, Leys, Doles of Meadows, 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 find 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 Columns, write the length of the lands, in the second put the breadth, and 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 farther, I shall here give you a more particular draught of the Field-book.

The

The Survey of the Lordship of PILTON, in the County of Rutland, made in Octob. 1656

Middle-Hill Furlong begin. South.

	Leng. P.	Bread. P.	Quantity. P.
John Falkner 5 lands	51.18	7.60	393.9680
Tho. Tomblinson 2 lands	49.42	3.29	150.6150
Peter Blackley 8 lands	47.10	10.16	478.5360
Abraham Falkner 6 lands	46.70	7.12	332.5040
Tho. Tomblinson 1 land	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.

Tho. Tomblinson 1 land	36.20	2.50	90.5000
The Parsonage 4 lands	34.80	8.10	281.8800
John Falkner 6 lands	34.00	11.0	374.
Peter Blackley 2 lands	34.00	4.0	136.
Henry Swift 5 lands	34.00	9.20	312.8000
Abraham 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 1 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
Thomas 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 Falkner one dole	39.50	3.00	118.5000

Red-hill Furlong begin. South.

John Falkner 3 lands	45.00	12.0	540
Abraham Falkner 10 lands	45.00	20.0	900
Tho. Thomblinson 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
Peter 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 man's Arable, Leys, and Meadow-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 only the true quantity in his Plot, but also consideration for the Quality of his ground, as near as may be.

To which end, in drawing your particular 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 Meadow. Then turning to the Field-book, I begin with *John Falkner*, and write in the Particular in its proper Column, under Arable, 393. P. 908; 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 Man's Arable, Leys and Meadow in their Order. Which being effected, then make your *Summa totalis*, as you may see in the following Synopsis.

A Particular of certain Arables, Leys and Meadow-grounds in part of the Lordship of Pilton Com. Rutland.

<i>John Falkner</i>			<i>Tho. Tomblinson</i>			<i>Peter Blackley</i>		
Arable	Leys	Med.	Arable	Leys	Med.	Arable	Leys	Med.
393	82	320	150		263	478	1000	90
529		118	58			136		460
374			90			200		
540			540					
1836	82	438	838	0	263	814	1000	550
	1836			838			814	
	82			0			1000	
	438			263			550	
Sum. tot.	2356		Sum.	1101		Sum.	2264	

<i>Abraham Falkner</i>			<i>Thomas Falks</i>			<i>Andrew Cook</i>		
Arable	Leys	Med.	Arable	Leys	Med.	Arable	Leys	Med.
332	234	420	353	500	240	176		240
900						100		
1232	234	420	352	500	240	276	0	240
	1232			352			276	
	234			500			0	
	420			240			240	
Sum.	1886		Sum.	1072		Sum.	516	

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 Man's 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, shall be garnished with Colours upon Vellum or Royal Paper, it 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.

An Advertisement, concerning the Measuring of Lands, or Furlongs, in Common-Fields.

IT often times falls out, that in the *Surveying* of *Lordships, Mannors, Farms, &c.* That a considerable part belong to such *Demaine*, may lie disperfed in *Common-Fields*, in several *Shots*, and in several *Lanes* in those *Shots*, which cannot be laid down in their true Positions, without the whole *Field* be first *Platted*, which very rarely, any single *Proprietor* will be at the *Charges* to have done: And, forasmuch as such *Lands* or *Furlongs* are generally reputed to be *One, Two or Three Acres, Half-acres, Quarters*, or the like, they seldom fall out to be found so much by *Measure*: I do therefore sometimes, in such *Cases*, insert in some vacant place in the *Plot* of the *Mannor, Farm, &c.* in which such *Common-Fields, Lands* is a part, add such a *Table* as this following: Whereby, any single *Lands* or *Furlong*, may be found in such *Common-Fields*, with what *Shot* it is in, its *Boundaries* on all sides; its *Length, Mean Breadth*, and *Real Content* by *Measure*, and also the *Reputed Quantity* thereof, and so discover the *Difference*. View the following *Table*.

The Parcels of Land belonging to the Mannor of Coxon, lying in Norcot Great-Field, with their Boundaries and Contents, both Real and Reputed.

	East.			West.			North.			South.			Length			Mean Breadth			Content Real.			Content Reputed		
4 High-way Shot	Ch. Cheesman	N. Watson	Fr. Childe	Tho. Barnard	C.	6	60	1	45	0	3	33	1	2	0									
2 East Shot	N. Watson	Ch. Gray	Job. Windsor	Tho. Barnard	10	95	0	80	0	3	20	1	0	0										
1 Head-Land	Job. Windsor	Nic. Watson	Job. Hilliar	Ch. Gray	6	92	0	73	0	2	00	0	2	0										
7 Head-Land	Job. Windsor	Nic. Watson	R. Faulkner	Ch. Cheesman	7	30	1	15	0	3	14	1	0	0										
1 East-way Shot	Job. Windsor	Fr. Hampton	Job. Hilliar	Ch. Cheesman	9	67	0	35	0	1	14	1	0	0										
1 East Shot	Job. Windsor	Fr. Hampton	Fr. Hampton	Ch. Gray	9	75	0	30	0	1	07	0	2	1										
3 East Shot	Rob. Hampton	Ch. Cheesman	Rob. Hampton	Tho. Assier	9	60	0	51	0	2	30	1	0	0										
1 High-way Shot	Ch. Cheesman	Ch. Cheesman	Rob. Hampton	Tho. Assier	6	40	0	75	0	1	33	0	3	0										
1 East Shot	Rob. Assier	John Horn	Ch. Gray	Tho. Barnard	9	00	0	42	0	1	22	0	2	0										
4 High way Shot	Nic. Watson	Th. Assier	Ch. Cheesman	Ch. Gray	7	92	1	65	1	1	10	1	2	0										
5 High-way shot	Nic. Watson	Ch. Cheesman	Ch. Greg	Ch. Cheesman	6	85	1	70	1	0	25	1	2	0										
1 Long Shot	Rich. Faulkner	Will. Mead	Ch. Cheesman	Ch. Gray	14	100	0	46	0	2	26	1	0	0										
6 Long Shot	Rich. Faulkner	Rob. Assier	Ch. Cheesman	Ch. Cheesman	14	60	1	53	2	0	33	2	2	0										
2 Long Shot	Rich. Faulkner	Rob. Assier	Ch. Cheesman	Job. Brent	14	50	1	38	2	0	02	2	2	0										
1 West Shot	Th. Assier	Ch. Gray	Ch. Gray	Ch. Gray	9	80	0	65	0	2	21	0	3	0										
1 West Shot	John Short	Job. Brent	Ch. Gray	Th. Barnard	7	45	0	67	0	1	30	0	2	0										
1 Head Land	R. Franklin	Jan. Childe	Ch. Gray	Th. Barnard	7	90	0	72	0	2	10	0	3	0										
1 Pendle Shot	Fr. Childe	Ch. Cheesman	Fr. Childe	Th. Barnard	10	90	0	30	0	3	35	1	0	0										
3 Pendle Shot	Ch. Gray	David Cole	Nic. Watson	Th. Barnard	10	100	0	80	0	3	09	1	0	0										
The Sums—													8	1	16	20	3	0						

C H A P. VII.

To find the Horizontal line of any Hill or Mountain.

THis Performance differeth nothing from what is before taught in the taking of Altitudes, in the beginning of the Fourth Book. Wherefore suppose you should meet with a Hill or Mountain as $A B D$, (*Fig. 39.*) the thing required is, to find the length of the line $B D$ on which the Mountain stands.

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 a Mark, which must be so much above the top of the Hill, 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 on 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 $A D$, 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 find 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 $B C$, $48\frac{1}{2}$ 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 find 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 $C D$, $60\frac{1}{2}$ feet.

Which added to the line $B C$ giveth 109 feet; which you may reduce into Chains, by dividing it by 66: And this line must be protracted in stead of the Hypotenusal lines $A B$ and $A D$.

C H A P. VIII.

*How to plot Mountainous and uneven grounds,
with the best way to find the Content thereof.*

FOR the plotting of any Mountainous or uneven piece of ground, as *ABCDEFG* (*Fig. 38.*) you must first place your Instrument at *A*, and 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 find the Horizontal line thereof, and draw that upon your Table, accounting thereon the length of the Hypotenusal line: Then measure round the Field according to former Directions, and having the figure thereof upon your Table reduce it into *Trapezia*'s, as into the *Trapezia*'s *ABEG*, *BCDE*, and the Triangle *GEF*: then from the angles *A*, *C*, *E*, and *F*, let fall the Perpendiculars *A K*, *CH*, *EL*, and *FM*. Now in regard there are many Hills and Vallies 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 *BD*, set the number of Chains and Links as you find them to be by such measure, which will be much longer then the straight line *BD* measured on your Plot by the Scale. Then by your Instrument find the point *H*, in the line *BD*, and measure from *C* to *H* as before, and set to it the number as you find it by the Chain. Then find the Perpendicular *LE*, and measure that with your Chain also: All which lines (in respect of the Hills and Vallies) will be found longer, then if they were measured upon the Plot by the Scale: And therefore by the lines *BD*, *CH*, and *LE*, as they are thus measured, must the *Trapezia* *BCDE* be cast up, as also the *Trapezia* *ABEG*, and the Triangle *GEF*: And this is the exactest way that I can prescribe for the measuring (or finding the true Contents) of uneven Grounds; which being carefully, and with discretion performed, will not differ much from truth. For, if such uneven Grounds should be Plotted, according to their true measures in the Field, they would not be contained within their proper limits, which laid down among other Grounds would swell beyond their bounds, and force the adjacent Grounds out of their places.

But now, to distinguish these Grounds from others in your Plot, you may shadow them off with Hills as in this Figure, lest any man seeing your Plot, should measure by your Scale, and find them to differ.

C H A P. IX.

Of the Mensuration and Plotting of Roads, High-ways, Streets, Lanes, &c. And of the taking of the Ground-plot of Cities, Towns, or Hamlets.

HE that well understandeth and can put in practice what is delivered in the former part of this *Fourth Book*, cannot but perform what is intended to be taught in this *Chapter*; therefore I shall only discourse the manner how these things are to be performed, leaving the Practice thereof to the ingenuity of the Learner.

For Roads or High-ways.

In the describing of Countries, there is no fitter Instrument for the performance thereof then the *Circumferentor*, and that Card which is divided into 4 Quadrants, each divided into 90 degrees, beginning from the *North* and *South*, and numbred towards the *East* and *West*, as is described *Book 2. Chap. 10.*

Then, have a *Field-Book* for that purpose, (the fittest is in a long Folio, like your narrow Shop-Book) with two Parallel Lines drawn through the middle of each Page, the distance between which need not be above half or three quarters of an Inch.

Now at the beginning of your Journey, at the bottom of one of the Leaves of your Book, write the name of the place where you begin your Journey, and a Prick or this Mark $\odot$ between the Parallel Lines. Then setting forward, always carry one of the Cardinal Points of the Compass either *North* or *South* before you, and direct your Sight so far as you can see along the Road, noting the Degrees that the Needle cuts, and in what Quarter of the Compass, which you may call the Bearing; and when you come to that place, write down the distance, in *Paces*, *Chains*, or whatsoever *Measure* you measure by, between the Parallel Lines.

Then again direct your Sight forwards, so far as 'till you can see another turning or bend, and note down the Degrees of Bearing, and which way; and when you come to that place, set down the distance thereto from the last Station. And in this manner proceed 'till you come to your Journey's end.

Now in your Perambulation you are to observe, 1. What *By-lanes* or *Turnings* you meet withal in your way, whether they be on your Right hand, or on your Left, and at what distance from your last Station; as if there be a *Lane* on your Right hand 300 Paces from your last Station, you must on the Right hand Parallel Line

E e e

make

make two little Strokes thus =, bending them either upwards, or downwards, or straight at right Angles, according as you see the Lane to incline this or that way : And at the end of these two Parallel Lines write the name of the Place to which that Lane leaneth, and if you will, or can obtain it, the reputed distance thither ; and and under the Line write the distance from your last Station 300.

2. When you pass over any eminent *Bridge*, by any *Wind mill*, over any *Great Hill*, through any *Town* or *Village*, note them all down with their distances from your last Station.

3. In your going along the Road, if you see any *Churches*, *Mansion-Houses*, *Beacons*, *Wind-mills*, *Towns*, *Villages*, or any other thing remarkable ; at your next Station see how they bear from you, writing down their names, and how they bear from you, on that side of the Book on which they lie from you.

Then in your Journeyings forwards, when you come to see those things or Places, or so many of them as you can, there take notice also how they bear, and their names also, with the distance from the last place where you observed them before ; and continuing this Method, you may accurately describe the Roads of any Country.

For Streets or Lanes in Cities or Towns.

1. In the Plotting of *Streets*, there must be somewhat more exactness used then can possibly be in *Roads* and *High-ways* : for *Roads* being both long and large, cannot be plotted by any other then a very small *Scale*, so that every small bout, or turning, cannot be taken notice of ; or if they be, they cannot be expressed in any *Plot* : but in *Streets* and *Lanes* every small *bowing*, though it make not an angle of above 3 or 4 degrees, must be taken notice of ; and therefore the *Theodolite* or *Semicircle* is more apt and fitter for this work then the *Circumferentor*. Yet in this you need not with your *Instrument* make observation of these small Angles, but having made observation of 4 eminent angles and the principal intermediat ones, you may by the help of *Rods* or other *Bevels* for that purpose more accurately find the quantity of those Breaks and Angles, and those also will be less troublesome.

2. When you have by your Instrument made observation of so many grand Angles in *High-streets*, as to do encompass divers other small *Streets* or *Lanes*, you must remember to take special notice of your Station-Points ; and in measuring with your Chain, take notice, as you pass by them, of all manner of *Breaks*, *Courts*, *Allies*, *Houses* of note, and other publick *Remarks*, with their true Perpendicular distance from your Chain, taking both sides of the way in every *Street* or *Lane* together.

3. Having protracted your Four, or more Grand or Cardinal Angles, first, lay down these four principal *Streets*, (and here you may examine by your Angles whether they will close or not, by the directions given in the 4 Book,) and on either side of the way make
Marks,

Marks, as this $\odot$ or the like Mark, where any other *Cross-street* or *Lane* enters, as also all *Courts*, *Allies*, and the like.

4. Plot your several By-lanes with the several Bows and Breaks in them, and take notice of the *Courts* and *Allies* that are in them; making Marks at their entrances, as you did of those By-lanes in your *High-streets*.

5. With *Rods* or a *Bevel*, take the Plot of all *Courts* and *Allies*, and eminent *Houses*, &c. And having taken all these in a Book, you may plot and transfer them into your *Map*, between the eminent *Streets* that you first took your Angles in. And thus having taken one Part or Quarter of a *Town* or *City*, you may proceed to another, and so one after another, 'till you have finished what you intend to have a Plot of.

This is the best and most accurate way that I can prescribe for the plotting of *Cities* or *Towns*, and it is the way which I my self use in my Survey of the *City of London*, as it is now re-edified; wherein I take notice of all remarkable things therein. For, besides the *High-streets*, and *Streets* of note, I take notice of, and Plot, all *By-streets* and *Lanes*, all *Courts* and *Allies*, all *Churches* and *Church-yards*, and the 2 *Temples*, all *Inns of Court*, all *Colleges*, the *Guild hall*, and all eminent *Halls of Corporations*, all *Market-places* and *Market-houses*, &c. This task is now under my hands, and I hope with God's assistance in a few Months to compleat it.

CHAP. X.

How to enlarge or diminish a Plot, according to any assigned proportion.

IT may so fall out, that when you have taken the Plot of a whole Mannor upon your *Plain Table*, in divers sheets of Paper, or observed the Angles, and afterwards protracted them, it may, I say, so fall out, that your Plot may be either bigger or lesser than is desired. Now if at any time it be required to enlarge 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 12 Chapter of the Second Book. Now for generality and exactness, the two Indices 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 wherof 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 to which you would have your Plot reduced, fix the *Parallelogram* 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 Plummer of Lead or Brass, to keep the Pen down close 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 always 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.

Another way how to reduce a Plot according to to any proportion assigned, is this. Suppose you would have a Plot diminished in proportion as four to three. Cause a Scale to be made of such a length, that it may reach from the center or 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

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 small Protracting Pin quite thro' 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.

Again, there is another way how to reduce Plots to any proportion, and that is this. About your foul Plot draw the largest Square you can, so that it may comprehend your whole Plot, and divide that Square into as many small Squares as you please: Then make another Square in proportion to the Square about the foul Plot, as to which you would have it reduced: And then laying your foul Plot and the fair Squared Paper both before you, see in which of the small Squares of the foul Plot the several Angles or remarkable Points fall, and in the correspondent Square of the fair Paper make the like Angle or Point: And in this manner proceed till you have finished your Work: This is a good way, and is the course which *Painters* use to copy any large Painting into a smaller Picture or Print. This method is to be used when you are to reduce a lesser Plot to a greater: But to reduce a greater to a lesser, which is most usual, you may then lay your fair Paper under or over your foul Plot, and fix the *Parallelogram* about the middle of the Plot, and then tracing over the large Plot, you shall have it reduced upon the fair Paper, either over or underneath; especially if you lay a Black-lead Paper over your fair Paper.

C H A P. XI.

How to draw a perfect draught of a whole Manor or Lordship, and to furnish it with all necessary Ornaments; also to adorn and beautify the same with Colours; in which (as in a Map) the Lord of the Manor may at any time see the symmetry, situation and content of all or any parcel of his Land.

Fig. XIV. **H**AVING 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 Colour, neatly go over your Black Lines; so shall you have a transparent stroke
F f f f or

or margin on either side of your Black Line; which being shadowed 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 mountainous and uneven Grounds with Hills and Valleys, expressing all kind 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 Mariner's Compass according to the situation of the Grounds, with a *Flower-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, with a pair of Compasses upon it.

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, Helm, 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 farther trouble.

Also in your Plot must be expressed the Manor-house according to its symmetry or situation, with all other Houses of note, also all Water-mills, Wind-mills, 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. As is Fig. XIV.

CHAP. XXII.

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 Velum, 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 commendable, and easy to be attained: And besides, a Painter is not to be found in every Country, nor is every Painter furnished with Colours fitting for such a purpose, they for the most part using more gross and ordinary Colours. Now for the benefit of such

such who desire to exercise themselves in this kind of practice, I have added these necessary Directions following.

How to make Gum-Water.

Take *Gum Arabick* what quantity you please, of the whitest and clearest you can get, which bruise into small pieces, and tie them up loosely in a fine Linen Rag: Then take of the clearest Water you can get, and put it into a clean Vessel, as a Porringer, (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 find them to stick together as if they were glewed, your Water is too stiff of the *Gum*, which you may remedy by putting thereto more fair Water; and if you find it to weak, you may add more Gum. With this Water most Colours are to be tempered.

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.

The Names of such Colours as are necessary for the Washing of Maps, Plots, or Charts.

REDS	YELLOWS	BLEWS	GREENS
Vermilion	Gumbooge	Bice	Bice
Lake	Yellow Berries	Indigo	Sap Green
Red Lead	Orpiment, <i>i. e.</i>	Verditer	Vertdegriee
Rosset	Arfnick	Litmoſe	Verditure.
Brazeel	Maſticot.	Logwood.	
Turnſoil			
Indian Cakes.			

BLACKS	WHITES	BROWNS
Lamp black	White Lead in flakes.	Spaniſh Brown
Printers Black		Umber
Ivory	Shavings burnt.	Wood Soot
Hartſhorn		Rindes of green Wall-nuts.

Being

Being thus provided of these several Coloures 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-shells, to put your Colours in when they are ground 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.

Of the Ordering of Colours.

Of these Colours before mentioned, some are to be Ground some Washed, some only Steeped or dissolved, others to be Boiled, and some to be Burnt, and then Ground.

1. How any Colour is to be Ground.

Take what Quantity of any Colour you please, that is to be Ground, and lay it upon your *Grinding-stone* being clean, as also your *Muller*; then with your *Muller* bruise the Colour, if it be lumpish, and when it is reasonable small or fine, put some fair Water to it, and with your *Muller* grind the Colour and Water together till it be very fine: Then with a *Knife* or piece of thin *Lanthorn-Horn*, bein clean, take it off from the *Stone*, and put it into a *Shell*; and when it is dry, you may take it out of the *Shell*, and keep it for your use.

The Colours to be Ground are.

Vermilion Lake Indigo Masticot White Lead.

In grinding of your Colours put not too much Water to them upon the Stone, for they ought to be ground stiff like weak Paste, or Pap.

2. How Colours are to be Washed.

Take a good quantity of the Colour which you intend to Wash, and put it into a *Basin*, pouring to it a good quantity of fair Water, and stir the Colour and the Water often together, and then you will see a great deal of filth swim at the top of the Water. When the Colour is settled to the bottom of the *Basin*, pour away that Water gently into another Vessel or *Basin*, and pour more fair water to the Colour, then stir the Colour and that fresh water together; and when the Colour is settled, pour away that second water to the former, and so put a third and fourth water, stirring it often,
till

'till the water come from the Colour without filth, then is your Colour washed. But before you take the Colour out of the Vessel, lay it with your hand very thin about the sides of the Vessel, and when it is dry, some of it will fall to the bottom, which put out upon a Sheet of Paper, which will be good Colour; but the remainder, which sticks to the sides of the Bason, is best of all, which with a Feather strike off the sides of the Vessel, for it will be finer then any Flower.

The Colours to be Washed are

Rosset	Bice	Orpiment
Red-Lead	Verditer	Spanish Brown.

These or other Colours thus washed, you may reserve in white paper free from Dust, and make use of them as you have occasion.

3. *How Colours are to be Steeped.*

This is only to put the Colour into some kind of Liquor and there to dissolve it; some in cold Liquors, others upon the fire.

The Colours to be Steeped in cold Liquors are

Yellow Berries	Sap Green	Vertdegreece
Gum Buge	Litmose	Indian Cakes.

The Colours to be Steeped or Boiled are

Brafil	Turnfoil
Logwood	Wood Soot
Rinds of Wall-nuts.	

These Colours when steeped or boiled are to be kept close in Glasses, 'till you have occasion to use them.

4. *How Colours are to be Burned.*

Some use only to put a lump of Colour into a red-hot place of the fire, and there let it lie 'till it be thoroughly burnt: But this is both wastful and slovenly. *The best way is this:*

Take a quantity of your Colour, and put it into a clean *Crucible*, putting thereto some fair Water: Then cover the *Crucible* with *Clay*, and set into a hot place of the fire, letting it there continue 'till the *Crucible* be red hot: Then take it out, and when it is cold you may take out the Colour, and grind it as is before taught.

The Colours to be Burnt are

Spanish Brown
Umber

Printers Black
Lamp black

Ivory
Hartshorn

or any other gross and foul Colour.

Having shewed you the way how to Grind, Wash, Steep, Boil, and Burn your Colours, I will shew you now.

5. How to Temper your Colours.

First, such Colours as are Ground with fair Water, take a small quantity thereof, and put it into a *Muscle-shell*, putting thereto some *Gum-water*, and the Colour in a short time will be mollified: Then with your Finger (being very clean) bruise the Colour against the *Shell*, 'till you find no knots undissolved: Then with a clean Pencil stroak down the Colour towards the bottom of the *Shell*, and it is fit for use; but if it be too thick, add more *Gum-water* to it.

Such Colours as are Washed, you must temper in a *Shell* with *Gum-water*, in the same manner as you did those that were Ground.

Such Colours as are Steeped, the Liquor only of them is to be used, without any addition.

Of the several Simple Colours, how to order them, without any Mixture.

1. Of Reds.

Vermillion, being Ground and tempered with *Gum-water*, makes a deep Red or Scarlet Colour.

Lake, Ground and tempered with *Gum-water*, makes a deep Pink or Bloom Colour.

Red Lead, Washed, is a brave Orient Colour, between a Red and an Orange Colour.

Rosset, Washed, and tempered with *Gum-water*, differs not much in Colour from *Lake*, but it will soon fade and grow lighter; but being tempered with *Brazeel-water*, it will be more deep.

Brazeel. The Shavings or Grindings thereof, being boiled in *Vinegar* and *Small Beer* (or fair Water) in an earthen Vessel, with some Powder of *Allum* put therein to heighten the Colour, makes an excellent Pink or light Violet Colour. When you strain the Liquor from the dregs of the *Brazeel*, add thereto some *Gum Arabick* to bind it.

Turnsoil. It is made of Linnen Rags died, which being put into a Sawcer, or the like, with some *Vinegar*, and set upon a Chafindish of Coals, the Rags squeezed into the *Vinegar*, with some

some *Gum* to bind it, makes a good Colour to shadow all *Tellows* with.

Indian Cakes. Use them as you do *Turnsoil*, and they make a good *Red* transparent Colour: Into the Liquor put some *Gum* to bind it.

2. Of Yellows.

Gumbooge, Steeped in fair Water only, makes the most excellent and most transparent *Tellow* Colour: It is of that nature, that it will admit of no mixture.

Tellow Berries, Steeped in fair Water, and a little powder of *Allum* added thereto, (or steeped in *Allum-water*) makes a very good and transparent *Tellow*.

Orpiment, Washed, and tempered with *Gum-water*, makes an *Orient* or *Gold* Colour: There are several degrees of it, some more *Red*, and others more *Tellow*.

Masticote, Ground, and tempered with *Gum-water*, makes a good, but no transparent *Tellow*.

3. Of Blews.

Bice, Washed, and tempered with *Gum-water*, is an excellent *Blew*, but not transparent: And there are several sorts of it, some lighter, some sadder.

Indigo, Ground, and tempered with *Gum-water*, makes a deep *Blew*, and is fit to shadow all other *Blews*.

Verditer, Washed, and tempered with *Gum-water*, is a good *Blew*, but not transparent.

Litmose, Cut it in small slices, and steep it in a weak Water made of *Gum Lack*, for the space of a day or more, and you will have a transparent *Blew*.

Logwood, Boiled in all respects as *Brazeel*, makes an excellent *Violet* or *Purple* Colour.

4. Of Greens.

Bice, Washed, and tempered with *Gum-water*, makes a good, but no transparent *Green*.

Sap Green, Steeped in fair Water, and a little Powder of *Allum* added thereto, makes a good *Green* to shadow or damask withall.

Verditure, Washed, and tempered with *Gum-water*, makes a *Green* not transparent.

Half a pound of *French Vertdegriee* boiled with a quart of fair Water, and one ounce of *Red Argol*, gently for 6 Hours, make a *Green* Colour inclined to *Blew*, and very transparent. If you let it settle, and then pour of the clear part for your Use, it will be still better if it stand continually near a Fire, or as oft as convenience permits, in the Sun.

5. Of

5. Of Blacks.

Lamp Black
Printers Black
Ivory
Hartshorn } Shavings } Being burnt, ground, and tempered with
Gum-water, are all good *Blacks*.

6. Of Whites.

White Lead, Ground, and tempered with *Gum-water*, is the best *White*.

7. Of Browns.

Spanish Brown, Burnt, ground, and tempered with *Gum-water*, makes a *Reddish Brown*, or *Liver Colour*.

Umber, Burnt, ground, and tempered with *Gum-water*, makes a good *Haw Colour*, and is good to shadow upon *Gold*.

Wood Soot
 or
Rinds of green Wall-nuts } Boiled in fair Water, and strained, and
 some *Gum Arabick* put into the liquor,
 to bind it, either of them makes a most
 excellent Colour for to expresse *High-ways*, *Lanes*, &c.

Of Mixture of Colours.

All the fore-mentioned Colours that we have hitherto treated of, are such as are simply of themselves, without any mixture, of which infinite may be compounded; nay, almost what you will: But for our purpose of Colouring *Plots*, those are more preferable, which are most transparent. Of which *Brazeel* and *Logwood-water*, *Indian Cakes*, *Turnsoil*, *Gumbooge*, *Yellow Berries*, *Litmoſe*, *Sap Green*, *Vertdegriee* distilled, *Wood Soot* and *Wall-nut Husks*, are the principal; and of these several others may be compounded.

For Green.

Vertdegriee-water and *Yellow-Berry-water* make a transparent *Green*, either sadder, or lighter, according to the quantity that you take of either.

For Blew.

Litmoſe-water, to which add *Yellow-Berry-water*, and you have a sad *Blew*.

For

For Orange Colour.

Brazeel-water and Tellow-Berry-water.

Infinite Colours I say may be made of these, which may better be found out by practice then by many Words: And therefore now I will shew you what Colours do shadow one another.

Concerning Shadowing

All Light Colours are Shadowed with Colours of their same nature, but more sad; for which take these brief directions.

Vermilion	Is Shadowed with	Lake, or Spanish Brown
Verditer, and Bice		Indigo
Gumbooge, and		Umber, with Red Lead, or
Yellow Berries		Vermillion
Red Lead		Lake, or Spanish Brown
Masticote		Red Orpiment
Spanish Brown		Burnt Umber with Brazeel-
Umber		water
Rosier, and Bra-		Umber burnt
zeel, &c.		Spanish Brown, mixed with
Vertdeg iece		Brazeel-water
		Indigo and Yellow-Berry-
		water mixed
Wood Soot, and		Umber.
Wall-nuts.		

Concerning the laying on of your Colours.

For the laying on of your Colours, you must provide your self of *Pencils* of several sizes, bigger and lesser: And if you will be curious, you ought to have a great and a small to each respective Colour; if not, you must always have by you a Dish of fair Water, in which you must swill or cleanse your *Pencil*, wiping it with a clean Linnen Cloth, before you put it into another Colour.

For your *Pencils*, you may chuse, in your buying, those that are good in this manner. See that they be fullest next to the Quill, descending or lessening into a small room and sharp Point, which you may produce by putting of the Hair into your Mouth, and drawing it through your Lips once or twice, then may you see what it is, and if you find any extravagant Hairs, singe them off by a Candle's flame.

Being thus provided with *Colours* and *Pencils*, if you would lay any Colour about the edges of any part or piece of Ground in a Plot, as suppose you would inclose a Field in a Plot with *Yellow*,

H h h

with

with your Pencil take of *Gumbooge* or *Tellow Berries* a very small quantity, and on the inside of the Black-lead Line draw the Colour along of an equal breadth (as near as you can) from the Line, broader or narrower, according as your Field is in bigness, (not dawbing your Field all over with your Colour, as I have seen some (otherwise good things) by this plastering way (as I may call it) most notoriously abused.) Then having gone round your Field in this manner with your Colour, wet your Pencil in your Mouth, or have a small quantity of Water by you to dip it in, and strike along the inside of the coloured Line, bringing it more down to, wards the Center of the Field: And this will sweeten your Colours and make it shew as if it lost it self by degrees, to the very colour of your Paper or Parchment. And this course is to be taken not only for *Yellows*, but for all other Colours. Then lastly, with a Pen (if you cannot handle a small Pencil handsomly and evenly) take some of that Colour which shadoweth that Colour you colour'd your Field with, and go over your Black-lead Line only, so shall your Field be finish'd.

And in this manner may you do a hundred Fields in one Plot, of divers Colours: Only observe this, that, as near as you can, you colour not two Fields adjoyning one to the other both of the same Colour, but of different: And therefore it will be convenient to understand what Colours do set one another off best, and as near as you can to lay Closes adjoyning to one another, of two such Colours, that one Shadow may serve both. And thus I conclude this Chapter and this Matter.

C H A P. XIII.

*Of Water Leveling, Draining, &c.**I. How to find whether Water may be conveyed from a Spring-head to any appointed Place.*

THere is an Instrument call'd a *Water-Level*, for the Performance hereof, the making whereof is sufficiently known to most that do make Mathematical Instruments: They are usually made about 5 or 6 Foot long, having a Trough cover'd over, or a Copper Pipe to hold the Water, and two Cups, at each End one, into which the Water must issue to set the Level truly. Besides this Trough, there ought also to be two Sights, and another Level for a Plummet, a Staff to stand always of an equal Height, and two Station staves with moveable Veins upon them, to move up and down, as shall be directed by him that standeth at the *Water-Level*. In this Form, or somewhat like this, are *Water-Levels* usually made. But I have lately seen and used a *Water-level*, contriv'd by Mr. R.
Shot.

Shotgrave, not above 18 Inches long, where the Water (or some Spirit to prevent Freezing) is inclosed, with a Tube or Telescope underneath the Case that holds the Trunk, with a Spring and Screws to bring the Water to its true Position. But to say no more concerning the Instrument and the several sorts of them, I will now proceed to shew the Use thereof.

Water-Levels now a days are generally made with Spirits enclos'd either in a Glass Tube or a circular flat Box, cover'd with a Glass Cover ground Concave, fix'd to a Telescope with Horizontal Hairs, in such manner, that if the Bubble be brought to the Mark of the Glass, the Hairs are Horizontal.

Now if it were requir'd to know whether Water may be convey'd 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 convey'd; as at 30, 40, 60, or 100 Yards distance from the Spring-head. Then have in a readiness your two 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 convey'd. These Station-staves being erected perpendicular, and your Water-level about the Mid-way 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 Sign 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 Sight 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 Mind, 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 forwards towards the Place to which the Water is to be convey'd, 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 them a Sign, 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 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 convey'd: 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 look'd 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 convey'd; 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 convey'd from the Spring head to the desir'd Place or not, though there be many Hills 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 Error will ensue, *viz.* that your *first Assistant* must at every Station stand between the Spring-head and your Water-level, and your *second Assistant* must always stand between your Water-level and the Place to which the Water is to be convey'd: Thus by observing this Order in your Work, you shall have no Confusion, neither shall one of your Assistants take more Pains than 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 than) 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 than the Spring-head.

The first Assistant's Note.			
Station	Feet	Inch	Parts.
1	15	3	$\frac{1}{2}$
2	2	1	$\frac{1}{4}$
3	1	6	0
Sum	18	10	$\frac{3}{4}$

The second Assistant's Note.			
Station	Feet	Inch	Parts.
1	3	2	$\frac{3}{4}$
2	14	0	$\frac{1}{4}$
3	3	11	0
Sum	21	2	0

By

By this Table you may perceive that the Notes of the *first Assistant*, collected at his several Stations, being added together, amount to 18 Feet, 10 Inches, and $\frac{3}{4}$ of an Inch; and the Notes of your *second Assistant* at his several Stations, being added together, amount to 21 Feet and two Inches: So the number of the *first Assistant's* Observations being taken from the number of the second, there will remain 2 Feet, 3 Inches, and $\frac{1}{4}$ of an Inch; and so much is the Place to which the Water is to be brought, lower than the Spring-head, according to the straight Water-level, and therefore the Water may easily be convey'd. 'If the Surveyor suspects his Level, 'he may try it thus; on Ground not above 4 or 5 Feet out of the Level, at any Distance from one another; suppose 10 Chains set upon 'two Staves; and in the Middle of that Distance set up your Level, 'then direct your Level to the *First*, and make your Assistant move 'the Mark upwards and downwards 'till the Hair cut it at A; do 'the like to your other Assistant's Mark (see *Fig. 39.*) 'till the Hair 'have cut it at B.

'*Lastly*, Move your Level to A, and if it cut B, the Hairs are truly 'adjusted; but if not, level your Telescope, and let your Assistant 'at B mark the Division on the Staff, and then move the Signal 'till 'the Hairs cut it, and as much higher or lower than it was before, 'so much is the Error of the Level in 10 Chain's Length; and so 'much must be accordingly allow'd proportionally in all Distances; 'and these Distances must be measured from every Station of the Level 'to every Staff.

'And tho' the Hairs of the Level be not truly adjusted, yet if it 'be placed exactly in the Middle of the Station-staves, the Errors 'mutually destroy each other

Figure XV.

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 represents the Instrument or Water-level, and B 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 call'd your two Assistants together, and examin'd their several Notes, and added them together, if then you shall find the Sum of your *first Assistant's* Note to be greater than the Sum of your *second Assistant's* 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.

‘When Water-Levels are made with Telescopes of four or five Foot long, then great Distances may be seen very distinct; and in such Cases, Allowances may be made for the Curvature of the Earth. Which must be as in the following Table.

Distances in Chains.	Allowances in Inches and Parts.
5	,031
10	,124
15	,279
20	,496
25	,772
30	1,116
35	1,519
40	1,984
45	2,511
50	3,088
55	3,751
60	4,464
65	5,239
70	6,076
75	6,948
80	7,936
85	8,959
90	10,044
95	11,191
100	12,400

‘Or by the Pen thus; multiply the Square of the Chains by 124, and divide the Product by 100000.

‘So, if it be requir’d to know what Allowance must be made when the Level is 40 Chains distant from the Station-staves; work thus,

$$\begin{array}{r}
 40 \\
 40 \\
 \hline
 1600 \\
 124 \\
 \hline
 6400 \\
 3200 \\
 1600 \\
 \hline
 \end{array}$$

$$100000) 198400 (1,984$$

‘That is almost two Inches. And in like manner, if the Station Staff were distant from the Level 80 Chains, or one Mile, the Allowance is 7 Inches $\frac{2}{3}$.

‘And by these Allowances must each Observation be lessen’d in the Accounts of both your Assistants. These Rectifications give us the true Level; but for the Current of the Water, another Allowance must be made, according and proportional to the Velocity requir’d in that Current.

‘Lastly, Observe, that of these three Allowances, that for the Error of the Level which is the first, is always proportional to the Sum of the Distances; and the second, which is for the Curvature of the Earth, is as the Sum of the Squares of the several Distances; and the last, which is for the Current is like the first, and is as the Sum of the Distances themselves.

¶ Note 2. That the most approved Authors concerning this Particular, do aver, that at every Mile’s End, there ought to be allow’d 4 $\frac{1}{2}$ Inches more than 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

which you must lay your Pipes equal with the straight Water-level, with the former Allowance. And if in this Case there be a Valley, you must then make a Trunk of strong Wood, well under-propp'd with strong Pieces of Timber, and well pitch'd 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 nearest 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 observ'd but in some Cases only, where the Water will have too violent a Current.

II. *How to take the Level, whereby to convey Water from some Pond or Level-Water.*

IT may sometimes so fall out, that you are requir'd to find whether Water may be convey'd from some *Pool* or *Level-Water*: To effect which, take two Boards of about two Foot over, or thereabouts, of what Form or Shape, is not material, the larger the better; about the Midst of each of which Boards bore a Hole, into the which put the Ends of two Sticks, setting them up in those Holes perpendiculary: The Sticks must be exactly of one Length, and have at the Tops of each of them Marks of white Paper or the like; and the Sticks must be of such Length, that when the two Boards, with the Sticks in them, are floating upon the Water, the Marks of Paper at the Tops of them may be seen at a competent Distance from the Pond. The two Sticks being thus seated in the Water, and in a right Line (as near as you can guess) towards the Place to which the Water is to be convey'd; then, at as great a Distance as you can conveniently, erect a third Stick upon the Land, setting a Mark thereupon in an exact Level with the two former which are in the Water; removing the Marks that are either upon those in the Water, or that upon the Land, which you last erected, higher or lower (as Occasion offers it self,) till you have brought them all three to a right Level: Then taking exact Notice how high the Marks are above the Top or Surface of the Water, go on with a fourth, a fifth, a sixth, &c. Staff, so long as you go in a right Line; for having plac'd two Marks in an exact Level, it is easy to find as many more as you please: And when you are to alter your Course, that is, you are to vary from a straight Line, you may then make use of your Instrument, and proceed in all respects, as is before directed: And according as you find the Ground at the Place to which the Water is to be convey'd, either higher or lower than at the Pond, you may determine the Possibility or Impossibility of its being convey'd thither.

III. *How (without a Level, or Level-water) to try whether Water may be convey'd from a Spring or Head to a designed Place, though at a considerable Distance.*

AT the Spring-head begin to make a little Trench, about three or four Pole long, towards the Place which the Water is to be convey'd; whether this Trench be straight or crooked is not material in this Case. Then let so much Water run as will only fill this Trench, letting none run over at either End of the Trench; but when either End is full up to the Brink, then stop the Course of the Water. Now, if you find the Trench dry, or shallower of Water at that End which is next the Head, than at that End farthest from the Head, it declares the Ground to be falling. Then do the like for three or four Pole farther, still making the Water to follow you. And having filled the Trench, so that the Water may stand level at both Ends thereof, then at both Ends erect two Staves of about four Foot long, at each End of the Trench, being both of equal height from the Surface of the Water. This done, go on in the same Line about ten or twelve Pole farther, where set up a third Mark, so that you standing behind it, and looking to the middlemost Mark, you see all the Tops, or all the Bottoms, according to which you measur'd your equal heights, may all agree. And then, if that stick which is below the Mark be longer than the other two, it shews a Descent; but if it be shorter, it shews the Ground is higher: But if any rising Place of Ground be in the way, you may easily find the height of its rise by setting up a Stick, and measuring it, as before is shew'd.

IV. *To know how high you may set your Cock in your House, when Water is convey'd thither.*

WHen you have brought the Water from any Head or Spring to your House, and would know how high you may place your Cock, begin at the Conduit-head, and dig a Trench near a Foot deep; but as you go farther off, let it be still shallower, for 5 or 6 Pole in length, more or less according to the fall of the Ground, so that the Water may but just follow you; and when it begins to run over, there stop it, and begin a new depth as before: But be sure, let the Fall of the Water be down-right, like the Steps of a Pair of Stairs: And in this manner go on, 'till you come to the Place to which you intended to bring it. Having thus done, add the

the Fall at the Conduit, and the Depth of your great Works, for
gether: And so high in your House above the Level Time brought
may you set your Cock.

V. Concerning the Cleansing of Water:

IF the Water which comes to your House be noisome, you may
thus purify it. Make a Trench from your House about three
or four Perches long or more, (for the longer it is the better,) and
a Foot and half deep : Fill this Trench a Foot thick from the Bot-
tom with Hurlock or Clunch cut in Pieces (as fit for the Lime-
Kiln :) Then fill it one Handful higher with Pebble-stones ; then
fill it up with Gravel or Earth ; the Water running through it will
be so purified, that it will be fit for Brewing, for the Pot, Wash-
ing, or any thing else.

This also greatly mendeth Well or Pump-water : For the Well
being cleansed from Mud, and Clunch put therein almost as high
as the Water riseth, it will mightily mend the Water.

VI. Concerning Flowing of Grounds.

TO describe the manner of making of *Mills*, to go either with
the *Wind*, *Water*, or other Force, or *Sluces*, or other *Engines*
for the *mounting* of *Water*, is not my Design in this Place ; but to
deliver such plain Rules and Directions to any Gentlemen or others,
who occupy or possess Grounds ; how, when Occasion requires,
they may *flow* them ; it being of good Use in a dry Season : For by
this Means some one Man by *flowing* of his Ground, having a
River adjoyning, hath made his Ground yield him 5 *l.* an Acre,
whereas his Neighbour hath scarce made 20 Shillings an Acre of his,
although, at other Seasons, the one Man hath made his worth as
much an Acre as the other, the Grounds being naturally of an e-
qual Goodness.

Having by *Drains* and *Dams* brought the Water to the highest
Part of that Ground which you would flow, you must cut a little
Trench as level as you can guess (having no Instrument) by your
Eye, which Trench let be about nine Inches broad, and seven or
eight deep, and about fifteen or sixteen Foot in length at the first,
laying the *Turfs* which you cut out close to the Trench, on the
lower side thereof, with the Grass-side downwards. This done, let
the Water into this Trench, allowing it to run over a little at the
lower End thereof : And thus may you stop the Water with a *Turf*,
and cause the Water to run over in any Part of the Trench.

Now, in the making of this Trench, if you find that the Water will not follow you, you must with a Spade, made crooked at the End, sink it deeper, and cast out the Earth, and in your going on, go deeper and deeper, as you shall find Occasion, yet not deeper than that the Water may just follow you; thus proceeding 'till you come to the farther side of the Ground. And in your Passage, according as you find the Ground to fall, you may make cross Trenches, of about four or five Pole one from the other, the same Way as formerly is said, 'till you have made Drains enough.

In case you are to carry your Water over some Ditch, Brook or Valley, you must then make a Boat of Boards nailed together, making a Trough thereof, through which the Water may run.

VII. Of Draining of Grounds.

THis is more easy and with less Charges performed then *Float-
ing*, and is altogether as necessary, and as advantageous as *Floating* is, and that not only in *Arable*, but in *Meadows* which lie low, in *Woods*, *Bills* and *Boggs* upon Hills.

The Instruments necessary for this purpose are, a *Plow*, *Spades*, *Scoops*, *Shovels*, and *Forks*.

The *Plow* makes the Way, and the *Spades*, *Scoops*, *Shovels*, *Bills*, &c. are used by those which follow the *Plow*, in clearing of the Way which the *Plow* hath made, from *Turfs* and other Obstacles which fall in after the *Plow*, as *Roots*, *Stones*, and several the like. This Instrument (I mean the *Plow*) is so necessary, that (saith my Author) in some Parishes they maintain a Town-Plow, that will hold eight or nine Yoke of Oxen, and two Horses for Boys to ride on to guide the *Plow*, while others (booted up to the Middle) hold the *Plow*: And with these *Plows* much good hath been done in hard and stoney Grounds, and also in the throwing out of Ditches which have been stopp'd, and in making good of High-ways, as also in Clay-grounds, and such like; and thus (saith the same * Author) they do serve their *Pease-stubble*, *Barley-stubble*, and *Low Meadows*, especially their *Commons* once a Year, and that about *All-Saints* Day. And for the making of any new *Drain*, *Ditch* for *Quicksets*, *Brook* or *River*, he giveth this Direction. First, ' Set
' up your *Mark* or *Marks* at the End of each nine or ten Poles, on
' both sides of the Riders, to guide the Horses by: Then plough
' once all over that Breadth, and throw out the Earth; then set
' the Horses single, and with any other lighter *Plow*, plough again,
' and throw out as before, 'till you are deep enough. And by this
' means (saith he) more may be dispatch'd in one Hour, than in

* Mr. George Atwell of Cambridge, an Experienced Man both in Art and Husbandry, from whom I receiv'd several such like Directions concerning Grounds.

‘ three Days otherwise. And also, that many great Works, for
 ‘ many Years deem’d impossible, have been in short Time brought
 ‘ to great Perfection, to the great Profit of the Owners, the sa-
 ‘ ving of Cattle, and ease of Travellers. And moreover, he saith
 ‘ in these Words: ‘ I have known divers *High-ways*, where one
 ‘ Furlong hath abutted upon them, and another run long-wise
 ‘ by the side of it, where the Way hath not been above a Pole
 ‘ broad, that the *Plow* continually carrying out of Mold upon
 ‘ it, hath so raised that Linsey-side, that it hath been so Linsey, that
 ‘ not a loaden Cart hath gone on it in Harvest, or Hay-time,
 ‘ since the Memory of Man, yet the most necessary Harvest-way:
 ‘ This (saith he) have I mended and made level with my own
 ‘ *Plow*, and my own People, in two Hours, a quarter of a Mile
 ‘ together: And the like have I done to raise a Road-way in the
 ‘ Middle, by ploughing and throwing up both sides.

And thus you have the Way how to *Drain* such Grounds where-
 in the Use of the *Plow* is required: I shall now shew how to *drain*
 such Grounds where the *Spade* is the principal *Instrument*, which
 may be called.

Water-Furrowing.

When any *Grain* whatsoever is new *Sown*, presently *Water-furrow*
 by *Plow* and *Spade*, (as the Ground requires.) For if it so fall out,
 that (in a Flood) the Water goes not away so fast as it comes, (al-
 though in two or three Days it will be clean gone,) yet you are
 never the nearer, it hath done (already) what Hurt it can, your
Grain is drowned, and the Fault is in the main Drains, yet not
 their Depths, (for they will be dry in two or three Days,) but in
 their Breadths. Wherefore, if you are to make a new Drain, you
 may do it with the *Plow*, as before; but only to deepen or to wi-
 den old ones, the *Spade* is best. But many times Drains are stopp’d
 by several Accidents, as at Places where Cattel go over, which
 may be remedied by making a Bridge of Splinters of Timber with
 Bavons and Gravel over them.

VIII. Concerning Bogs and Quagmires.

THese do issue (for the most part) of *Spewing Springs* that
 are in a Vein of *Gravel*, most commonly near the Superficies
 of the Ground, and still drawn more upwards by the Heat of the
 Sun: Or else they are in such places which formerly have been all
 Water, (as the *Fens* sometimes have been,) and so growing of
 Weeds at first, they rotting have turn’d to Earth, and so in process
 of Time have swoln up to a great Height.

Now

Now if your *Bog* be so tender that you cannot go upon it, then at the upper Part (where it first riseth) make a large and deep *Ditch*, so deep that it may be lower than the Bottom of the *Springs* by a Foot or two: This Water convey so, that none of it may stand in the Ditch ; so that the Water of the *Springs* may be cut off. Then make a lesser *Ditch* round about, and when it hath drain'd thus a while, that you can go upon it, dig *Drains* up the Hill, as deep as you can, and about twenty Foot from each other : And by this means (in a short time) you may have good Ground either for *Orchard*, *Hops*, or *Pasture*.

The End of the Second Part of the Fourth Book.

VIII. Concerning Bays and Quagmires.

Fig I.

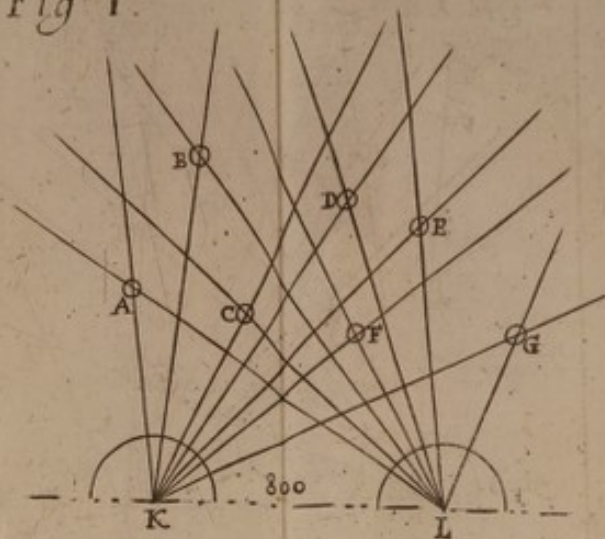


Fig: II

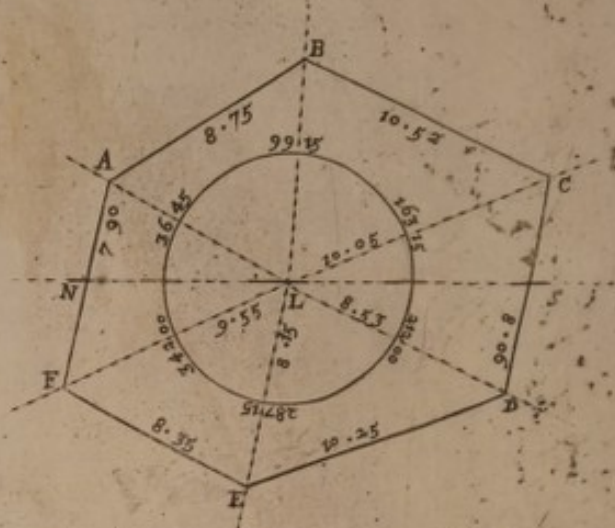


Fig: III.

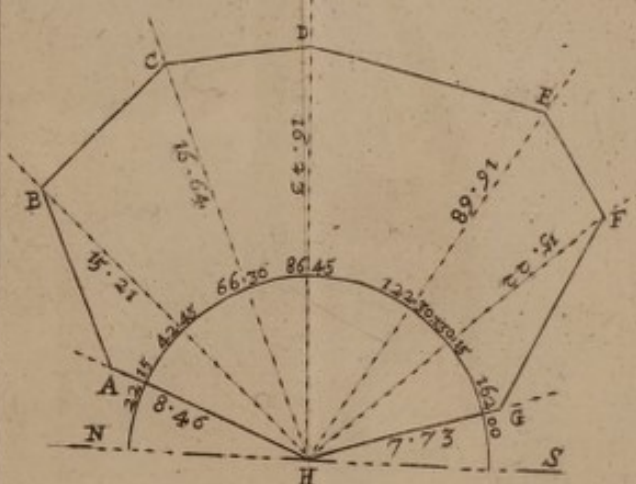


Fig: IIII

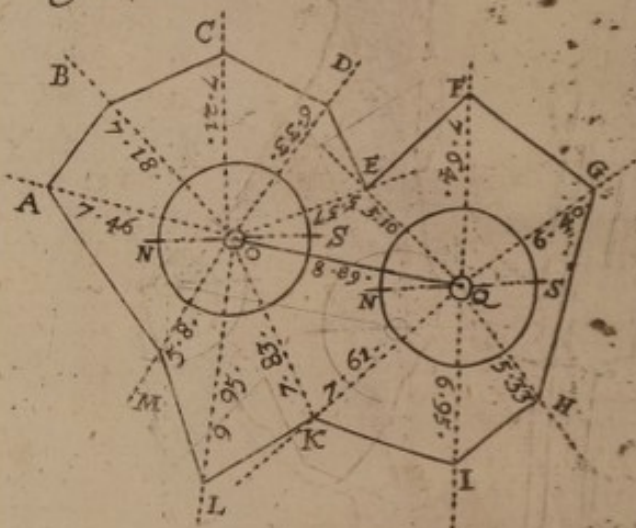


Fig: V.

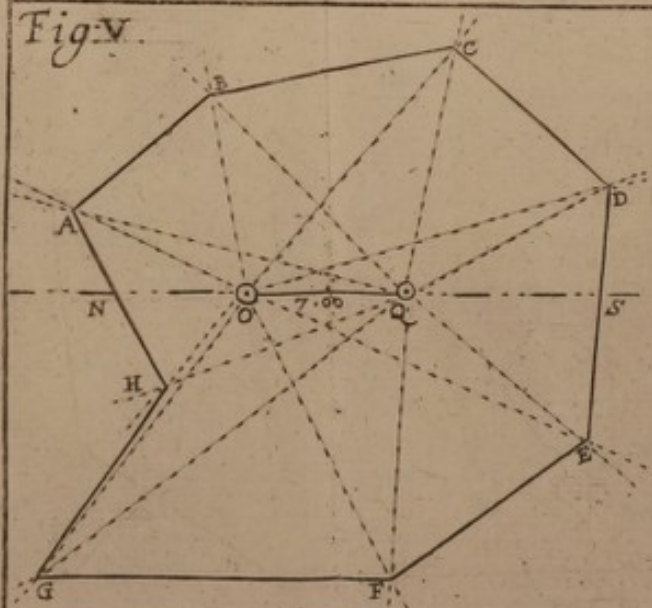


Fig: VI

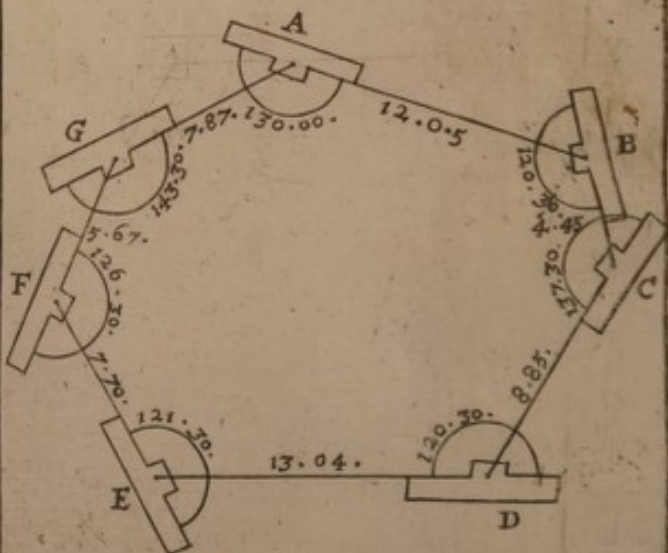


Fig. II



Fig. III



Fig. IV



Fig. V

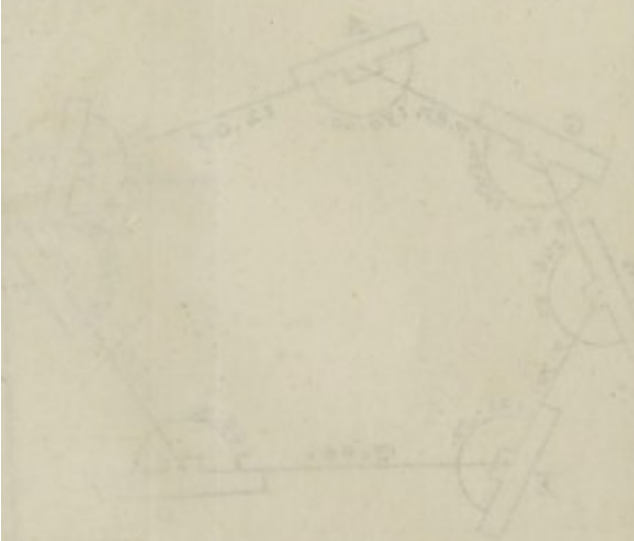


Fig. VI



Fig: VII

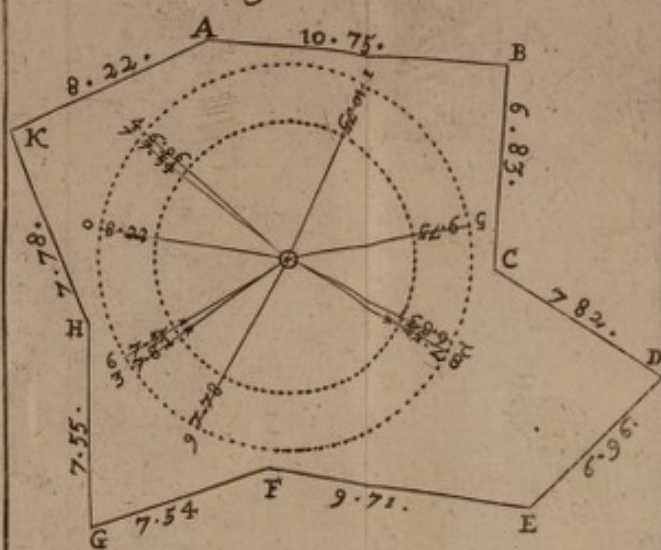


Fig: VIII

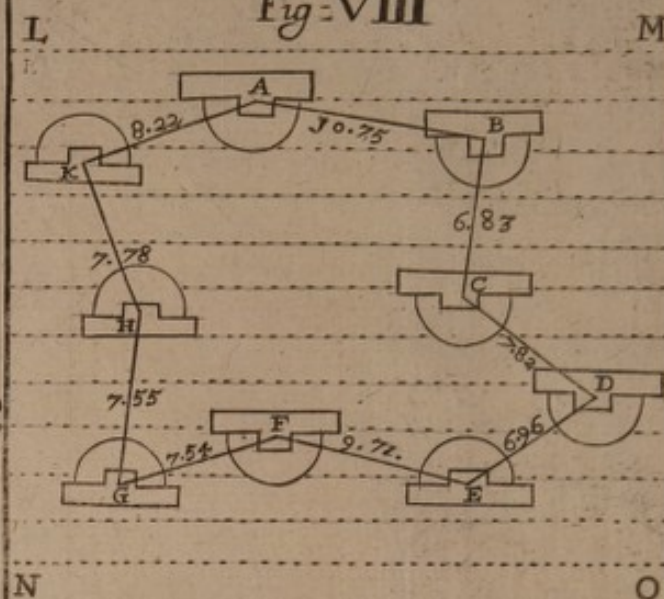


Fig: IX

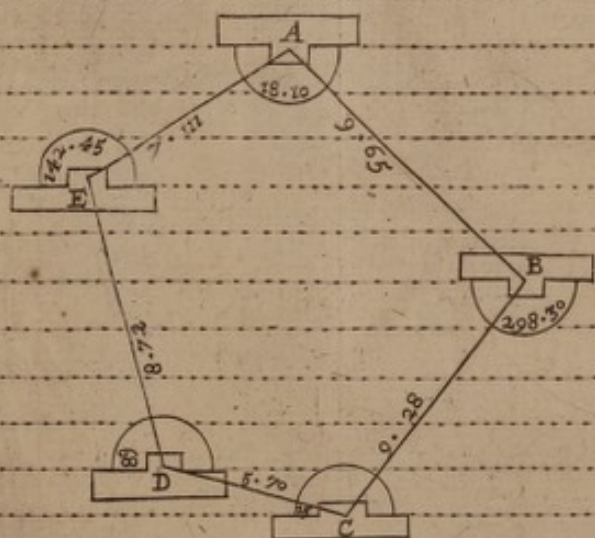


Fig: X

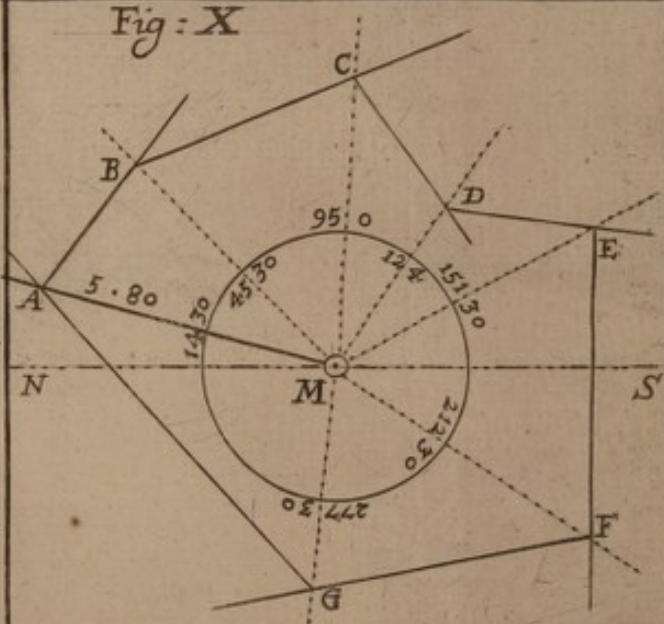


Fig: XI

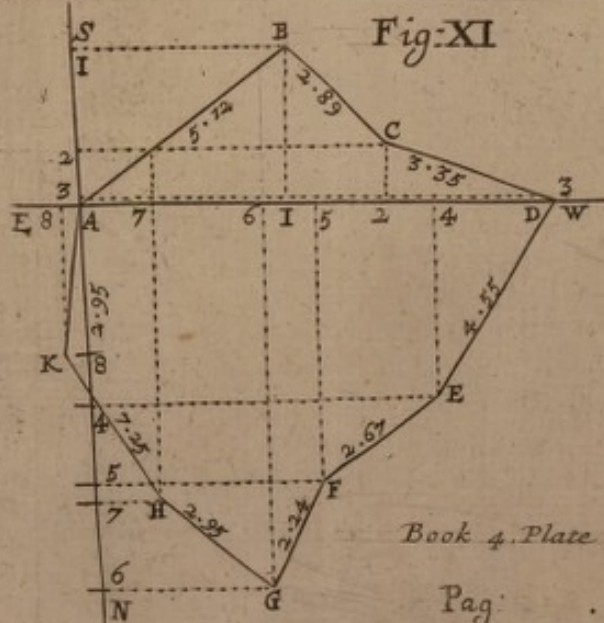
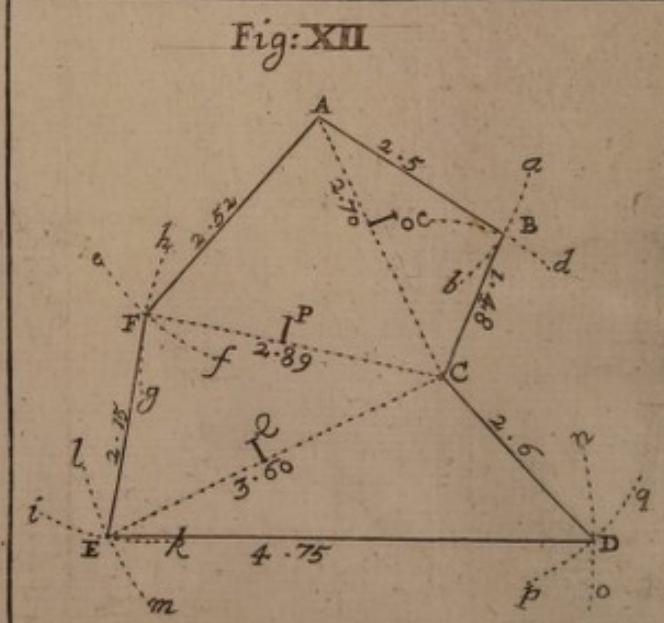
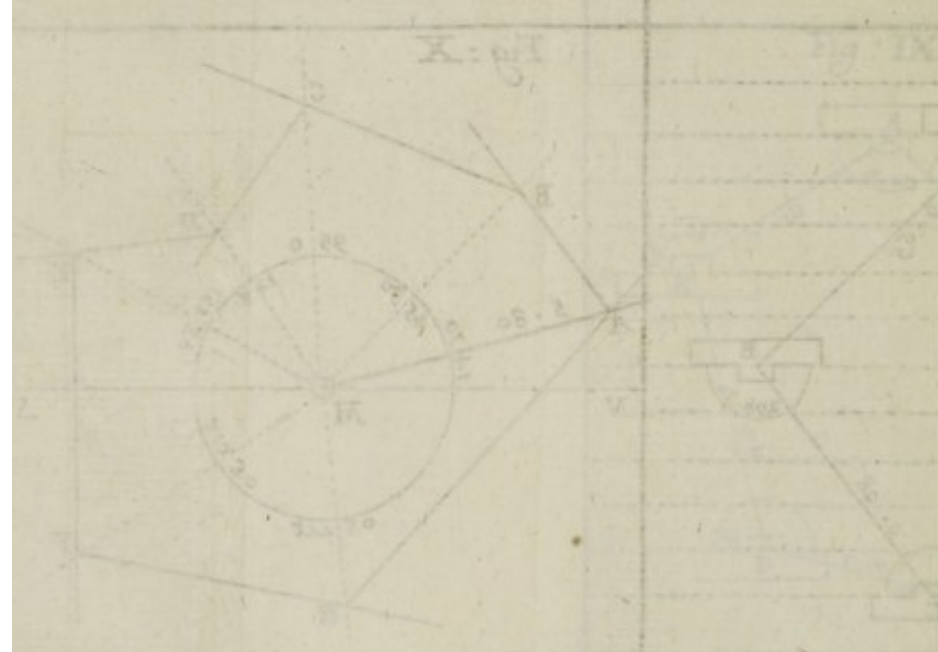
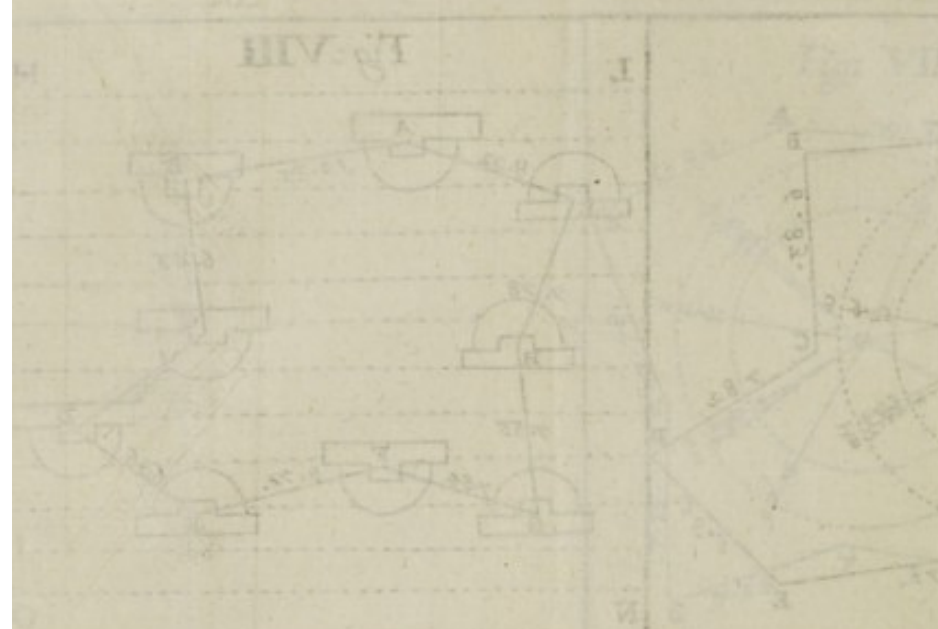


Fig: XII





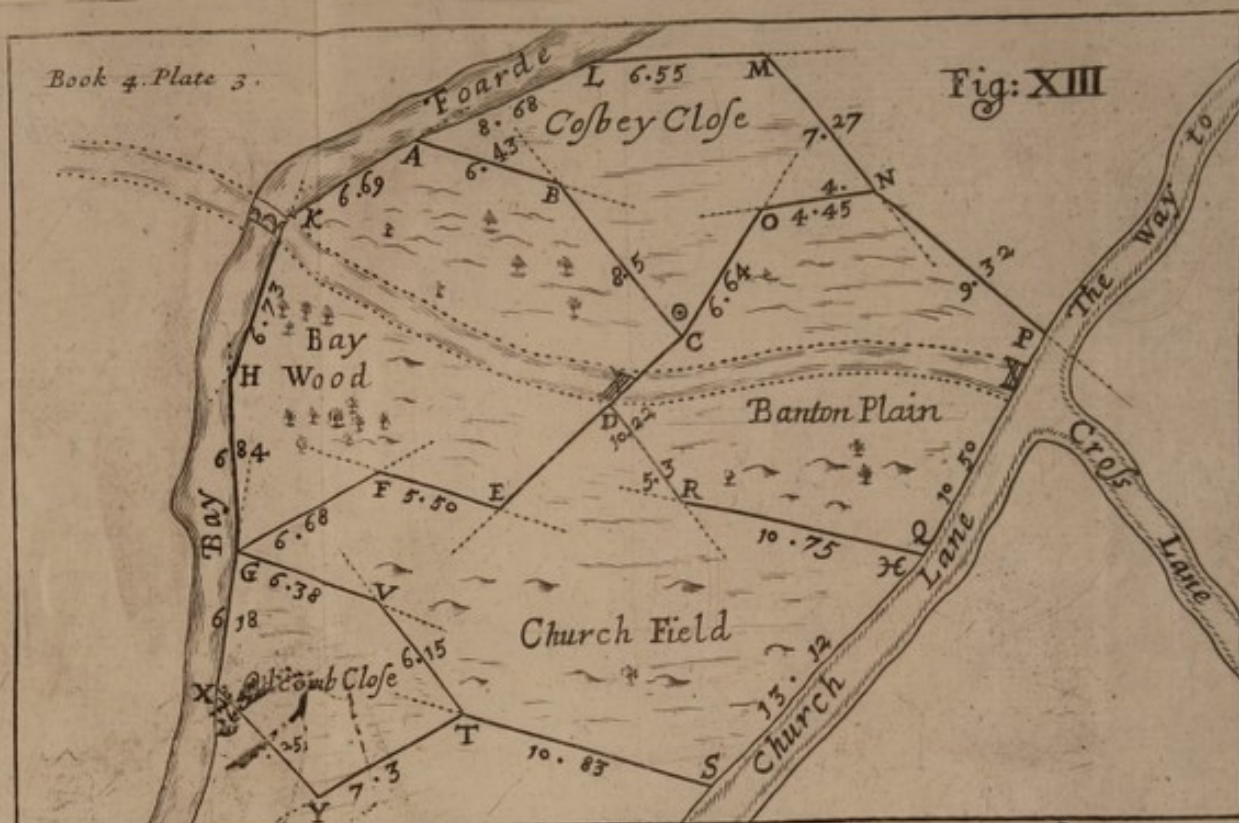


Fig: XIII

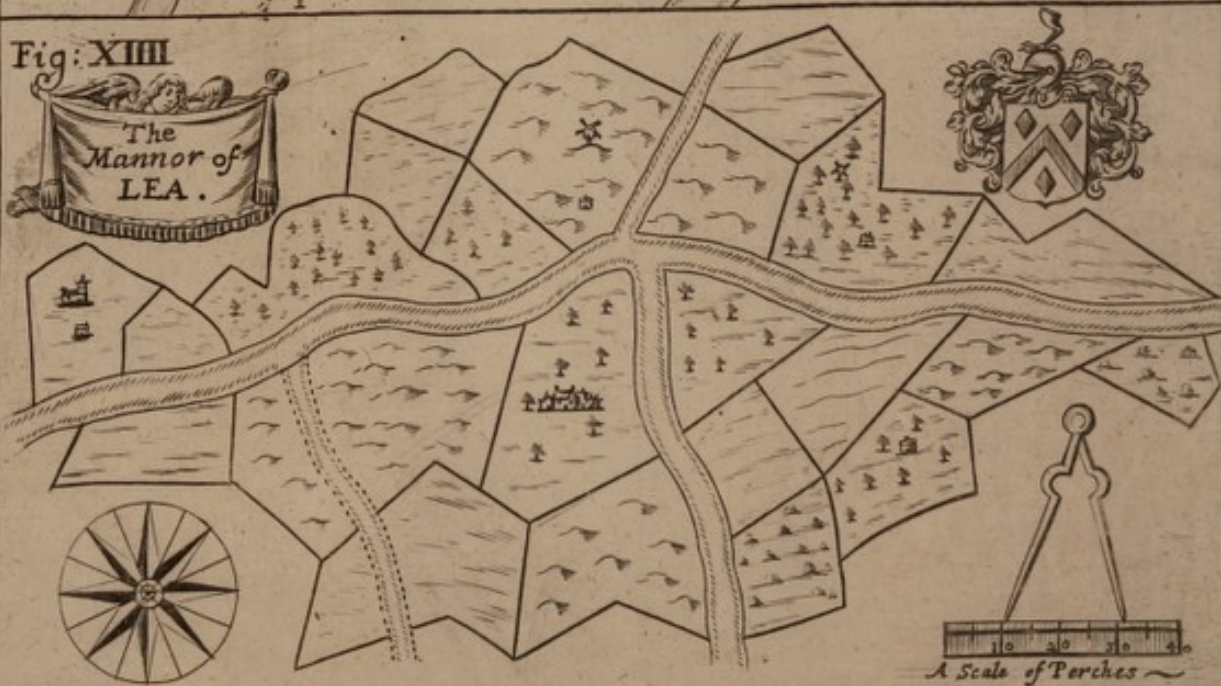
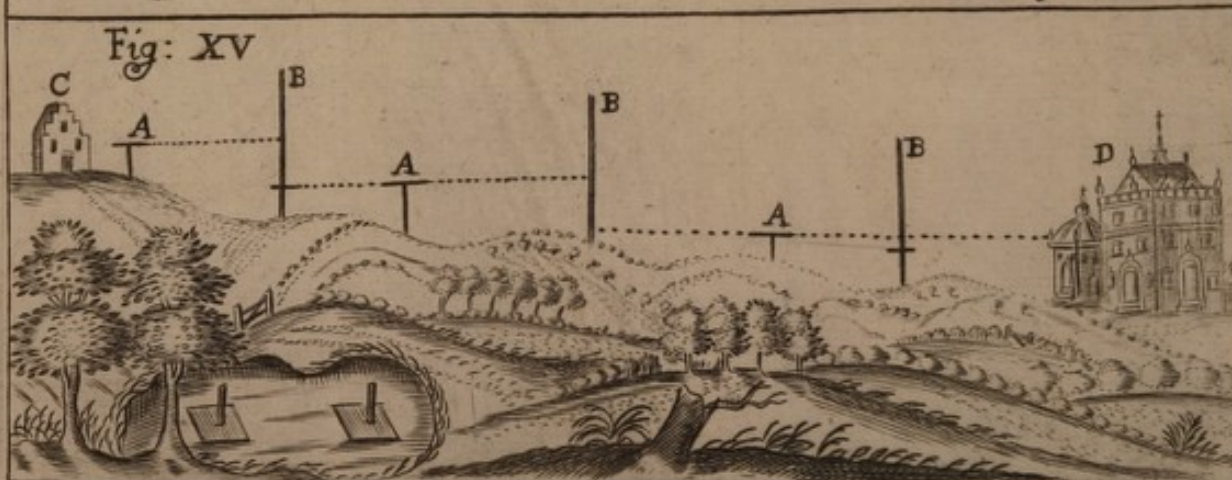
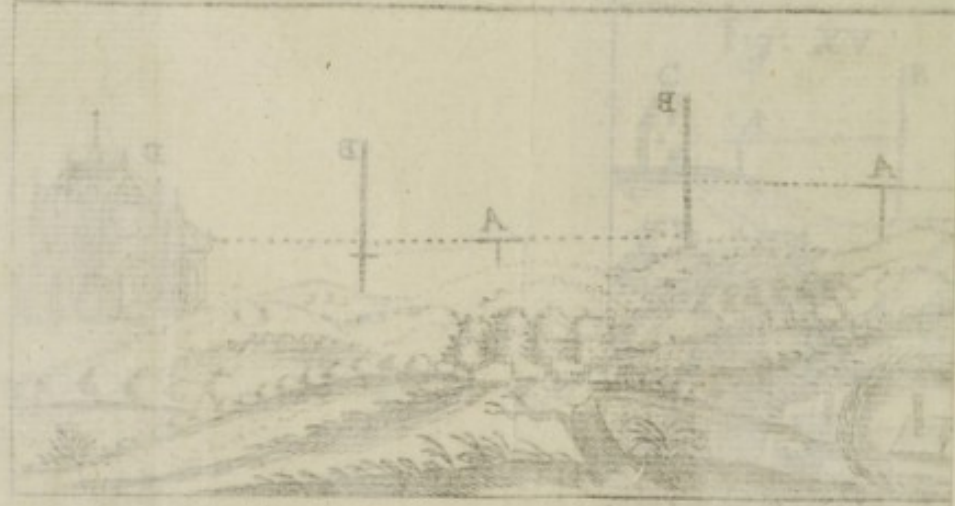
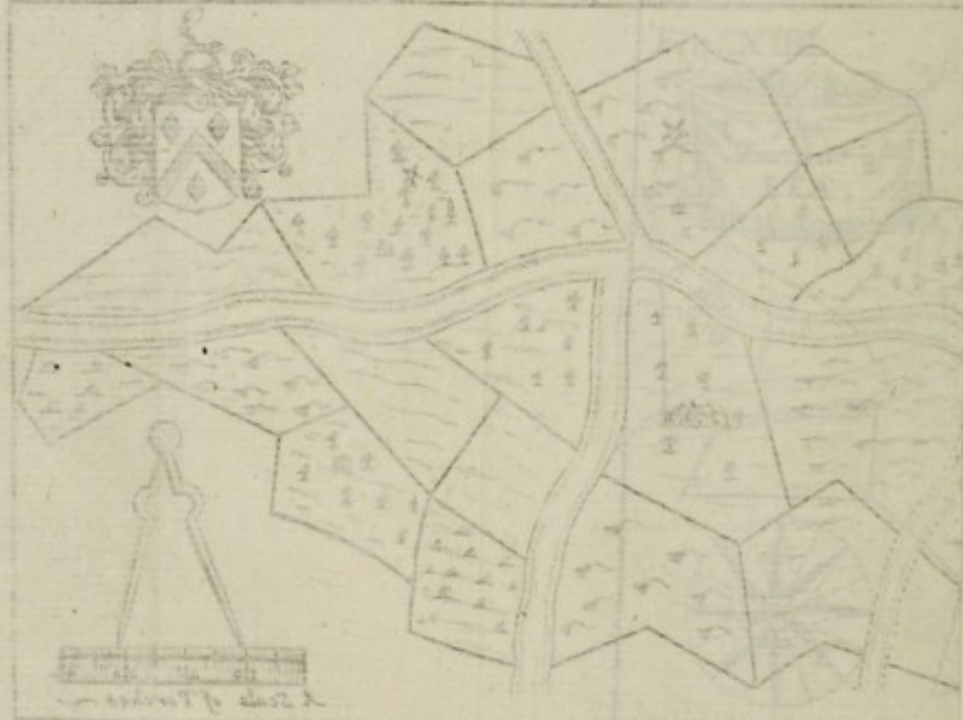
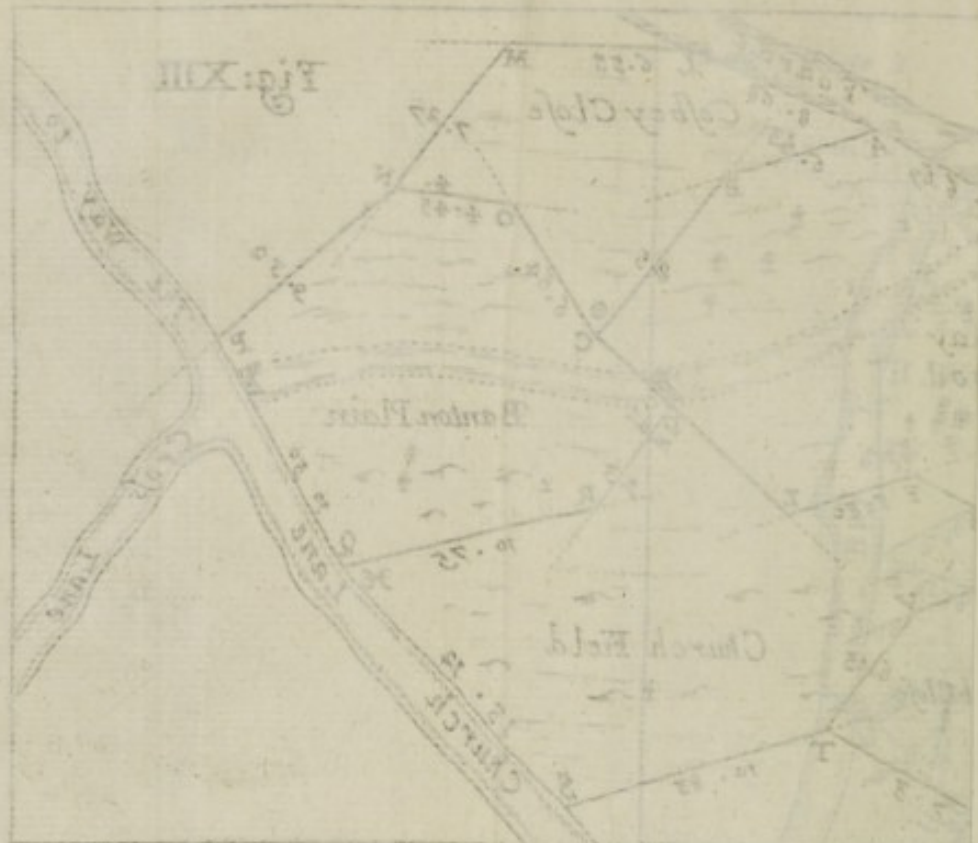
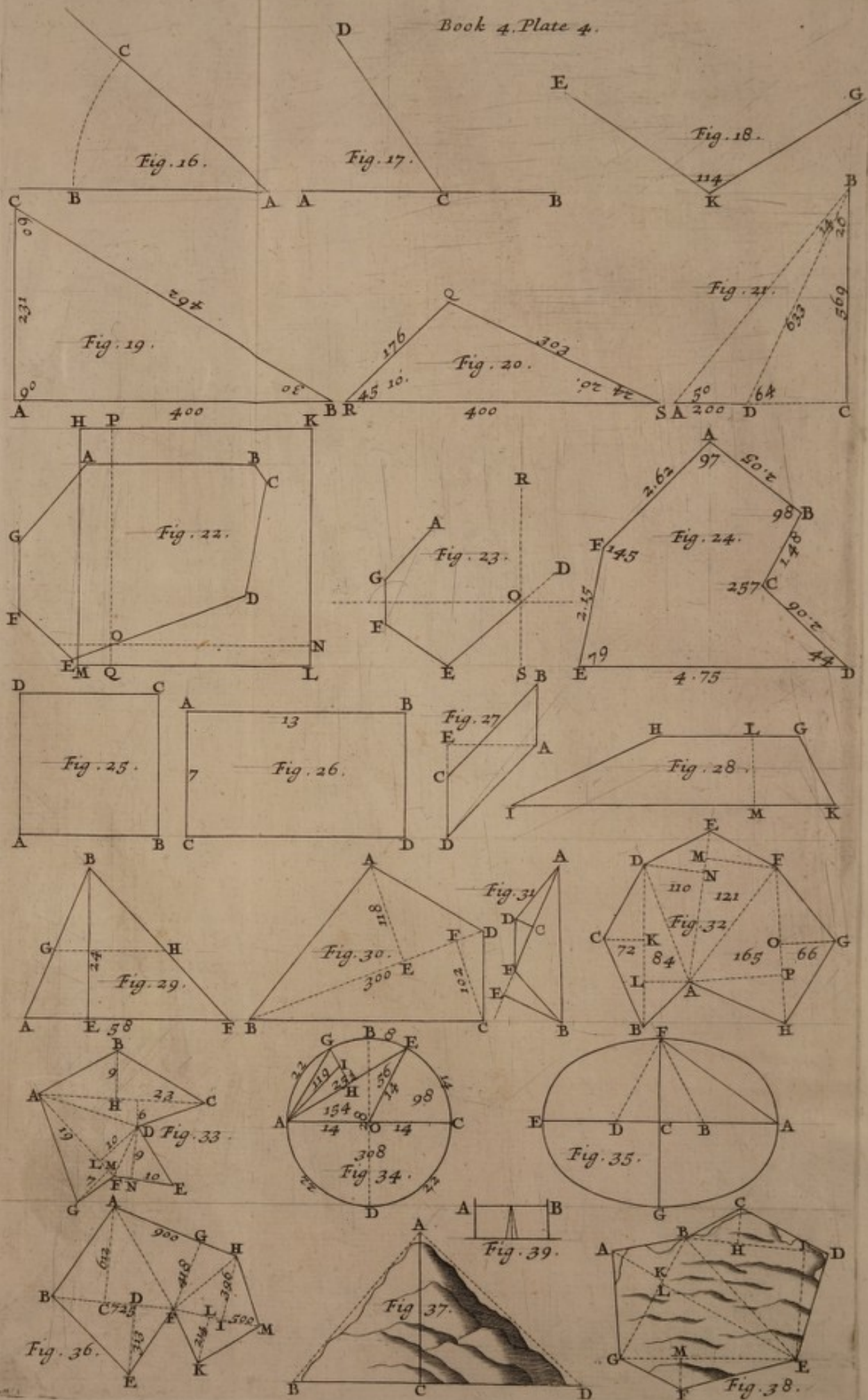
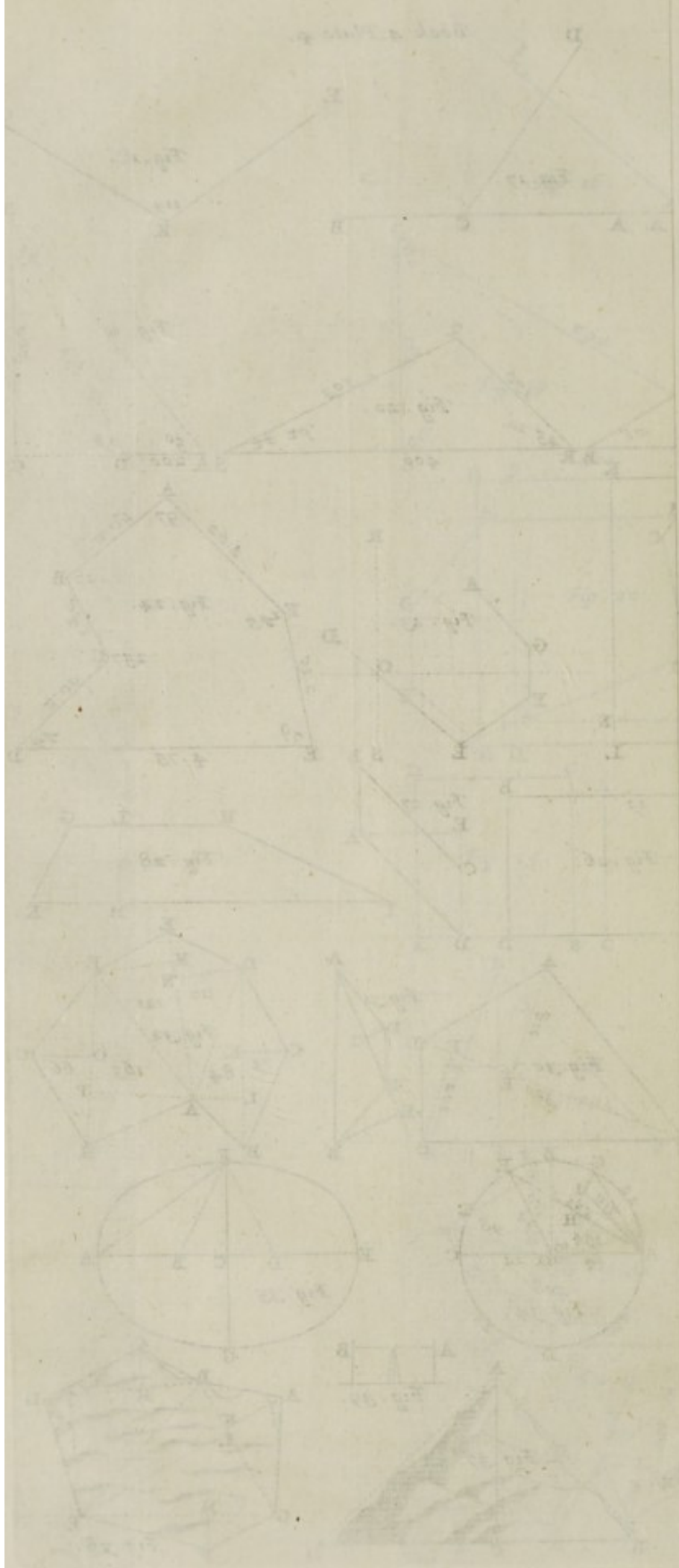


Fig: XV









THE
COMPLETE
SURVEYOR:

SHEWING
How to take *Heights, Distances,* and to
Survey all manner of *Land* by

A SEMI-CIRCLE:

Which (to distinguish it from the *THEODOLITE, CIRCUMFERENTOR, PERACTOR,* or other graduated *Instrument* :)
I call,

The Perambulator.

The Fifth BOOK.

A Description and Figure of the INSTRUMENT.

THE *Instrument* (Fig. 1.) is no other than a *Semicircle*, and may be made in *Brass* or *Wood*, of what *Largeness* you please: In *Brass* (which is best) the *Diameter* thereof may be about *Fifteen* or *Sixteen Inches*: In *Wood* Larger.

The outermost *Limb* of the *Semicircle* is divided into *180 Degrees*, which are number'd by *10, 20, 30, &c.* (from the left Hand towards the Right,) to *180 Deg.* at *B*: And again (beginning at the same Place, and the same way) from *180* to *360 Degrees* at *B* also.

Then, in another *Circle* under these, the two *Quadrants* are divided each into *90 Degrees*, beginning at *S*, and number'd from thence, both ways, by *10, 20, 30, &c.* to *90* at *E* and *W*: And

under these two Quadrants, is engraven in one of them *South-East*, and in the other *South-West*: For the Letters E, S, N and W, signify *East, South, North and West*, and your *Instrument* (when you use it,) must have respect to those *Quarters* or *Parts* of the *Heavens*.

In the middle Bar of the *Semicircle*, S, N, (which is of Breadth sufficient) let there be plac'd a long *Box* of *Brass*, wherein to hang a *Needle*, with a *Glass* over it, which may be so order'd, to lie under the *Semicircle*, that the *Index* with its *Sights*, may freely move over it.

Then upon the *Diameter*, at D and F, and also upon the *Index* at G and H, let there be *Doughts* sawder'd, to slide *Sights* upon; and so is your *Instrument* finish'd, as to the *Superficies* thereof; all which the *Figure* of it, will demonstrate to your View better than many Words.

See the Figure.

On the Backside of the *Instrument* there is to be screw'd a small *Socket*, into which goeth another *Socket*, call'd a *Ball-Socket*, which serveth to set the *Instrument*, when it is upon the *Staff* in any Position whatever, as *Horizontal* or *Level* (which it ought always to do in *Surveying* of *Plain Grounds*) *Vertical* or *Perpendicular*, (when in taking of *Altitudes*.)

Into the *Ball-Socket* there goes the *Head* of a *Staff* with three *Legs*, upon which the *Instrument* with all its *Parts* resteth.

Thus much concerning the *Instrument*; and for the *Protractor*, (whereby to lay down any thing taken or *Surveyed*) let it be divided, number'd, and noted with the same Letters as the *Instrument* itself is divided and figured.

The Use of the Instrument.

I. In taking of Altitudes and Distances, either Accessible or Inaccessible.

P R O P. I.

How to take the Height of a Tree, Tower, Steeple, or other Object, being Accessible.

LET A B, (Fig. 2.) be a Castle Wall, and you standing at C, would know the Height thereof.

Place your *Instrument* (it being upon its *Staff* well fixed) at C, and direct it to the Object, and hanging a *Line* and *Plummet* upon the Centre of the *Instrument*; move the *Instrument* up and down (by help of the *Ball-Socket* only) 'till the *Thread* and *Plummet* hang directly upon the *Line* N S, and then, looking through the two

two Sights which are upon the Diameter of the Instrument, mark what Part of the *Castle Wall* you see ; for that Part is in the just *Level* with your Eye, which Point will be at B — Then move the Instrument upwards or downwards, 'till (through the same Sights) you see the very Top of the *Castle Wall* at A : Then (the Instrument there resting) look what number of Degrees and Minutes are cut by the Thread ; we will suppose them 35 Degr. which note down: And then measure with your Chain ; (a Foot Chain is fittest for these Conclusions) the Distance from F to B, or from C to D, the Foot of the Castle, which we will suppose to be 205 Foot: And by the help of these two, the *Height* required may be found, as followeth.

1. By Protraction.

Upon a Sheet of *Paper*, or the like, draw a right Line at pleasure, as *mn*, towards one End whereof, as at B, erect a Perpendicular B A, representing the *Castle Wall*: Then from any *Scale*, take 205 Foot, your measured Distance, and set it from B to F.

This done, upon the Point F, protract an Angle of 35 Deg. (which were the Degrees cut by the Thread) and through that Point draw a right Line, as F A, 'till it cut the Line A B, representing the *Castle Wall* in the Point A: So shall the Length of the Line A B, be the Height of the Wall required: Which measured by the same Scale will be found to be 143.5 Foot, to which add B D 5 Foot, the Height of the Instrument above the Ground, and you'll have 148.5, and so high is the *Castle Wall*.

2. By Calculation.

This Work might have been done without Protraction, by the *Second Case* of right Angled Plain Triangles, as in *Book 3. Chap. 4. Case 2.* hereof,

In this Manner;

As the Co-Sine of 35 Degrees the Angle cut by the Thread, 9.91336

Is to the measured Distance F B 205 Foot, 2.31175

So is the Sine of the Degrees cut by the Thread 35° 9.75859

To the Height required A B, 143.5 Foot, 12.07034

2.15698

PROP.

PROP. II.

How to take an Inaccessible Altitude.

Suppose *A B* (*Fig. 2.*) to be the *Wall* of a *Fort* or *Castle*, and that you can come no nearer to the Bottom of the *Wall*, than to *G*, for that there is a *Ditch* or *Moat* about the *Castle* of that Breadth.

First, Place your Instrument at *G*, the Brow of the *Moat*, and directing the Sights to *A*, the Top of the *Wall*, you'll find the Degrees cut by the Thread and Plummet, to be 60 Deg. 52 Min.

Secondly, Go backwards a competent Distance of Ground in a right Line, as to to *F* 125 Foot, and there placing your Instrument as before, direct the Sights to *A*, where you find the Thread to cut 35 Deg.

By the help of this Distance, and the other two observ'd Altitudes, the Height of the *Wall* *A B* may be attained, as followeth.

1. *By Protraction.*

First, Draw a Line at pleasure, as *m n*, upon which, towards one End thereof (as at *F*) with a Scale of Chords, or your Protractor, lay down an Angle of 35 Deg. the same as were cut by the Thread and Plummet when the Instrument stood at *F*, and draw the Line *F A*.

Secondly, Your measured Distance being 125 Foot, take 125 out of your Scale, and set them from *F*, forwarder, to *G*.

Thirdly, Upon the Point *G*, protract an Angle of 60 Deg. 52 Min. the same which the Thread and Plummet did cut, when you stood at *G*: And draw the Line *G A*, crossing the former Line *F A*, in the Point *A*.

Lastly, From the Point *A*, let fall a Perpendicular upon the Line *m n*, and it will fall upon the Point *B*: So is *A B* the Height of the *Castle Wall* required: Which, if you measure upon your Scale, you will find to contain 143.5, that is 143 Foot and a half.

2. *By Calculation.*

As by the VIIth and III^d Cases of right Lines Triangles: Thus, In the oblique angled Triangle *A G F*, you have given, (1.) The Angle *A F G*, observ'd when you stood at *F* 35°. (2.) The Angle *A G F*, 119 D. 8 M. the Complement of 60 D. 52 M. (as you observ'd when you stood at *G*) to 180 Deg. And (3.) The measured Distance between *G* and *F* 125 Foot. And having the Angles at *F* and *G*, you have the Angle *G A F* also given. Then say,

represents your *first Station*, protract an Angle of 110 Deg. and from C, through that Point draw a Line at pleasure, as the Line Cx, upon which Line, set your *measured Distance* 120 Foot, from C to B, the Point of your *second Station*. Upon which Point B, protract an Angle of 40 Deg. (the same which your *Index* cut at your *second Station*) and through that Point, from B, draw a right Line at pleasure, as B s, cutting the Line v w first drawn, in the Point A, which is the *Point* representing the Place where the *Tree* stands: And therefore, if you take the Lines C A and B A (severally) in your *Compasses*, and *measure* them upon the same *Scale*, from whence you took your *measured Distance* C B, you will find, that C A will contain 145.5 Foot; and B A 224.5 Foot; and so far is the *Tree* at A, distant from B or C.

2. By Calculation.

The three Points A, B, C, do make an *oblique angled Triangle*; in which there is given, (1.) The *Angle* A C B, observed at your *first Station*, to be 110 Deg. (2.) The *Side* C B, your *measured Distance* 120 Foot. (3.) The *Angle* A B C, observ'd at your *second Station* to be 40 Deg. And (4.) The *Angle* C A B 30 Deg. For the *Angle* at C being 110 Deg. and the *Angle* at B 40 Deg. their Sum 150 Deg. subtracted from 180 Deg. leaves 30 Deg. for the *Angle* at A, and then the *Proportion* is,

As the Sine of the Angle B A C, 30 Deg.	9.69897
Is to the Distance C B 120 Foot,	2.07918
So is the Sine of the Angle A B C 40 Deg.	9.93753
	12.01671
To the Distance C A, 207 8 Foot,	2.31774

For the Distance from C to A:

And so the Sine of 110 (70 Deg.) the *Angle* B C A, to the Distance B A, 225.5 Foot.

PROP. IV.

How to take the Distances of several Places remote from you; and also, of the several Distances of those Places one from another.

LET ABCDEFGHIK, (Fig 4.) be several Places remote from you, as *Churches, Halls, &c.* in a *Town* or *City*; or other like *Objects*.

First, Make choice of two *Places*, from either of which you may see all the *Objects* or *Places*, whose *Distances* from each other you desire to know, which two *Places* let be S and N, distant from each other 1000 *Paces*, or other Measure.

Second.

Secondly, Set up your *Instrument* at S (which call your *first Station*) and direct the back *Sights* that are upon the *Diameter* to N, (which call your *second Station*) and then screw it fast: Then,

Thirdly, Turn the *Index* about, 'till through the *Sights* thereof, you see the first *Object* at A; and note what *Degrees* the *Index* cutteth, as in this *Example* it doth cut 23 Deg. 30 Min. which note down:

First Station at S	Deg. Mi.	Sec. Sta- tion at N	Deg. Mi.
A	23 30	12	45
B	48 45	19	30
C	78 15	40	45
D	97 30	62	30
E	139 00	84	30
F	152 45	121	30
G	200 00	121	00
H	225 15	279	15
I	229 0	287	30
K	284 20	325	20

Stat. Dist. 1000 Paces.

And move the *Index* about till through the *Sights*, you see your *second Object* at B, where the *Index* cuts 48 Deg. 45 Min. which set down also. Do the like to all the rest of the *Objects* at C, D, E, F, G, H, I and K, noting the *Degrees* which the *Index* cuts at every *Object*, and you'll find them to be such as in the *Margin* under [*first Station* at S.]

Fourthly, Remove the *Instrument* to your *second Station* at N, and from thence look through the *Sights* on the *Diameter*, 'till you see your *first Station* at S, and then screw it fast: Then,

Fifthly, Turn your *Index* about, 'till thro' the *Sights* you see your *first Object* at A, and

see what *Degrees* are cut by the *Index*, which in this *Example* are 12 Deg. 45 Min. which set down as you see them in the *Margin* under *second Station* at N: And thus directing the *Sights* to all the *Objects* B, C, D, E, F, G, H, I and K; you will find the several *Degrees* cut by the *Index* to be such as are set down in the *Table* in the *Margin*, under [*second Station* at N.] And now,

Lastly, By help of the *Stationary Distance*, and these *Angles* taken at both the *Stations*, S and N, you may make a perfect *Plot* or *Map* upon *Paper* or *Vellum*, of all those *Places* with their true *Positions* and *Distances* one from another, as you may see done in this *Figure*: In this manner,

1. By Protraction.

Being provided of a large Sheet of *Paper*, or *Skin* of *Vellum* or *Parchment*.

First, Draw a Line thereupon, to contain 1000 *Paces*, taken from any *Scale*, as the Line S N, representing the *South* and *North Points*.

Secondly, Place the Centre of your *Protractor* upon the Point S, and the *Diameter* thereof upon the *Station Line* S N, and there keep it fast, making Marks with your *Protracting Pin*, against those *Degrees* which the *Index* cut when the *Sights* thereof were directed to the several *Objects* at A, B, C, &c. as against 23 Deg. 30 M. 48 D. 45 M. 78 D. 15 M. &c.

Third-

Thirdly, From the Point S, through your first Point, draw the right Line S a at liberty, and from the Point S, thro' the second Point, draw the right Line S b at liberty, and so through all the rest of the Points draw the Lines S c, S d, S e, S f, S g, S h, S i and S k: Then

Fourthly, Apply the *Protractor* to the *Stationary* Line S N, laying the Centre upon N, and the Diameter upon the Line S N, and make Marks or Points against the Degrees cut by the *Index* at the *second Station* at N: As against 12 D. 45 M. 19 D. 30 M. 40 D. 45 M. &c. and through those Points draw Lines from N, as the Lines N a, N b, &c. And where those Lines intersect, or cross each other (each to his Correspondent) as where the Line S a crosses the Line N a, which will be at A, that is the Point of the *first Object*: And so of all the rest. As

Where the Line	{	N b	Crosses	the	Line	{	S b	Which will be at the Point	{	B	} the	{	Second	} Obj.
		N c					S c			C			Third	
		N d					S d			D			Fourth	
		N e					S e			E			Fifth	
		N f					S f			F			Sixth	
		N g					S g			G			Seven.	
		N h					S h			H			Eighth	
		N i					S i			I			Ninth	
		N k					S k			K			Tenth	

And those Points A, B, C, D, &c. are the true Places of the respective *Objects*, to which you directed your *Sights* from S and N.

2. By Calculation.

I shall not need to give *Examples* in the Distances of all the *Objects* from the *Stations*, nor of all the *Distances* of them one from another; it shall suffice to instance in *One*, by which all the rest may be found in the same manner, and by the same *Proportion*: And that shall be in the *Object* at A, and the two *Stations* at S and N do make an *Oblique angled Triangle* A S N; in which there is given, (1.) The *Angle* made at the *first Station* S, to A, 23 Deg. 30 M. (or it's Complement to 180 De. viz. 156 Deg. 30 M. equal to the *Angle* A S N,) (2.) The *Angle* observed at the *second Station* N, to A, viz. 12 Deg. 45 M. equal to the *Angle* A N S; by the help of which, the third *Angle* S A N may be found; for the Sum of the other two 156 Deg. 30 M. and 12 Deg. 45 M. is 169.15, whose Complement to 180 Deg. is 10 Deg. 45 M. for the *Angle* S A N. And (3.) The *Stationary Distance* S N 1000 Paces. By which may be found (1.) The *Distance* of the *Object* at A to N; and (2.) From A to S. By this *Canon* following.

(1.) As the Sine of the *Angle* at the *Object* A, 10 D. 45 M. 9.27073

Is to the Sine of the *Angle* made at the *Sta.* S, 23 D. 30 M. 9.60070

So is the *Stationary Distance* S N 1000 Paces, 3.00000

12.60070

To the *Distance* of the *Object* at A, from } 3.32997

the *Station* at N 2138 Paces }

(2.) As

(2) As the Sine of the *Angle* at the *Object* at A, 10 D. 45 M. $\frac{9.34379}{\text{---}}$
 Is to the Sine of the *Angle* made at the *Sta.* N, 12 D. 45 M. $\frac{9.34379}{\text{---}}$
 So is the *Stationary Distance* S N, 1000 Paces, $\frac{3.00000}{\text{---}}$
 To the Distance of the *Object* at A, from the } $\frac{12.34379}{\text{---}}$
Station at S, 1183 Paces, } $\frac{3.07306}{\text{---}}$
 And in the same manner may all the rest of
 the Distances be found.

II. Of Surveying of Land, by the Perambulator.

Argument.

I Shall not herein, again reiterate the Manner how to take the *Plot* of any *Field*, or other *Enclosure*, at one *Station* taken in the *Middle*, one *Side* or *Angle* thereof: Neither by going round about the same, either without or within, and making *Observations* of the *Quantities* of every notable *Angle* of the same in *Degrees* and *Minutes*: All which are already sufficiently taught how to perform (several ways) in the *Fourth Book* hereof: Notwithstanding, all such Performances may be wrought by this Instrument also, by help of the two outermost *Limbs* (or *Margins*) of this *Semicircle* which are number'd by 10, 20, 30, &c. to 180, in the *uppermost*; and again, from 180, by 190, 200, 210, &c. to 360 Deg. in the *Margin* under it: By the Directions given in those *Chapters*, where the Performance of such *Conclusions* are particularly treated of, as also in the preceding *Problems*.

And therefore, my Business here shall be, only to shew you how to take the *Plot* of any *Park, Chase, Forrest*, or other *Large Piece of Ground*, by this *Instrument*; by the Assistance of the *Needle*, and the innermost *Margin* of the *Semicircle*, which is divided into two *Quadrants*, each number'd by 10, 20, 30, &c. from S, both ways, towards E and W; which *Quadrants* (or *Quarters*) I call, one the { *South East*
North West } *Quadrant*; and the other, the { *South West*
North East } *Quadrant*.

And now, to prevent Mistakes in the Use of this *Instrument* (the *Semicircle* being double number'd.) I will (in the first place) lay down some general cautionary *Rules*, carefully to be observ'd in the using of it: As

III. That (at what *Place* or *Angle*, you set down your *Instrument*, to make any *Observation*.) you set it upon its *Staff* as *level* as you can: And then, move it by help of the *Ball* in the *Socket*, till the *North* and *South* ends of the *Needle* do hang directly over the *North* and *South Points* noted in the *Bottom* of the *Box*:

N n n

And

And there keep the whole *Instrument fixed*, 'till you have made your *Observation*.

2. When the *Instrument* is thus fixed, the *Diameter* of it will point to the *East* and *West*: And the *Semidiameter* (in which the *Box* and *Needle* is) will point towards the *North* and *South* Quarters of *Heaven*; as the *Letters E, W, N, S*, engraven upon the *Instrument* do signify.
3. When you direct your *Sights* to any *Object*, you must always count the *Degrees* cut by that *End* of the *Index* which is farthest from your *Eye*, and denominate them by the *Name* of that *Quarter*, which the *End* farthest from your *Eye* pointeth towards; as *South East* or *South West* (so many *Degrees* as are cut by the *Index*) if the *End* of the *Index* farthest from your *Eye* do rest upon the *Semicircle*: But *North East* or *North West* (so many *Degrees* as are cut by the *Index*) when the *End* of the *Index*, farthest from your *Eye*, falls off of the *Semicircle*.
4. In *Surveying* of *Land* by this *Instrument*, by going about the *Ground* you are to measure, (whether within the *Ground*, or on the out-side thereof) you need not, as in the Use of the *Theodolite*, take *Back-Sights* at every *Angle*, and so find the *Quantity* of it; but you may go on still forward, and so you have the *Quantity* that every *Angle* makes with the *Meridian*: And your *Chain Line*, which is best (especially) in large *Grounds*.

P R O P. V.

How to Survey, and make a True Plot of any large irregular Piece of Ground, with all remarkable Things therein contained and adjoyning.

LET *Old Oak-Mead*, (*Figure 5.*) be to be Survey'd.
L First, Having prepar'd your *Field Book*, as in the following *Figure* thereof: Make the Point *A* to be the Place for your *first Station*; at which Place set up your *Instrument*, *Level*, and the *Needle* over the *North* and *South Line* in the *Box*: Then look for, (or set up) some *Mark*, or *Beacon* at *B*: To which direct your *Sights*, and so doing, you will find the *Degrees* cut by that *End* of the *Index* farthest from your *Eye*, to be 43 Deg. 30 Min. in the *North West* Quadrant of the *Instrument*, (because the farther *End* of the *Index* fell off of the *Semicircle*) which set down in your *Field Book* in the *middle Column* thereof, whose *Title* is [*Station Lines*] and finding that the *Station Point A*, is distant from the *Hedge* on your *Left hand* 70 *Links* of your *Chain*; set down 0 Ch. 00 Lin. in the *middle Column*, and 0 C. 70 Lin. in the *Left-hand Column* of

of your *Field Book*: And also, you may find, by directing your *Sights* to an *Elm* standing in the *Field*. the Degrees cut by the End so the *Index* farthest from your *Eye*, in the N W Quarter 20 Deg. which set down in the *Right-hand Column* under [*Remarks*.]

Secondly, Measure with your Chain from the Station A towards B, and in your going along, you shall find, That

At the End of	{	4	Ch. 40 L.	} of Ram-book Mead, The Hedge was distant from your Chain L. to- wards the Left-hand	{	11	C. 1.55 L.
		5	30			4	30
		9	00			3	05
		10	00			0	65
		15	90			1	40

All which set down, as you see them in the *Figure* of your *Field Book*: And under them draw a Line quite cross your Book, to signify, that you are come to the End of your *first Length*; all which *Hedge* is the Boundary of *Ram-book Mead*: Which note in your *Field Book* in your Column of *Remarks*.

Thirdly, Bring your Instrument to your *second Station* at B, and there placing it level, and the Needle hanging directly over the North and South Line in the Box, direct your *Sights* to C, where you will find the Degrees cut by the End of the *Index* farthest from your *Eye*, to be 7 Deg. 30 M. in the N. E. Quarter, because that End of the *Index* fell off of the Semicircle: Then your Station Point B, being 85 L. distant from the Hedge, set down 0 Ch. 00 L. in *middle Column*, and 0 C. 85 L. in the *Left hand Column*. Also your Instrument still standing at B, direct the *Sights* to the *Elm*, where the *Index* will cut S. E. 71 Deg. And directed to the *Barn*, it will cut 60 Deg. in the N. E. Quadrant, both which set down in the *Right-hand Column* of *Remarks*: And then measure with your Chain from B towards C, taking notice of the *Breaks* in the Hedge, and measuring of the *Off-Sets*, set them all down in your *Field Book* in the *Middlemost* and *Left-hand Columns*; and because the Hedge on the Left-hand of your Chain Line, was the Hedge next the *Road*, note that also down in your *Left-hand Column* of *Remarks*, as you see them done in the *Field Book*.

Fourthly, Remove your Instrument to C, the place of your *third Station*, and there setting it Level, and the Needle over the North and South Line in the Box; if you direct your *Sights* to D, you will find that the End of the *Index* farthest from your *Eye*, will cut 64 Deg. in the South East Quadrant, because the End of the *Index* farthest from your *Eye* did rest upon the Semicircle in that Quadrant; which note down in your *Field Book*: And now if you direct your *Sights* to the *Church*, you will find the *Index* to cut N. E. 30 Deg. and directing them to the *Barn*, to cut S E 22 Deg. and that the Hedge is distant from your Station Point at C 85 Lin. All which you must set down as is done in the *Figure* of the *Field Book*: Then, in measuring along from C to D, you do not find any notable Breaks in

in the River on your Left-hand, but a gradual bending like a *Bow*, therefore, you must, in measuring along, take the Distances from your *Chain Line* to the *River*, at the End of every *Chain*, or two *Chains*, as is here done at every second *Chain*; which Distances set down, and also the *River* as its Boundary, as is done in the *Field Book*.

Fifthly, Remove your Instrument to your fourth Station at D, setting it level and directly North and South (as at other times) direct the Sights to E, where you will find the End of the Index farthest from your Eye to cut 57 Degrees in the N. E. Quadrant, which set down; and at the same time also, direct the Sights to the *Church*, where you will find it to bear from you N. W. 36 Deg. And being directed to the *Old Oak*; you will find that to bear from you S. W. 70 Deg. all which note down in your *Field Book*. And then measuring from D towards E, you'll find, that at 0 Ch. 80 Links end, the *River* is distant from your *Chain Line* 60 Links; and at 1 C. 35 Lin. it is distant 75 Links, and that between these two is the *Mill-House*: All which set down as you see done, and measuring on towards E, observing the *Breaks* made by the *River*, you will find them to be such as are set down in the *Field Book* under Station @ 4. And now being arriv'd to your fifth Station Point at E, there place your Instrument, and rectify it; but, (before you direct your Sights to the next Station at F,) direct them to the several Angles made by the winding of the *River*, as from E, to G, H, K, L and M: Noting what Degrees the Ends of the Index farthest from your Eye cuts; and also, measure the Distance from E to every of them, so will you find them to be, from E to G, 37 Deg. and the Distance 4 C. 30 L. &c. all which set down in the Column of *Remarks* on the Left-hand, as you see them done in the Figure of the *Field Book*. And then,

Sixthly, (Your Instrument standing at E, in the same Position as before) direct your Sights to F, your sixth Station, where you will find the End of the Index farthest from your Eye, to cut 9 Deg. in the S. E. Quadrant; which note down; and measuring from E towards F, you will find, that at the End of 1 C. 75 L. the *River* will be distant from your *Chain Line* 55 L. and at the End of 5 C. 10 L. the *Chain Line* will pass just by (or touch) the Brow of the *River*. All which set down in their proper Places, as you see them in the *Field Book*. And

Lastly, Remove your Instrument to F, your sixth Station, rectifying it as before, and direct your Sights to A, your first Station, where you will find that End of the Index which is farthest from your Eye to cut 41 Deg. 30 Min. of the S. W. Quadrant: And also, being directed to the *Old Oak*, it will cut 70 Deg. in the S. W. Quadrant; both which set down in their proper Columns of your *Field Book*: And then measuring from F towards A, you find that your Station Point at F is distant from the Hedge of *Broom-Field* 1 Chain, and at the End of 11 Ch. 30 L. there is a *Gate* in the Hedge going into *Broom-field*, which with all the *Breaks* and *Bend-*

ings

ings in the Hedge between F and A, you must measure and set down as you see done in this Figure of the *Field Book* for this *Meadow*: And thus is your Work in the *Field* ended.

FIELD-BOOK:

A Survey of Old-Oak Mead, in the County of Devonshire, being Part of the Demeasn of W. R. Esq; Surveyed in the Month of August, Anno 1683. By W. L.

REMARKS.	Sets off	Station Lines	Sets off	REMARKS.
	C L	At C L	C L	
		St. ①	NW	43 Deg. 30 Min.
Ram-hook Meadow.	0 70 1 51 4 30 3 05 0 65 1 40	0 00 4 40 5 30 9 00 10 00 15 90		At Station ① the Elm Bears N. W. 20 Deg.
		St. ②	N. E.	7 Deg. 30 Min
The Road to Colliton.	0 85 A Gate 2 10 1 95 0 75 1 35 0 65 1 65	0 00 2 10 3 85 4 15 5 70 8 10 10 85		At Station ② the Elm bears S. E. 71 Deg. And the Barn bears N. E. 60 Deg.
At Station 3, The Church Bears. N. E. 42 Deg.		St. ③	S. E.	64 Deg. 0 m.
The River.	0 80 1 50 1 90 2 20 1 85 1 40 1 30	0 00 2 00 4 00 6 00 8 00 10 00 11 90		At Station ③ the Barn bears S. E. 22 Deg.
At Station 4, The Church Bears. NW 36 Deg.		St. ④	N. E.	57 Deg. 0 m.
River. Mill	0 60 0 75 2 40 1 30	0 80 1 35 3 70 6 20 9 55		The Mill Houfe. At Station ④, Old Oak bears S. E. 30 Deg.
At the End of ④ ... There is an Out-let Bearing.		St. ⑤	S. E.	9 Deg. 0 m.
C L	0 55 4 30 5 40 6 30 5 35 4 00	0 00 1 75 5 10 8 30 10 10		
NW 37 D. NW 3 NE 23 NE 64 SE 85		St. ⑥		
		S. W.		At Station ⑥ Old Oak bears S. W. 70 Deg.
		41d. 30m.		
	1 00 1 50 2 65 0 90 2 60 A Gate 0 90 1 80	0 00 3 35 3 50 6 40 9 10 11 30 13 10 17 15		
Broom-Field.				

0 0 0

The

Colliton Mead.

The *Work* in the *Field* thus finished, it resteth now to shew you how to *protract*, or make a true *Plot* of it upon *Paper*, *Parchment* or *Velom*: But before you begin that *Work*, you may (if you will take the Pains, which will compensate the Labour, and abundantly satisfy you in your Performance) know, whether your *Plot* will close or not, that is, whether, when you come to lay down your last *Chain Line* *F A*, whether the Length you measure from *F* to *A*, will, upon your *Plot*, reach to, or fall upon the first Point *A*: Which if it do, your *Field Work* is rightly performed, otherways not; and the Error which causes the Difference may be either in the *Quantities* of the *Angles*, or in the Lengths of the *Lines*, or both: Which, how to discover, shall be shew'd in this following Problem.

PROP. VI.

How to know whether the Station Lines in the former Plot will close or not, before you begin to protract, or lay them down upon Paper.

FIRST, Prepare a Table, which divide into six Columns, as the Table following; in the first Column, set down the Degrees cut by the Index at every Station, with the Name of the Quadrant or Quarter in which they were observ'd to be in at every Station, which you must take out of your *Field Book*: So, at Station $\odot 1$, the Index cut 43 Deg. 30 Min. in the N. W. Quadrant: Which set down in the first Column of the following Table, and right against it, in the second Column, set the Length of the *Chain Line* between the First and Second Stations, which was (as appears by the *Field Book*) 15 Chains 90 Links: So will the first Line of the First and Second Columns stand thus:

At Stat. $\odot 1$ A. N. W. 43 D. 30 M. | 15 C. 90 L.

And so all the rest of the *Angles* at every Station, and the *Chain Lines* between Station and Station, taken out of your *Field Book*, and put into a Table ruled for that purpose, they will stand as in the two first Columns of this following Table.

	D. M.	C. L.	East C. L.	West C. L.	North C. L.	South C. L.
At St. $\odot 1$ A. N. West	43. 30	15. 90		10. 94	11. 53	
At St. $\odot 2$ B. N. East	7. 30	10. 85	1. 42		10. 76	
At St. $\odot 3$ C. S. East	64. 00	11. 90	10. 70			5. 22
At St. $\odot 4$ D. N. East	57. 00	9. 55	8. 01		5. 20	
At St. $\odot 5$ E. S. East	9. 00	10. 10	1. 66			9. 97
At St. $\odot 6$ F. S. West	41. 30	17. 15		10. 85		12. 30
The Sums of the Columns			21. 79	21. 79	27. 49	27. 49

The

The two first Columns of this Table being taken out of your *Field Book*, and enter'd into this *Table*; the other four Columns noted at the Head with *East, West, North* and *South*, must be supply'd by working of the following Proportion (either by the *Tables of Sines* and *Logarithms*; or by the *Lines of Sines* and *Numbers* in the third *Book*) The *Analogy* or *Proportion* being thus,

As the Radius, or Sine of 90 Deg.
Is to the *Length* of the *Chain Line*:
So is the *Sine* of the *Degrees* cut by the *Index*, at every *Station*,
To the *Chains* and *Links* of the *Easting* or *Westing*.

And

As the Sine of 90 Deg. is to the *Length* of the *Chain Line*,
So is the *Sine Complement* of the *Degrees* cut by the *Index*,
To the *Northing* or *Southing*.

The first Observation wrought by the *Tables*.

As the <i>Sine</i> of 90 Deg.	10.00000
To the <i>Length</i> of the <i>Chain Line</i> A B. 15 D. 90 M.	1.20139
So is the <i>Sine</i> of the <i>Degrees</i> cut at that Sta. 43 D. 30 M.	9.83781
To 10 C. 94 L. for the <i>Westing</i> ,	×1.03920

And therefore must be put in the *West* Column of this *Table*, because they were cut by the *Index* in the *North West Quadrant*.

Again,

As the Sine of 90 Deg.	10.00000
To the <i>Length</i> of the <i>Chain Line</i> A B. 15. 90.	1.20139
So is the <i>Co-Sine</i> of the <i>Degrees</i> cut 46 Deg. 30 M.	9.86056
To 11 C. 53 L. for the <i>Northing</i> ,	×1.06195

And therefore must be set in the *North* Column of this *Table*, because the *Index* cut them in the *North West Quadrant* of the *Instrument*.

And this Work must be done at every *Station* (that is, six times in this *Example*) which, if it seem tedious, it may be more readily performed by the *Lines of Sines* and *Numbers*, by the same *Proportion*: For,

If you extend the *Compasses* from the *Sine* of 90 Deg. to the *Length* of the *Chain Line* 15 C. 90 L. on the *Line of Numbers*: That *Extent* will reach from the *Sine* of 43 Deg. 30 M. (the *Degrees* cut by the *Index*;) to 10 C. 94 L. upon the *Line of Numbers*; for the *Westing*: And the same *Extent* will also reach from the *Sine* of 46 Deg. 30 M. (the *Complement* of the *Degrees* cut) to 11 C. 53 L. upon the *Line of Numbers*, for the *Northing*, as before.

Thus working by either of these ways for every *Station*, and setting down the *Distances* of *Easting* or *Westing*: And *Northing* or *Southing* in their respective Columns [as above is done] your *Calculatory Work* is ended: And then,

Add up every *Column* severally, and if you find the *Sums* of the *East* and *West* Columns to be equal: And also the *Sums* of the *North*

North and South Columns to be equal; as in the Table above they are; you may then assure yourself, that your Work is true, and that your Chain Lines will close: And now you may with Confidence proceed to the Protracting, or laying down the Plot of your Field, which, how to perform is shew'd in the following Proposition.

How to protract the former Observations, and to make a true Plot of your Field.

UPON your Paper or Vellum, provided for that purpose (*Fig. 5.*) draw a right Line quite through the same, as the Line N S, representing the *General Meridian*: And,

First, Assume any convenient Point upon it, as the Point A, for your *first Station*: Upon which Point A, lay the Centre of your *Protractor*, (which ought, most conveniently, to be a whole Circle, having a *Flower-de-Luce* at the North, and the four Quadrants thereof divided each of them into 90 Deg. and number'd from the North and South Points, towards the East and West, by 10, 20, 30, &c. to 90 Deg. and every Quadrant nam'd according to its proper Coast, that is, *South East* and *South West*, on either side of the South Point: And *North East* and *North West*, on either side of the North Point.) The Centre of the *Protractor* being laid to the Point A, turn it about 'till the Diameter thereof do lie just upon the *Meridian Line* of your Paper, the *Flower-de-Luce* towards N, and there hold it close to the Paper: Then your *Field Book* lying before you, look what Degrees were cut by the Index at that first Station, and in what Quarter, and you will find them to be 43 Deg. 30 M. in the *North West* Quadrant: Against which Degrees, in that Quadrant of your *Protractor*, and close by the Edge thereof, make a Mark with your *Protracting Pin*; and also, because (at that Station) the Elm did bear from you *North West* 20 Deg. make another Mark at those Degrees also close to the Edge of your *Protractor*; then take away your *Protractor*, and through your first Point, from the Point A, draw a right Line, for your *Chain Line*, which by your Book you find did contain 15 Ch. 90 L. which taken from any Scale, and set upon the *Chain Line* from A to B, the Point for your *second Station*: And also, through the second Point made at N. E. 20 Deg. draw a Line at pleasure, as the Line A, O, not setting any Number to it.

Secondly, Through the Point B, your *second Station*, draw an obscure Line n B s Parallel to the *General Meridian Line* N. S. first drawn: Then, bring the Centre of your *Protractor* to the Point B, and the *Meridian Line* thereof to lie just over the obscure Line n B s, and there keep it close to the Paper: And look in your *Field Book*, what Degrees were cut by the Index at your *second Station*, which you'll find to be 7 Deg. 30 M. in the N. E. Quadrant, against which Degrees make a Mark, close by the Edge of the *Protractor*:

And

And also, because (at that Station) the *Elm* did bear from you *South East 71 Deg.* make there a second Mark by the Edge of the *Protractor*: Then taking away the *Protractor*, through your first Point, and the Station Point B, draw a Line for your *Chain Line*, which by your Book contains 10 Ch. 85 L. which set from B to C, so is C the the Point of your third Station: Also, through the second Mark, draw a Line at pleasure, as the Line B P, crossing the Line A O drawn at pleasure from the *first Station*, for that Point is the Place where the *Elm* stands in the *Field*.

Thirdly, Through the Station Point C, draw an obscure Line *n C s*, parallel to the *General Meridian Line N S*; and laying the Center of your *Protractor* upon C, and the *Meridian* thereof upon the Line *n C s*, there hold it close to your Paper, and seeing that the Degrees cut by your Index at your *third Station* were 64 Deg. in the *South East Quadrant*, against those Degrees make a Mark by the Edge of the *Protractor*, through which to draw your *Chain Line*: And also, because (at this Station) there was a *Church* which did bear from you *North East 42 Deg.* and a *Barn* which did bear from you *South East 22 Deg.* make Marks against those Degrees also, through which draw two obscure Lines at pleasure, as the Lines C Q and C R, not setting any numbers to them, but upon your *Chain Line*, you must set the Length thereof as you find it in your *Field Book* 11 Ch. 90 L. from C to D, which point D, is the Point for your fourth Station.

Fourthly, Through this Station Point D, draw an obscure Line *n D s*, parallel to the *General Meridian Line N S*. Then laying the Center of your *Protractor* upon D, and the *Meridian Line* of it upon the Line *n D s*, hold it fast close to the Paper; and forasmuch as the Degrees cut by your Index at the *fourth Station*, were 57 Deg. in the *North East Quadrant*: Against those Degrees make a Mark by the Edge of the *Protractor*, through which your *Chain Line* must be drawn: And also, because (at this *fourth Station*) the *Church* did bear from you *North West 36 Deg.* and an *Old Oak South East 30 Deg.* make Marks against those Degrees also in their proper *Quadrants*, through which draw two obscure Lines at pleasure, the one D T, crossing the obscure Line C Q drawn from the third Station at C, in the Point where the *Church* is to stand; and the other D V, which will pass through the Point where the *Old Oak* stands, setting no Numbers to these Lines, but to your *Chain Line*, you must set the Length thereof 9 Chains 55 Links, from D to E, which is the Point of your *fifth Station*.

Fifthly, Through the Station Point E, draw an obscure Line *n E s*, parallel to the *General Meridian Line N S*. Then, laying the Center of your *Protractor* to the Point E, and the *Meridian* thereof upon the Line *n E s*, keep it there fast: And repairing to your *Field Book*, you there find that there is several *Out-let Bearings* against this *Station Point E*, as *North East 36 Deg North West 3 Deg. &c.* against all which numbers of Degrees in their several *Quadrants*, make Marks by the Edge of the *Protractor*, and through them draw ob-

scure Lines from the *Station Point* E; setting upon each of them, such Lengths as you find noted against them, in your *Field Book*, as against the first, there is 4 C 30 L. which set from E to G, against the Second 5 C, 40 L. which set from E to H, do so with the rest, setting them from E, to K, L and M, and then if you draw the Lines G H, H K, K L, and L M, you will have *protracted* your *Out-let Piece*: And forasmuch as the Degrees cut the Index at this *fifth Station*, were 9 Deg. in the *South East Quadrant* (your *Protractor* resting as before) make a Mark against 9 Deg. in the *South East Quadrant*, and through it draw your *Chain Line*, setting upon it the Length as you find it in the *Field Book*, 10 C. 10 L. from E to F, which point F, is the place of your *sixth* and last *Station*; Then

Sixthly, Through the Point F, draw an obscure Line, *n F s*, parallel to the *General Meridian*, and to the Point F, apply the Centre of your *Protractor*, laying the *Meridian* thereof upon the Line *n F s*, where fix it; then look into your *Field Book*, where you shall find, that at your *sixth Station* at F, the Index did cut 41 Deg. 30 Min. in the *South West Quadrant*, make a Mark at them, close to the Edge of the *Protractor*, through which your last *Chain Line* must pass; and (if you have committed no former Error in your *Protraction*) it will pass through the *first Station Point* A, and contain in Length 17 C. 15 L. as by your *Field Book* you see it ought to do. And because at this *sixth Station* you find by your *Book*, that the *Old Oak* did bear from you *South West* 70 Deg. make a Mark by the Edge of your *Protractor* (it resting in the former Position) through which, draw an obscure Line from F, as F X, crossing the obscure Line D V before drawn from the *fourth Station Point* D, in the Point where the *Oak* stands in the *Field*.

And thus having *protracted* your *sixth Chain Line*; the *Out-let* at the *fifth Station* E, as also, the *Church*, the *Elm*, the *Barn* and the *Old Oak*, all in their proper places: It remains in the next place to *protract* the several *Off-sets* against every *Chain Line*, and draw the *irregular Hedges*, *River* and *Highway*.

For the *protracting* of the *Off-sets*, and drawing the *irregular Hedge Lines*, it is to be performed altogether in the same manner, as is taught how to do in that *Chapter*, which sheweth how to *Survey* and *Plot* a *Field*, or other *irregular Piece* of *Ground* by the *Chain* only: Notwithstanding, I will repeat the manner thereof again, in laying down the *Hedge* lying on the *Left-hand* of your *first Station Line* A B.

First, By your *Field Book* you find, that at your *Station-Point* A, the *Hedge* was distant from A 70 Lin. Take from the *Scale* you *protracted* the *Station Lines* by, 70 Lin. and prick them down upon your *Paper* from A to 1,

Secondly, By your *Book* you find, that at 4 C. 40 L. from A, you set off from your *Chain Line* 1 C. 55 L. Take 4 C. 40 L. and set them from A to 2, and 1 C. 55 L. and set them from 2 to 3 perpendicular to the *Chain Line*.

Thirdly,

Thirdly, You find by your *Book*, that at 5 C. 30 L. from A, your *set-off* was 4 C. 30 L. Take 5 C. 30 L. and set them from A to 4, and 4 C. 30 L. and set them from 4 to 5.

Fourthly, You find that at 9 Ch. from A, your *Off-set* was 3 C. 5 L. Take 9 C. and set them from A to 6, and 3 C. 05 L. and set them from 6 to 7.

Fifthly, You find that at 10 Chains from A, your *Off-set* was 65 L. Take 10 Chains, and set them from A to 8, and 65 L. and set them from 8 to 9. And

Lastly, You find, that at 15 C. 90 L. from A, (which is the End of that *Station Line*) your *Off-set* was 1 C. 40 L. which set from B to 10, perpendicular to the *Chain Line*.

And then, if you draw the several *Lines* 1—3. 3—5. 5—7. 7—9. 9—10. you will have *protracted* the *crooked Hedge* lying against your *first Station Line* A B.

In this manner, you must *protract* all the rest, for the performance whereof, the comparing of the *Field Book* and *Plot* together, (with what hath been said already) will give the intelligent *Reader* far better Satisfaction than a multitude of Words.

How the foregoing Field Work may be abbreviated.

HAVING assumed the Points A, B, and C, (*Fig. 5.*) for your *First, Second* and *Third Stations*, and set up *Marks* or *Beacons* at either of them. Begin your Work in the *Field* thus:

First, Measure with your Chain from A, towards B, and at the several *Distances*, as you go along, take notice of your *Breaks* in the *Hedge*, and your *Off-sets* to them, and set them down in your *Field Book*, as before; and when you come to B, there set up your *Instrument*, level and directly *North* and *South*, as before: And then,

Secondly, Direct the *Sights* upon the *Index* backwards to A, where you will find the End of the *Index* next to your Eye, to cut N. W. 43 Deg. 30 M. the same as at the End of the *Index* farthest from your Eye did before at A; and set them down in your *Field Book* in the same Place as before: And then (the *Instrument* still standing at B,) direct your *Sights* to C, where you will find the End of the *Index*, farthest from your Eye, to cut N. E. 7 Deg. 30 M. the same as before, and measuring on to C, set off your *Distances*, &c.

Thirdly, Measure from C to D; where set up your *Instrument*; and directing *Sights* back to C, you will find that End of the *Index* next to your Eye, to cut S. E. 64 Deg. the same as before were cut from C to D: And then directing your *Sights* to E, you will find the End of the *Index* farthest from your Eye, to cut N. E. 57 Deg. the same as before: And then measure from D to E, setting down your *Lengths* and *Off-sets*, as in the *Book* you find them.

Fourthly, Measure from E to F; and there set up your *Instrument*: And directing your *Sights* back to E, you will find that End of the

Index

Index which is nearest your Eye, to cut S. E. 9 Deg. And also, direct the Sights to A, you will find the End of the Index farthest from your Eye to cut S. W. 41 Deg. 30 M. the same as before: All which being set down in your Field Book, you will find to be the same as were set down before; there is only this *Abreviation*, viz. That whereas you did, before, set your *Instrument* up at six several *Places*; here you set it up but at three; which is very well worth the noting: For the fewer times that you set up the *Instrument*, the fewer Errors you will commit:

For the *Protraction*, that will still be the same as in the last.

A more Exact way for the casting up of the small Triangles, Trapezias, and other small irregular Pieces of Ground which lie between the Hedges and your Chain Lines, in going about any irregular Piece of Ground to Survey it.

IN going about a *Field*, and making Observation at every material Angle, where you set up *Marks* or *Beacons*: In measuring from *Beacon* to *Beacon*; as you pass by any small *Bow* or *Bending* in the *Hedge*: You (1.) Note down at what number of *Chains* and *Links*, such a *Bow* or *Bend* is from your *Beacon*, and set that Number down in the middle Column of your *Field Book*: (2.) You measure from your *Chain Line* up to that *Bow*, or *Bending*, and note that Distance down in your *Field Book* in one of the *side Columns* (on the Right-hand Column, if your *Hedge* be on your Right-hand; or, on the Left-hand Column, if the *Hedge* be on your Left-hand.

Then, when you come to *plot* your *Field*, you first lay down the *Chain Lines*, which you measured in the *Field*, which will include the greatest Part of the *Field*: Within the Limits of those Lines, in a Figure of four, five or six Lines, all consisting of right Lines; the same which you measured with your Chain.

Now, this large *right lined Figure* may best be cast up by dividing of it into *Trapezias* and *Triangles*; but, for the casting up of the other small Pieces, which lie between the *Chain Lines* and the *Hedges*, if you reduce them into *Triangles*, as they will be a great many in Number; so you will very much err in laying of them down first, and in taking them off afterwards: Especially, if the *Scale* you *protract* by be very small; where 10 or 12 Links of a Chain (which is half a *Rod*) is hardly to be estimated, altho' your *Scale* be well divided, and the Points of your *Compasses* very fine. For the removal of this great Inconvenience, I shall in this Place shew you a way not commonly used (because it may seem somewhat tedious) where by you may cast up the Quantities of the small Pieces or Off-sets, without reducing of them into *Triangles*, (and taking the *Basis* and *Perpendiculars*

pendiculars of them by Compasses, and applying them to *Scale*) but by the *Scales* which you actually measured with your Chain; and so let the *Scale* you plot by be never so small, you shall have the true Quantity of these *Off-set Pieces* as exactly as any of the greater parts of the Field.

What I have here deliver'd in general Terms, I will now make plain by Example.

Suppose you have measured in the in-side of a Field, (by a Hedge lying on your Left-hand) a Chain Line containing 8 Ch. 12 Links; which Line let be A B, (*Fig. 6*) and that at A, the Hedge is distant 25 L. of my Chain, which I note down in my *Field Book*; and measuring forward from A towards B, at the End of 1 Ch. 20 L. I find a *Bow* or *Bend* in the *Hedge*, from which I measure (with my Chain or Rod) and find the Distance thereof from my Chain, to be 90 Lin. on my Left-hand, which I set down also in the Left-hand Column: And going on forwarder towards B, till I have measured 2 Ch. 30 L. where I meet with another Bend in the Hedge, which is distant from my Chain Line 1 Ch. 05 Lin. which I set down in my *Field Book*, and so all the other Lengths and Distances, according as I find them in my Passage from A to B: And

C.	L.	C.	L.	C.	L.
0	25	Station A			
0	90	1	20		
1	05	2	30		
0	70	3	25		
1	50	5	30		
0	75	7	45		
0	25	8	12		

when I come to B, my Observations, which I made by the way, will appear in my *Field Book* to be such as in the *Margin*: By which I may protract the Line A B, (and consequently the *crooked Hedge*) as followeth: And also to find the *Area* of all the little *Pieces* intercepted between them.

I. How to Protract the same. Fig. 6.

1. From any *Scale* of equal Parts (or a *Diagonal Scale* rather) take the whole Length of your *Station Line*, as you found it by Measure, 8 Ch. 12 Lin. and lay that Distance down upon Paper, from A to B.

2. From the same *Scale* take 25 Li. and set them from A to C.

3. Take 1 C. 20 L. and set them from A to b, and from thence set 10 C. 90 L. to D.

4. Take 2 C. 30 L. and set them from A to c, and from thence set 1 C. 05 L. to E.

5. Take 3 C. 25 L. and set them from A to d, and from thence 0 C. 70 L. set them from d to F.

6. Take 5 C. 30 L. and set them from A to e, and from thence set 1 C. 50 L. to G.

7. Take 7 Ch. 45 L. and set them from A to f, and from f, set 0 C. 75 L. to H.

8. From B, at the End of 8 C. 12 L. set 25 L. from B to K.

Lastly, Draw the Lines C D, D E, E F, F G, G H and H K, it will represent the true Shape of the *Hedge*, with all its Bows or Bends: And the streight Line A B, represents the *Chain Line*.

II. To find the true Area, or Superficial Content of this Irregular Figure *ACD EFG HK B*, in Acres, Roods and Perches.

1. The Perpendicular (or Off-set) *AC*, is 25 L. and the Perpendicular (or Off-set) *bD*, is 90 L. these two added together make 1 Ch. 15 L. the half whereof is 57 L. This multiplied by 1 C. 20 L. (the Distance from *A* to *b*,) the Product will be .06840, for the Content of the *Trapezia L*.

2. The Perpendicular (or Off-set) *bD*, is 90 L. and the Perpendicular (or Off-set) *cE*, is 1 C. 05 L. which added together, make 1 C. 95 L. the half whereof is 97 Lin. Then subtract 1 C. 20 L. (your first Distance from *A* to *b*) from 2 C. 30 L. (your Distance from *A* to *c*) the Remainder will be 1 C. 10 L. which multiply by 97 L. and the Product will be .10670, for the Content of the *Trapezia M*.

3. The Perpendicular (or Off-set) *cE*, is 1 C. 05 L. and the Perpendicular (or Off-set) *dF*, is 70 L. which added together, make 1 C. 75 L. the half whereof is 87 L. Then subtract *Ac*, 2 C. 30 L. from *Ad*, 3 C. 25 L. the Remainder will be 95 L. which multiplied by 87 L. the Product will be .08265, for the Content of the *Trapezia N*.

4. The Perpendicular (or Off-set) at *F*, is 70 L. and the Perpendicular (or Off-set) *eG* is 1 C. 50 L. which added together, make 2 C. 20 L. the half whereof is 1 C. 10 L. Then subtract *Ad*, 3 C. 25 L. from *Ae*, 5 C. 30 L. and the Remainder will be 2 C. 05 L. And that multiply'd by 1 C. 10 L. the Product will be .22550, which is the Content of the *Trapezia O*.

5. The Perpendicular (or Off-set) *eG*, is 1 C. 50 L. and the Perpendicular (or Off-set) *fH* is 0 C. 75 L. which added together makes 2 C. 25 L. the half whereof is 1 C. 12 L. Then subtract *Ae*, 5 C. 30 L. from *Af*, 7 C. 45 L. and the Remainder will be 2 C. 15 L. which multiply'd by 1 C. 12 L. produceth .24030, for the Content of the *Trapezia P*.

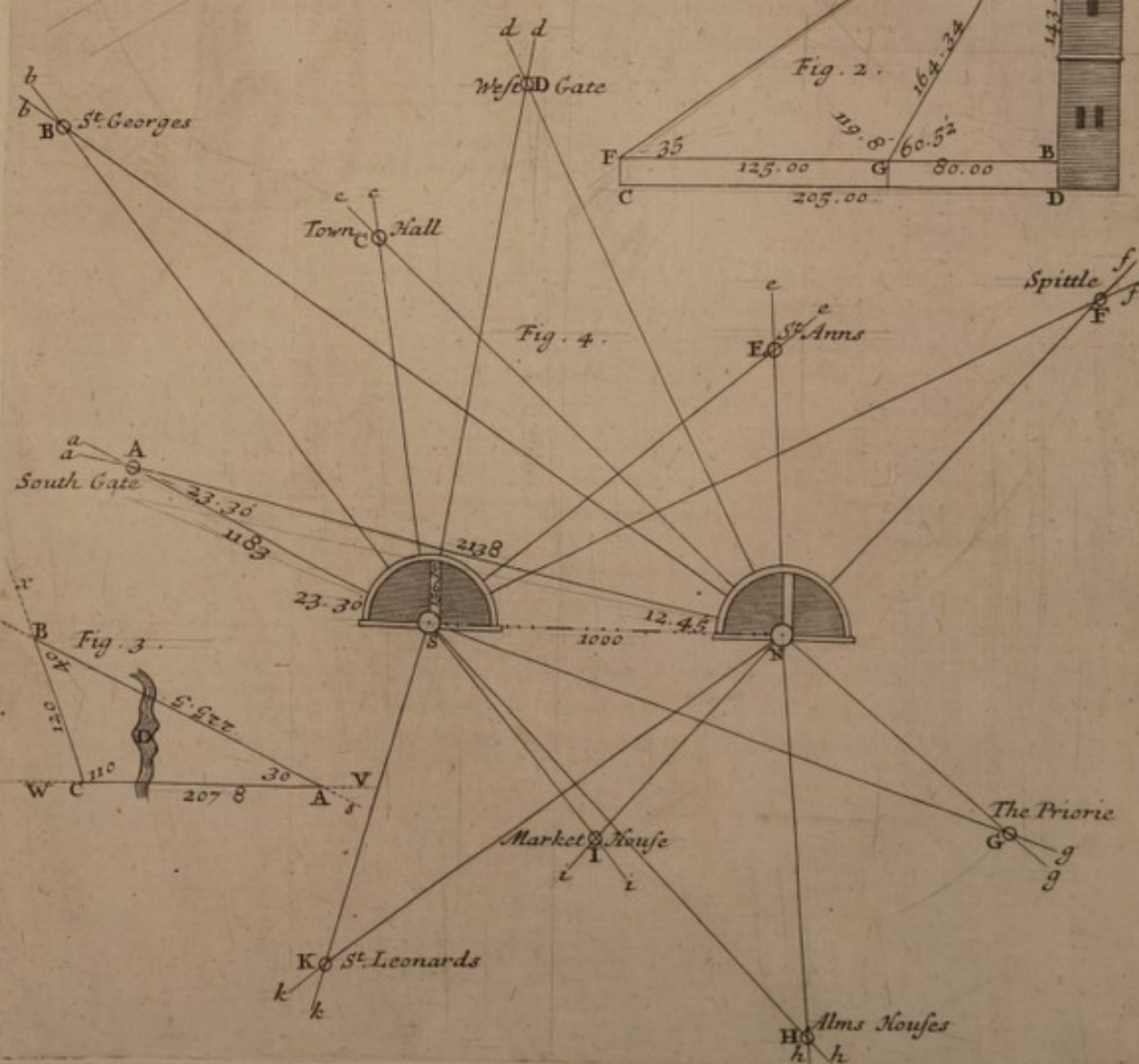
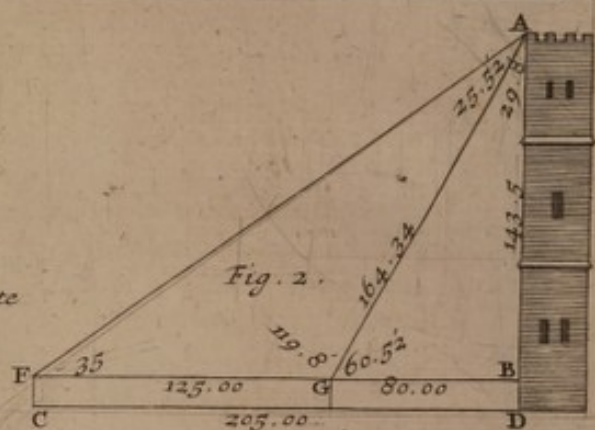
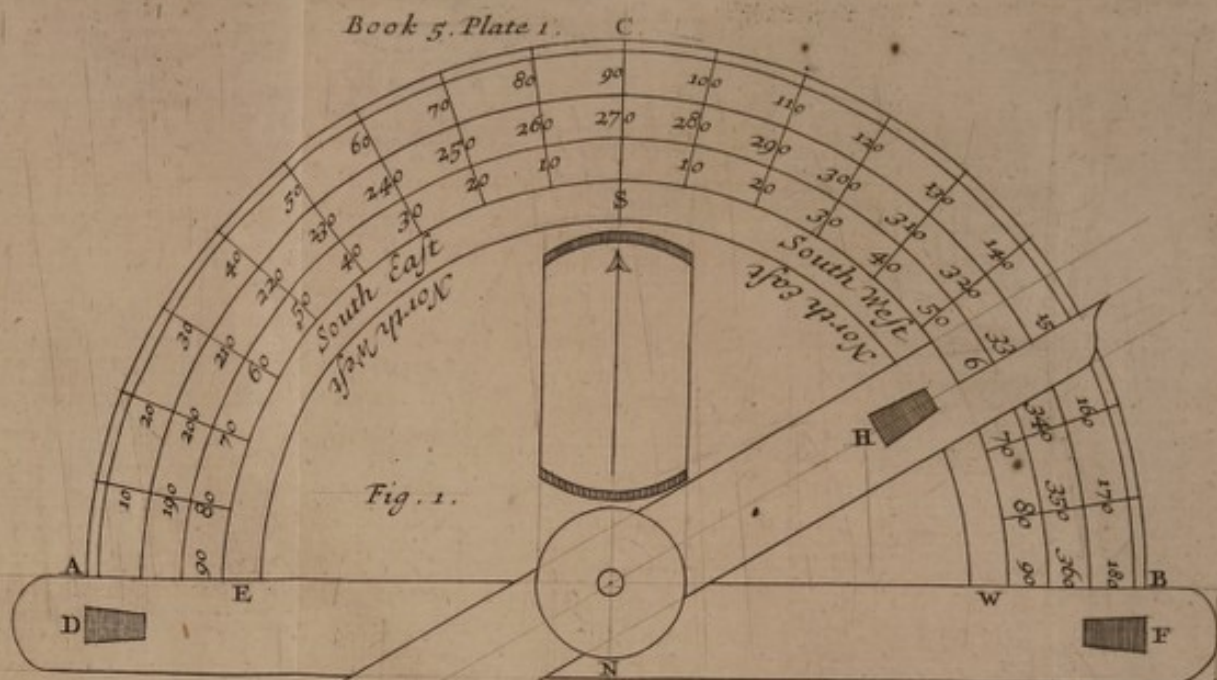
6. The Perpendicular (or Off-set) *fH* is 75 L. and the Perpendicular *BK*, 25 L. which added together make 1 C. the half whereof is 50 L. Then subtract *Af*, 7 C. 45 L. from *AB*, 8 C. 12 L. the Remainder will be 67 L. which multiply'd by 50 L. the Product 03350, will be the Area of the *Trapezia Q*.

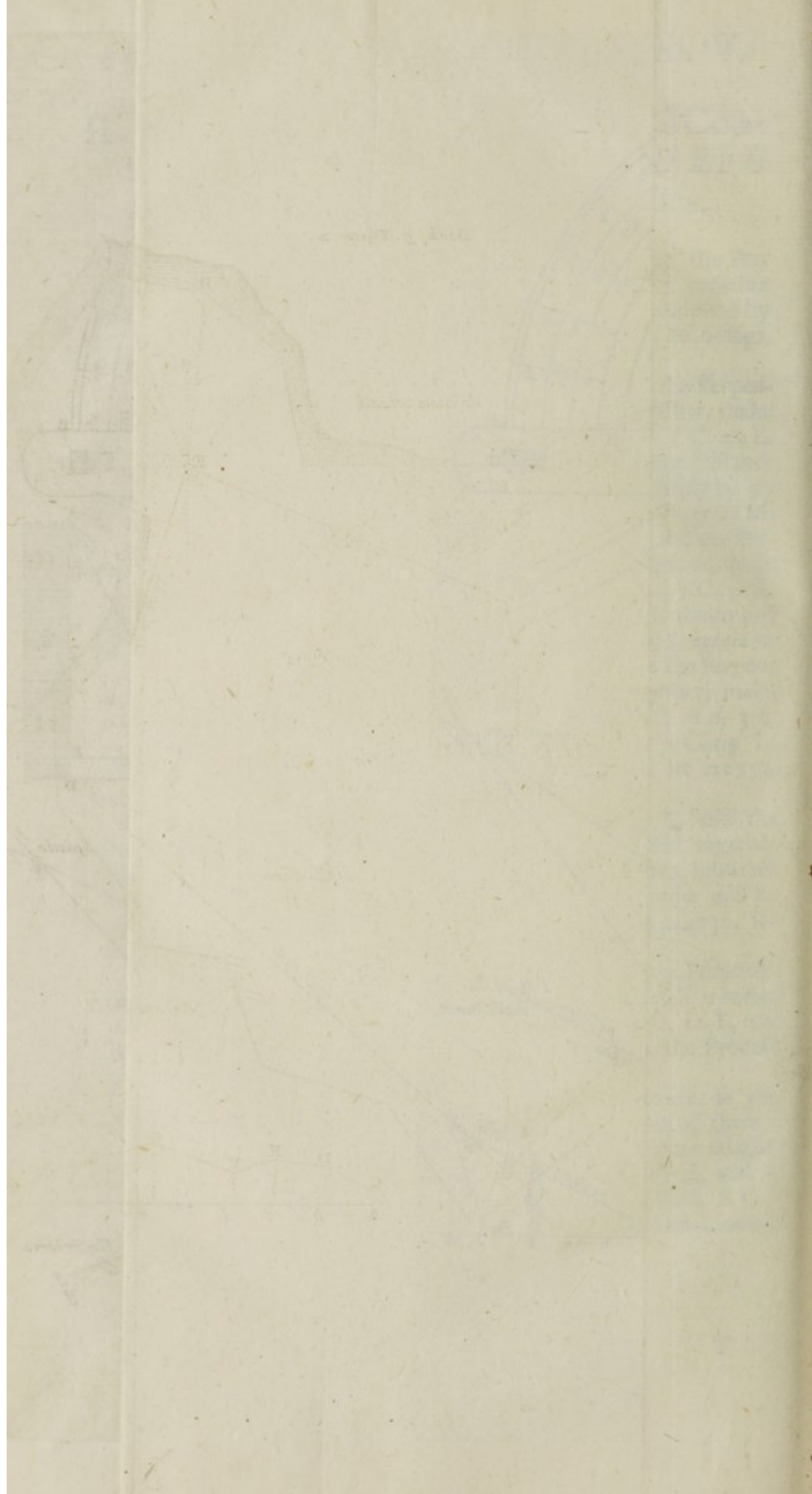
L	—	0	6	8	4	0
M	—	1	0	6	7	0
N	—	0	8	2	6	5
O	—	2	2	5	5	0
P	—	2	4	0	8	0
Q	—	0	3	3	5	0
Sum		7	5	7	5	5

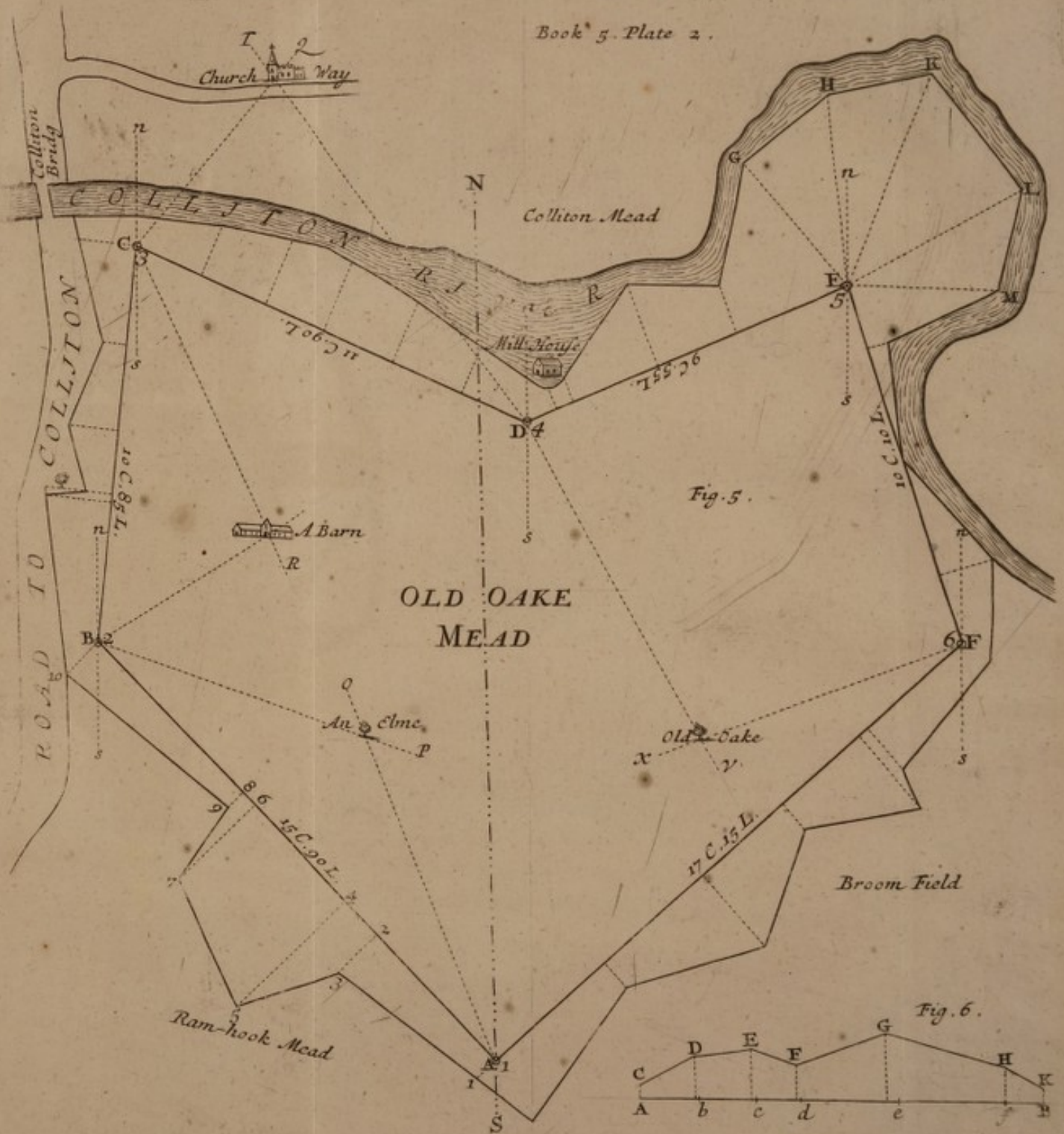
7. Add all these Products together, as you see done in the Margin, the Sum of them is .75755, which reduced (as is before taught) makes 0 Acres, 3 Roods and 1 Perch, and so much Land is contained in the Piece *ACD EFG HK B*, between the Chain-Line and the Hedge.

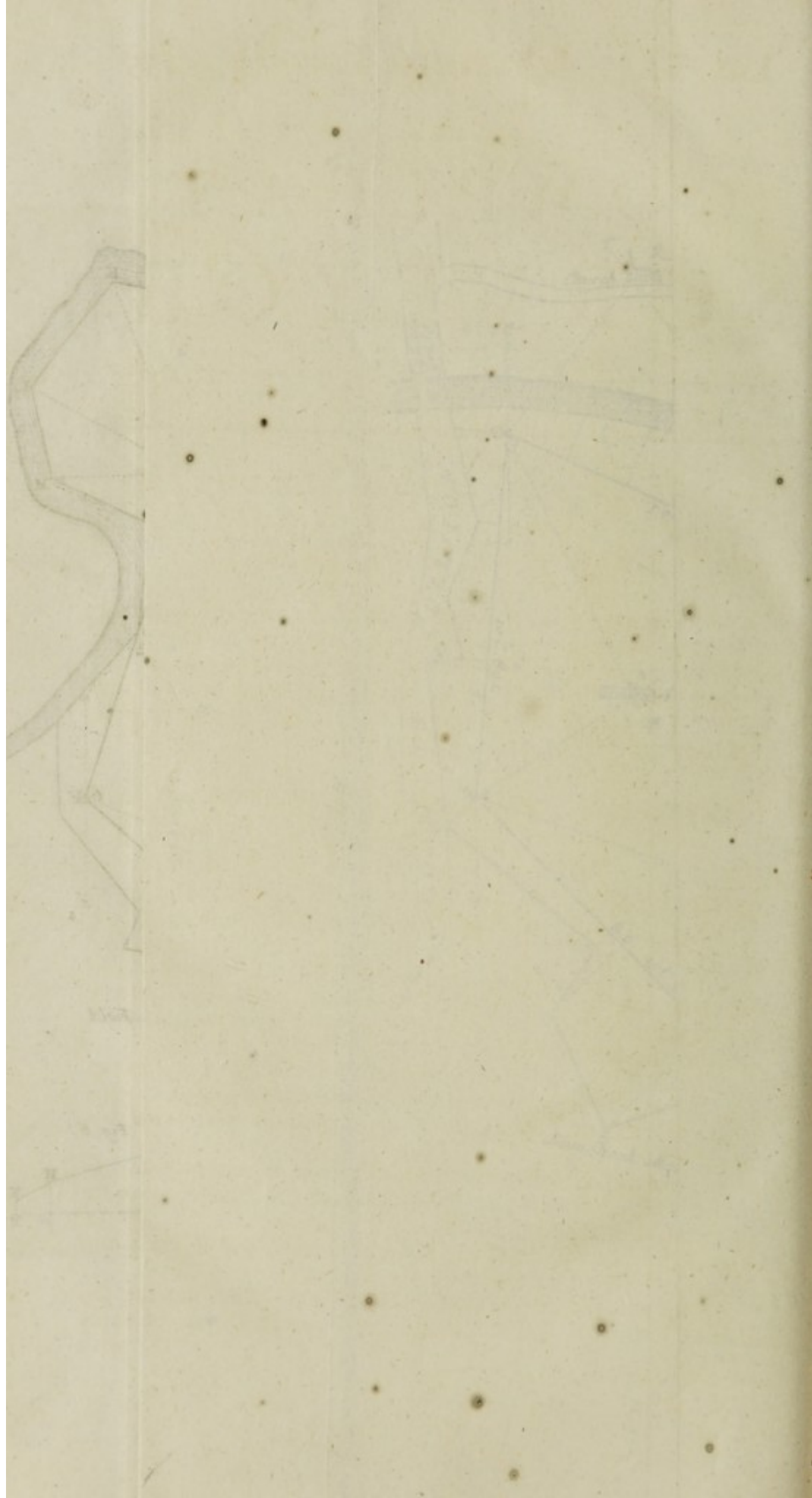
The End of the Fifth Book.

T H E









THE COMPLETE SURVEYOR.

The Sixth Book.

Of Surveying by the Chain only.

The ARGUMENT.

A Surveyor may, at some time or other, be required, to take a *Distance, Measure a Field, Close, or Wood*: And to make a *Plot* of the same upon *Paper or Parchment*; when his *Instruments* are not at hand: Now, how such *Works* may be performed without any graduated *Instrument*, (by a *Chain* only) I shall plainly shew in these few following *Examples*.

How to take an inaccessible Distance, by the Chain only.

LET A (*Fig. 1*) be a *Tree* (or other *Object*) and you being at B, should be required to tell how far the *Tree* at A is from you:

1. Standing at B, (which call your *first Station*) look towards A, and cause some Body to move so (at some convenient Distance from B) that he may stand between your *Eye* and the *Object* at A, as at D, and there let him set up a small Stick or *Mark*.

2. From B, measure out any number of *Chains* and *Links* to any *Mark* set up (either on the *right* or *left-hand* from B) as to C. 7 C. 00 L. and there set up another *Mark* (which call your *second Station*): And

3. From thence look towards the *Object* at A; and at some convenient Distance from C, in the visual Line CA, cause one to set up a small Stick or *Mark*, as at G.

4. In any two places of the Line, between B and C. cause two *Marks* to be set up, as, one at E, the other at F.

5. Measure the Distances B D, B E, D E: And also the Distances, C G, C F, G F: Setting them down in a Piece of Paper with

with their respective Lengths to them: As in the following *Example* is here done.

From *Station* 1 at B, to *Station* 2 at C, 7 Ch. 00 Lin.

From	{	B to D	2	00
		B to E	2	00
		D to E	2	10
		C to F	2	50
		C to G	2	50
		F to E	3	65

These Measures being thus noted down in a Piece of Paper; you may protract, or lay the same down upon Paper or Parchment, by the Directions following.

How to Protract, or lay down the former Measures, and thereby find the required Distances from B or C to the Object at A.

This is to be performed by the VIII *Geometrical Problem* of the *First Book*.

1. Upon Paper or Parchment, draw a right Line at pleasure, as H K.

2. From any *Scale* of *equal Parts*, take 7 Chains (which is the Distance between your two *Stations*) and set them upon the Line H K, from B to C.

3. Take the Distance B D or B E 2 Chains, and with that Distance, setting one Foot of the Compasses in B; with the other describe the obscure Arch E & D.

4. From the same Scale, take the Distance D E, 2 Ch. 10 Lin. and set them upon the obscure Arch, from E to D.

5. Through the two Points B and D, draw a right Line at pleasure, as the Line B D M. Then,

6. Take the Distance C F or C G 2 Ch. 50 Lin. with which distance, set one Foot of the Compasses in C, and with the other describe the obscure Arch F & G.

7. From the same Scale, take the Distance F G, 3 Ch. 65 Lin. and set them upon the obscure Arch, from F to G. And,

8. Through the two Points C and G, draw a right Line at pleasure, as C G L, crossing the former Line B D M in the Point A, which is the Point where the *Object* standeth.

9. If you take the Length of the Line B A, and measure it upon the same *Scale*, from whence you took your former Distances, you will find it to contain 14 Chain, which multiply'd by 66, gives 924 Foot for the Distance of the *Tree* at A, from the Place of your first standing at B: And

10. C A being measured by the same Scale, will be found to be 12 Chains (or 792 Foot.) In this manner, not only the Distance of one Place, but of many Places may be taken by the often Reiteration

of the same Work; which is so obvious, that an Example is needless.

How (by the Chain only) to take the true Plot of an irregular Field, consisting of many Sides and Angles: And how to make a perfect Draught of the same, upon Paper or Parchment.

LET ABCDEFGHIKLR, (Fig. 3.) be an irregular Field, to be measured by the Chain only.

1. At your first Entrance into the Field, cause Beacons or other visible Marks to be set up at (or as near as you can to) all the principal Angles or Corners thereof: As those at M, N, O and P.

2. Consider the fittest, or most convenient Corner to begin at (altho' any will serve) as I have here done with the Beacon or Mark at O.

3. Then laying one End of the Chain to the Beacon at O, measure out two Chains (more or less, as you see Occasion) from the Beacon at O, towards the Beacon at P, and at the End of two Chains (or other Measure) stick up a small Mark or Stick, as at the Mark * in the Figure. Again, from your Beacon at O, measure out two Chains 45 Links (or other Measure) from the Beacon at O, towards the Beacon at N, and there set up another small Stick or Mark as at † in the Figure: And then, measure with your Chain, the Distance between the two Sticks or Marks at * and †, which suppose to be 2 Chains 91 Links.

4. Prepare a Book, or Sheet of Paper, ruled as is done in the Margin hereof, to set down your Measures as you go about the Field. But first (at the Top of the Book or Paper, make a Triangle answerable to that which you measured out upon the Ground in the Field, (as Fig. 2.) and set such Numbers, Letters, and Marks to it, as you there measured, and designed to know them by, even as you see in Fig. 2.

Sets off	Ch.	L.	Sets off
0	30	0	00
0	70	1	40
0	50	3	40
1	20	6	50
0	40	7	20
0	70	0	00
Touch	2	10	
0	90	3	35
0	40	4	80
1	10	5	50
0	25	0	00
6	50	1	80
Touch	3	00	0 70
0	40	4	25
0	40	6	50
	0	00	0 00
	2	70	2 70
	5	90	5 90

This done, begin your Work at your Beacon at O, and measure the Distance of it from the Hedge on your left-hand, and finding it to be 30 Links of your Chain; set down 30 Links on the left-hand Column of your Book, against 0 Ch. 00 Links (or at the beginning of your Measure) because the Hedge was on your left-hand.

Then with your Chain, measure from the Beacon at O, towards the Beacon at P, in a right Line: And as you go along, at the end of 1 Ch. 40 L. you find a Break or Bend in the Hedge, which is distant from your Chain Line 70 Links. Set down the 1 Ch. 40 L. in the Middle Column, and the 70 Lin. against it, in the Left-hand Column of

the Table. Then going on farther towards P, at the end of 3 Ch. 40 Lin. you come against another *Break* or *Bow* in the *Hedge*, which is distant from your *Chain-Line* 50 Lin. both which set down in your Book or Paper in their respective *Columns*. And going on farther (in a straight Line) towards P; at the End of 6 Ch. 50 Lin. I find another *Break* or *Bow*, which is distant from your *Chain Line* 1 Ch. 20 L. both which set down in their respective *Columns*: And so measure on to your Beacon at P, which will terminate at the end of 7 Ch. 20 L. this set down in the middle *Column*: And because the Beacon at P, is 40 Lin. distant from the *Hedge*, set 40 Lin. in the Left-hand *Column*, against 7 Ch. 20 Lin. in the middle *Column*: And then draw a Line cross your Book or Paper, to signify, that you have done with that *Side* of the *Field*.

Then, in your stook, in the middle *Column*, under Ch. Lin. write 0 00. And because the Beacon at P, is distant from the *Hedge* on your Left-hand 70 Lin. set 70 Lin. in the Left-hand *Column* of the Table, against 0 00; then go on, and measure towards the Beacon at M, and measuring on, at the end of 2 Ch. 10 Lin. you find that the *Chain Line* just touches the Corner, or *Bow* of the *Hedge*; wherefore, set down 2 Ch. 10 Lin. in the middle *Column*, and against it in the Left-hand *Column* write *Touch*. And measuring on farther towards M, at the end of 3 Ch. 35 Lin. I find another *Bow* in the *Hedge*, distant from the *Chain Line* 90 Lin. both which set down in their proper *Columns*: And measuring on farther, against 4 Ch. 80 Lin. I find another *Bow*, distant from the *Chain Line* 40 Lin. both which set down. Then measuring on to your Beacon at M, you find the Length to be 5 Chains 50 Lin. which set down in the middle *Column*; and because the Beacon at M, is distant from the *Chain Line* 1 Ch. 10 Links, set 1 Ch. 10 L. in the Left-hand *Column* against 5 Ch. 50 Lin. And thus having finished this *Side* of the *Field*; and therefore draw a Line cross your Book, as before.

In this manner must you deal with the other two *Sides* (and *Chain Lines* M N and N O) in the *Field*, and set the several Distances at every Bend, and the Distance of every Bend from the *Chain Line*, as you see is done here in this Table.

And thus, having shew'd you how to measure such an irregular Piece of Ground (as to the Work in the *Field*) it resteth now to shew you how to make a true *Plot* or *Figure* thereof upon *Paper* or *Vellum*, in order to the finding of the *Content* or *Quantity* of the *Field*, in *Acres*, *Roods* and *Perches*.

How to Protract, or lay down upon Paper any irregular Piece of Ground, measured by the Chain only, as in the foregoing Work.

First, Upon a Sheet of good strong Paper, draw a right Line at pleasure, towards one end whereof, assume a Point, as at O, (*Fig. 3.*) representing the place where you set up your first *Beacon*.

Second

Secondly, With your Compasses, from any *Scale of equal Parts*, take out two Chains, and set them upon the Line before drawn, from O to *; also, out of the same Scale, take two Chains 91 Links, and setting one Foot of the Compasses in the Point *, with the other Foot describe an obscure Arch of a Circle $\approx \approx$: And then, take two Chains 45 Lin. from the same Scale; and setting one Foot of the Compasses in O, with the other describe another obscure Arch * +, cutting the former Arch in the Point T, through which Point draw the right Line O T N at pleasure: And now you have upon your Paper a *Triangle*, like in all respect to that which you measured out in the Field, and agreeable also with that at the *Top* of your Book or Paper.

Thirdly, Lay your Book or Table before you, by which you shall find that your first *Chain Line* did contain 7 Chains 20 Lin. wherefore take 7 Ch. 20 Lin. from your Scale, and set them from O to P, so is P the Place of your second *Beacon*. Again, by your Book you find, that the Distance between your first *Beacon* at O, and your last at N, was 5 Ch. 90 Lin. Take 5 Ch. 90 Lin. from your Scale, and set them upon the Line O T N, from O to N, so is N the place of your last *Beacon*. And now, finding by your Book, that your second Station (or Chain Line) doth contain 5 C. 50 L. take that Length out of your Scale, and setting one Foot of the Compasses in P, with the other describe the obscure Arch S S: And the Length of your third *Chain Line*, being 6 Ch. 50 Lin. take 6 Ch. 50 Lin. from your Scale, and setting one Foot in N, with the other Foot describe the obscure Arch V V, crossing the former Arch S S, in the Point M, which is the Point for your third *Beacon*: And thus have you drawn upon your Paper, your four *Chain Lines*, making the *Quadrilateral Figure* or *Trapezian* M N O P.

Fourthly, Having gone thus far, you must have recourse to your Book again, and there finding, that at your beginning at O, your *Beacon* at O, did stand 30 Links distant from the Hedge; take 30 Lin. from your Scale, and set them from O to *n*. Also, at the end of 1 Ch. 40 Lin. at *a*, the Bow of the Hedge was distant from the Chain Line 70 Lin. From your Scale, take first 1 Ch. 40 Lin. and set them from O to *a*, and the 70 Lin. from *a* to B, and then draw the Line *n* B, extending it to A. Then take 3 Ch. 40 Lin. and set them from O to *b*, and 50 Lin. from *b* to C; and draw the Line B C. Then take 6 Ch. 50 Lin. and set them from O to *c*, and 1 Ch. 20 Lin. and set them from *c* to D. and draw the Line C D. Then at 7 Ch. 20 L. which is at the *Beacon* at P, set 40 Lin. to the Hedge at *q*, and through that Point draw the Line D *q*, extending it to E. And thus is this *first Side* of your *Field* finished.

Fifthly, Begin again at the *Beacon* at P, where you find by your Book, that the *Beacon* was distant from the Hedge 70 Lin. set 70 Lin. from P to E, and draw the Lin. D *q* E. Then at 2 Ch. 10 Lin. you find that your *Chain Line* did touch the Bow of the Hedge; wherefore, take 2 Ch. 10 Lin. from your Scale, and set them from P to F, (or *d*) and draw the Line E F. In like manner, you find that

that at 3 Ch. 35 Lin. the Bow of the Hedge was distant from the Chain Line 90 Links: Set the 3 Ch. 35 L. from P to *e*, and the 90 Lin. from *e* to G, and draw the Line FG. Then your next Length 4 Ch. 80 Lin. will reach from P to *f*, where the Bend of the Hedge is distant from the Chain Line, 40 Lin. Set the 4 Chains 80 Lin. from P to *f*, and the 80 Lin. from *f* to H, and draw the Line GH. Then your last Length 5 Ch. 50 Lin. will reach from P to M, where the Beacon at M is distant from the Hedge 1 Chain 10 Links, set the 1 Ch. 10 Lin. from M to I, and draw the Line HG.

Thus have you finished your second Side, and in the same manner must you deal with the other two Sides; and in so doing, you shall have the true Plot of the *irregular* Piece of Ground upon your Paper, which you may cast up in Acres, Roods and Perches, by the Directions given in this Book.

How to take the Plot of a Wood (into which you cannot come to measure) by going round about the same, by the Chain only: And to make a Plot thereof upon Paper or Vellom.

LET W (Fig. 4.) be such an irregular Piece to be measured and plotted.

1. Go about the same, and as near as you can to the Hedges Sides that inclose the Wood; and at all eminent Turnings or Corners thereof, set up Marks or Beacons, as at A, B, C, D and E. Then,

1. At the Beacon B, measure out 2 Chains (or any other Measure) from B towards A, and also, towards C; to the Marks γ and $\odot$; and also measure the Distance between those two Marks.

2. Also, measure the Beacon at C, measure out towards the Beacons at B and D, 2 Chains (or other Measure) as at the Marks $\ast$ and δ , together with the Distance between those two Marks. And then,

3. Having prepared a Field Book ruled like this in the Margin. Begin to measure as followeth, viz.

1. From A towards B, where the Beacon at A stands 75 Links from the Hedge of the Wood, wherefore, against 0 Chains 00 Links (in the middle Column of your Field Book) set 75 Links in the Left-hand Column, because the Hedge was on your Left-hand. Then, measuring on in a right Line towards B, where, at 0 Ch. 50 Links, your Chain Line is distant from the Hedge 60 Links; set down 0 Ch. 50 Lin. in the middle Column, and against it 60 Lin. in the Left-hand Column. Then,

Measuring on farther towards the Beacon at B, you find that at	$\left\{ \begin{array}{l} 1 \text{ Ch. } 05 \text{ Links} \\ 1 \quad 75 \\ 3 \quad 40 \\ 4 \quad 30 \end{array} \right\}$	Your Chain-line is distant from the Hedge	$\left\{ \begin{array}{l} 0 \text{ C. } 50 \text{ L.} \\ 0 \quad 30 \\ 0 \quad 75 \\ 0 \quad 25 \end{array} \right\}$
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All which set down in your Field Book, as you see done in the President in the Margin.

2. And now being arriv'd to your *Beacon* at B, make in your Field Book a Triangle, like unto that which you set out in the Field at the *Beacon* B, setting to it the same Measures as you there measured, and as you see is done in (*Fig. 5.*) And then,

3. Begin to measure from B (in a right Line) towards C, and measuring along, you shall find,

That at $\left\{ \begin{array}{l} 1 \text{ Ch. } 55 \text{ L.} \\ 3 \quad 15 \\ 6 \quad 70 \\ 8 \quad 35 \end{array} \right\}$ The Hedge is distant from your Cha. Lin. $\left\{ \begin{array}{l} 0 \text{ Ch. } 50 \text{ Lin.} \\ 0 \quad 65 \\ 0 \quad 00 \\ 1 \quad 00 \end{array} \right\}$

All which set down in your Field Book, and being come to your *Beacon* at C, make there a Triangle, like unto that which you set out in the Field, setting the like Marks and Numbers to it, as is done in (*Fig. 6.*) And then,

4. Begin to measure from the *Beacon* at C, towards that at D in a right Line ; and in your measuring along, you shall find,

That at $\left\{ \begin{array}{l} 2 \text{ Ch. } 30 \text{ Lin.} \\ 4 \quad 30 \end{array} \right\}$ The Hedge is distant from your Ch. L. $\left\{ \begin{array}{l} 0 \text{ C. } 25 \text{ L.} \\ 0 \quad 55 \end{array} \right\}$

All which set down in your Field Book: And then,

5. Begin to measure from the *Beacon* at D, towards that at E, where you find,

That at $\left\{ \begin{array}{l} 0 \text{ Ch. } 65 \\ 2 \quad 35 \\ 3 \quad 50 \\ 4 \quad 90 \end{array} \right\}$ The Hedge is distant from your Chain Line, $\left\{ \begin{array}{l} 0 \text{ C. } 60 \text{ L.} \\ 0 \quad 35 \\ 1 \quad 35 \\ 0 \quad 60 \end{array} \right\}$

All which you must set down in your Field ; and so proceed.

6. Measure from the *Beacon* at E, to the *Beacon* at A, where you began ; and in your Progress you find,

That at $\left\{ \begin{array}{l} 1 \text{ Ch. } 75 \text{ L.} \\ 2 \quad 35 \\ 5 \quad 10 \\ 7 \quad 15 \\ 7 \quad 55 \\ 8 \quad 10 \end{array} \right\}$ The Hedge is distant from your Chain Line, $\left\{ \begin{array}{l} 0 \text{ G. } 55 \text{ L.} \\ 0 \quad 00 \\ 0 \quad 60 \\ 0 \quad 40 \\ 0 \quad 25 \\ 0 \quad 35 \end{array} \right\}$

S f s

All

Field Book.		
Sets off	C L	
0 75	0 00	From A to B
0 60	0 50	
0 50	1 05	
0 30	1 75	
0 75	3 40	
0 25	4 80	
0 00	7 15	From B to C
0 00	0 00	
0 50	1 55	
0 65	3 15	
Touch	6 70	
1 0	8 35	
0 00	10 0	From C to D
0 00	0 00	
0 25	2 30	
0 55	4 30	
0 00	4 80	
0 00	0 00	From D to E
0 60	0 65	
0 35	2 35	
1 35	3 50	
0 60	4 90	
0 00	7 20	From E to A
0 00	0 00	
0 55	1 75	
Touch	2 85	
0 60	5 10	
0 40	7 15	
0 35	7 55	
0 35	8 10	
0 00	9 30	

All which set down in your Field Book, in the Order as you see them set in the Exemplary Table in the Margin.

And thus having finished your Work in the Field, you may proceed to *Protract*, or lay the same down upon Paper, and make a fair *Plot* thereof, as followeth.

How to Protract, and make a fair Draught or Plot of the Wood before measured.

BEING provided with a Sheet of Paper or Parchment, upon it draw a right Line at pleasure; and laying your Field Book before you, therein you will find, that from your *first Beacon* at A, to your *second Beacon* at B, there was contained 7 Chains 15 Links: Therefore,

1. Take 7 Ch. 15 L. from your Scale, and prick that Distance down (upon your Line before drawn) from A to B: And because the *Beacon* at A was distant from the Hedge 75 L. Take 75 L. from your Scale, and set them from A to 1. Then, at 0 C. 50 L. from A, the Hedge is distant from the Chain Line 60 L. therefore take the 50 L. and set them from A to a, and the 60 L. from a to 2. Then,

At	$\left\{ \begin{array}{l} 1 \text{ C. } 05 \text{ L.} \\ 1 \quad 75 \\ 3 \quad 40 \\ 4 \quad 80 \end{array} \right\}$	at	$\left\{ \begin{array}{l} b \\ c \\ d \\ e \end{array} \right\}$	The Hedge	$\left\{ \begin{array}{l} 0 \text{ C } 50 \\ 0 \quad 30 \\ 0 \quad 75 \\ 0 \quad 25 \end{array} \right\}$	is distant	$\left\{ \begin{array}{l} 0 \text{ C } 50 \\ 0 \quad 30 \\ 0 \quad 75 \\ 0 \quad 25 \end{array} \right\}$	from the	Set	$\left\{ \begin{array}{l} b \quad 3 \\ c \quad 4 \\ d \quad 5 \\ e \quad 6 \end{array} \right\}$	which	$\left\{ \begin{array}{l} b \quad 3 \\ c \quad 4 \\ d \quad 5 \\ e \quad 6 \end{array} \right\}$	to		
				Ch. Lin.					from						

And draw the Lines 1. 2. 2. 3 3. 4 4. 5 and 5 6. And so have you finished that Side of the *Wood* that lies against the Chain Line A B. Then,

2. When you come to your *Beacon* at B, have recourse to your Field Book, and upon B make a Triangle equal to that you measured out in the Field, by setting 2 C. 00 L. from B to 6, and from B to 7, and 2 Ch. 50 L. from 6 to 7, and drawing the Line B 7 C, which by your Book you will find to contain 10 Chains. Then,

3. Going from B towards C, you will find by your Field Book, That

At	$\left\{ \begin{array}{l} 1 \text{ C. } 85 \text{ L.} \\ 3 \quad 15 \\ 6 \quad 70 \\ 8 \quad 35 \end{array} \right\}$	at	$\left\{ \begin{array}{l} f \\ g \\ h \\ i \end{array} \right\}$	The Hedge is	$\left\{ \begin{array}{l} 0 \text{ C. } 50 \text{ L.} \\ 0 \quad 65 \\ 0 \quad 00 \\ 1 \quad 00 \end{array} \right\}$	distant from	$\left\{ \begin{array}{l} 0 \text{ C. } 50 \text{ L.} \\ 0 \quad 65 \\ 0 \quad 00 \\ 1 \quad 00 \end{array} \right\}$	the Chain-	set	$\left\{ \begin{array}{l} f \text{ to } 7 \\ g \text{ to } 8 \\ h \text{ to } 9 \\ i \text{ to } 10 \end{array} \right\}$	which	$\left\{ \begin{array}{l} f \text{ to } 7 \\ g \text{ to } 8 \\ h \text{ to } 9 \\ i \text{ to } 10 \end{array} \right\}$	from		
				line.											

And draw the Lines 6.7 7.8 8.9 9.10, so shall you have protracted that Part of the *Wood*, which lies against your Chain Line B C. And then,

4. When

4. When you come to your *Beacon* at C, having recourse to your Field Book again; upon the Point C make a Triangle equal to that which you measured out in the Field, by setting 2 Ch. 00 L. from C to * upon the Line B C, and from C to δ upon the Line C D, with the Distance of 1 Ch. 30 L. between them, and through the Point δ draw the Line C D, which (by your Field Book) contains 4 Ch. 50 L. And then,

5. Measuring from you *Beacon* at B, towards the *Beacon* at D; you will find by your Field-book, That

At { 2 C. 30 L. } at { k } The Hedge was { 0 C. 25 L. } set which { k to 11
4 80 } { l } dist. from C. L. { 0 55 } from { l to 12

And draw the Lines 10. 11 and 11. 12, so shall you have protracted that Part of the Wood which lies against the Chain Line C D.

6. When you come to the *Beacon* at D, look for the Length of your next Chain-line from D to E, which you will find to contain 7 Ch. 20 L. which take in your Compasses, and setting one Foot in D, with the other Foot describe the obscure Arch H H: Also, the Length of your Chain-line from the *Beacon* at E, to the first *Beacon* at A, you find to be 9 Ch. 30 L. which also take out of your Scale, and setting one Foot of the Compasses in A, with the other describe the obscure Arch K K, crossing the other Arch in the Point E; and then draw the two Lines D E and A E; and so are all your Chain-lines *protracted*. And then,

7. You will find by your Field Book, that in measuring from D to E, you found that

At { 0 C. 65 L. } at { m } The Hedge { 0 C. 60 L. } Set { m to 13
2 35 } { n } was distant { 0 35 } which { n to 14
3 50 } { o } from the { 1 35 } from { o to 15
4 90 } { p } Ch. Line. { 0 60 } from { p to 16

And draw the Lines 13. 14 14. 15 15. 16. And so you have protracted that Part which lies against your Chain-line between D and E.

8. *Lastly*, In measuring from the *Beacon* at E, to the first *Beacon* at A, you do find by your Field Book, That

At { 1 C. 75 L. } at { q } The Hedge { 0 C. 55 L. } Set { q to 17
2 85 } { r } was distant { 0 00 } which { r to 18
5 10 } { s } from the { 0 60 } from { s to 19
7 15 } { t } Chain-line, { 0 40 } from { t to 20
7 55 } { u } { 0 25 } from { u to 21
8 10 } { x } { 0 35 } from { x to 22

And then draw the Lines 16. 17 17. 18 18. 19 19. 20. 20. 21 21. 22 And so is your *Protraction* ended: The form of the Wood being as in the Figure.

In the casting up whereof, you must first find the Content of the whole Figure made by the Chain Lines A B, B C, C D, D E and E A: And afterwards, of the *Triangles* and *Trapezias* made by the *Off-sets*; which being deducted from the Content of the whole Figure A B C D E, there will remain the *Area* or *Content* of the *Wood* only.

Several Errors in Measuring of Land, frequently practised (and too often trusted to) by the Vulgar, detected.

I. **SOME** there are who say, That if two Pieces of Land are of an equal Number of Poles, Perches (or other Measure) about; that those two Pieces of Land do contain equal Quantities of Ground; but this is evidently false:

For let the Piece of Land (Fig. 4.) which lies in a true Square Form, be every Side thereof 80 Perches; then four times 80 is 320, and so many Perches is that Piece of Land about: And 80 P. one of the Sides, being multiply'd in itself, that is, 80 by 80, the Product will be 6400 Perches, and that is the true Content of that Square Piece in Perches, which is just 40 Acres. Now there is another Piece of Land (Fig. 5.) which lies in a Square Form also (all the Angles of it being Right (or Square) Angles;) but the Length thereof is 110 P. and the Breadth 50 P. now this Piece of Ground is as much about as the other; for twice 110, and twice 50 added together, makes 320: But, if you multiply 110 the Length, by 50 the Breadth, the Product will be but 5500 P. which is less than the other by 900 Perches, that is, less by 5 Acres, 2 Roods and 20 Perches: Thus when both the Figures are Square (or right angled;) but if a Piece of the same Length in the Sides, and of the same Breadth at the Ends, should lie in such Form as the Figure 6, where two Angles are *Obtuse*, and two *Acute*, the Difference will be then greater; for such a Piece is not measured by multiplying the Length by the Breadth, but by the Length of the longest Side by the deepest Distance between those Sides, which is here but 32 P. So that 110 the Length, multiplied by 32, that Distance, produceth but 3520 Perches, which is less than the first by 2880 P. or 18 Acres.

Again farther: Let the irregular Piece of Ground D E F G H, (Fig. 7.) whose Sides are D E 57 Perches, E F 85 Perches, F G 72 Perches, G H 40 Perches, H D 60 P. all which added together, make 320 Perches for the Compass of the whole Figure, equal to the Number of Perches about the Square A: Now this Figure being cast up, the Superficial Content thereof will be found to be

be 5450 Perches, which is less than the perfect Square Figure A, by 950 Perches, and less than the long Square B by 50 Perches only; and greater than the Figure C by 1980 Perches. By these Presidents you may see that the nearer any right-lined Figure comes to a regular Polygon, the more capacious it is; for of all right-lined Figures, the regular Polygon is the most capacious: But if there were a circular Piece of Land, the Circumference whereof were 320 Perches about, as (Fig. 8.) equal to the Measure of the Square A about: Such a Circle will be found to contain 8142 Perches, which is more than the Content of the Geometrical Square A, by 1742 Perches; for of all Plain Figures whatsoever, the Circle is the most capacious.

But before I leave the Confutation of this Error, let us take again a View of the irregular Figure last treated of, *viz.* D E F G H: Which we found to contain 5450 Perches, the Compass whereof about was 320, equal to the Square A. But now suppose the Sides or Hedges D E, E F, and F G, to be in the same Form as they are drawn in the Figure; but the Hedge G H, may as well turn inwards to *h*, and the Hedge D H inwards also to *h*, and yet retain their same Lengths; but making another kind of Figure, namely, D E F G h D, equal about to the Figure D E F G H D, but lesser by the Quantity of the shadowed Piece D H G h, which contains 209 Perches. This needs no farther Proof.

II. Another Error frequently practised in measuring of Ground (especially, for Ploughing, Sowing, Mowing, Reaping, &c.) is this: That, if a Piece of Ground consisting of four Sides (how unequal soever they be,) if you add the two opposite Sides one to the other, and take their Halves, those two Halves multiplied together, shall be the true Content of that Piece of Ground.

Others there are that say,

If in a Four-sided Piece of Ground, you measure cross the Field from the Middle of one Side, to the Middle of the other Side, both Ways, that those two Lengths multiplied into each other, shall give the true Content of that Piece.

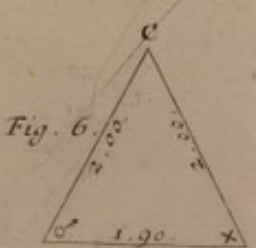
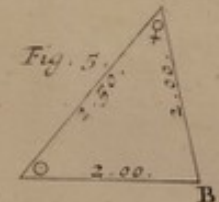
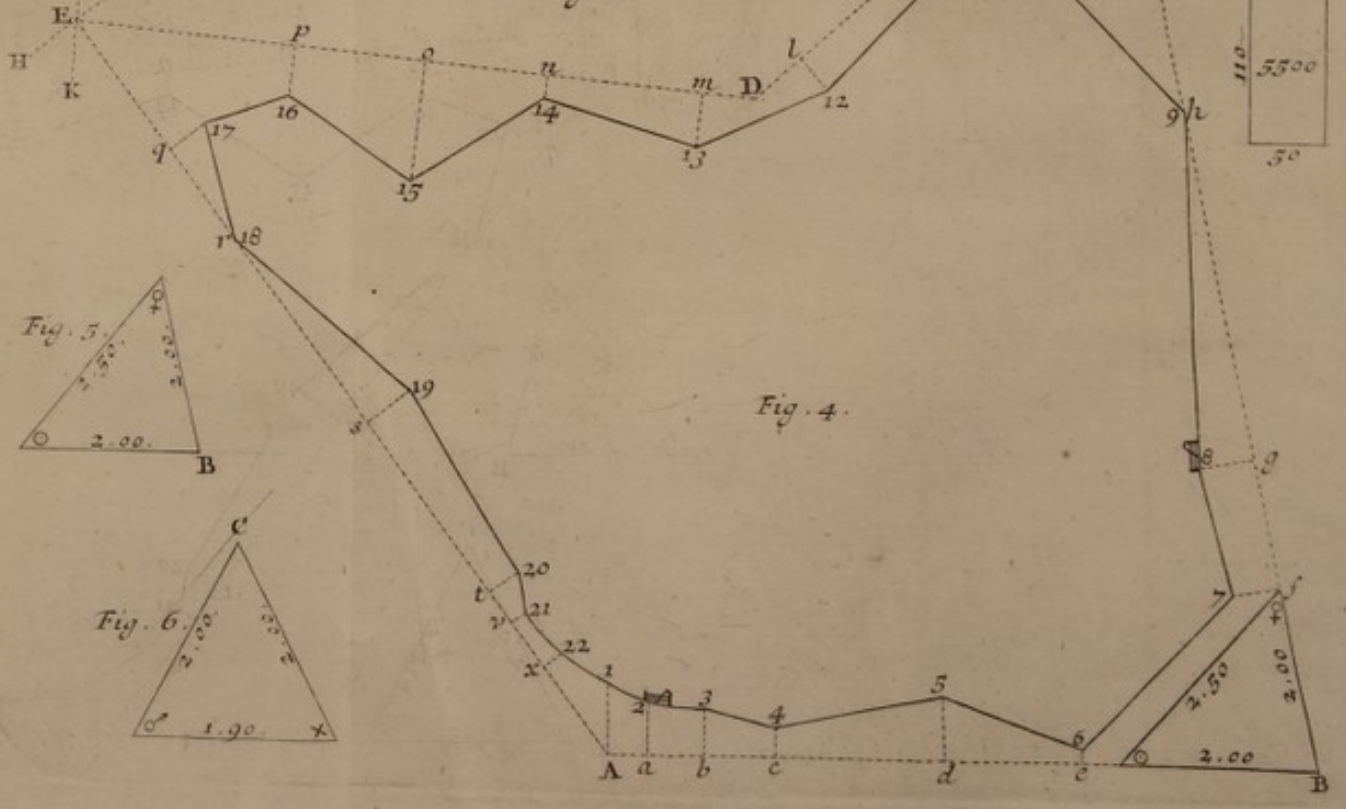
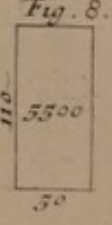
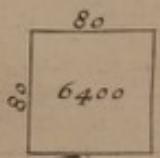
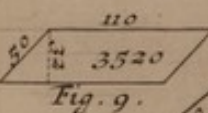
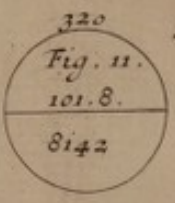
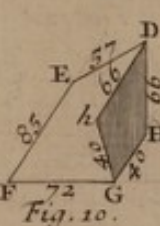
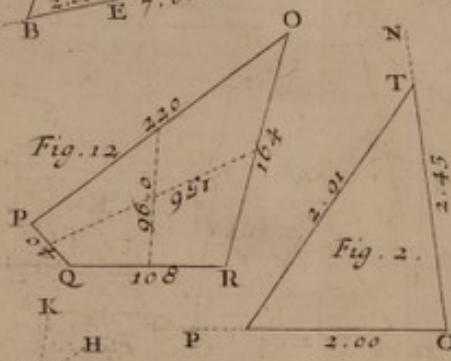
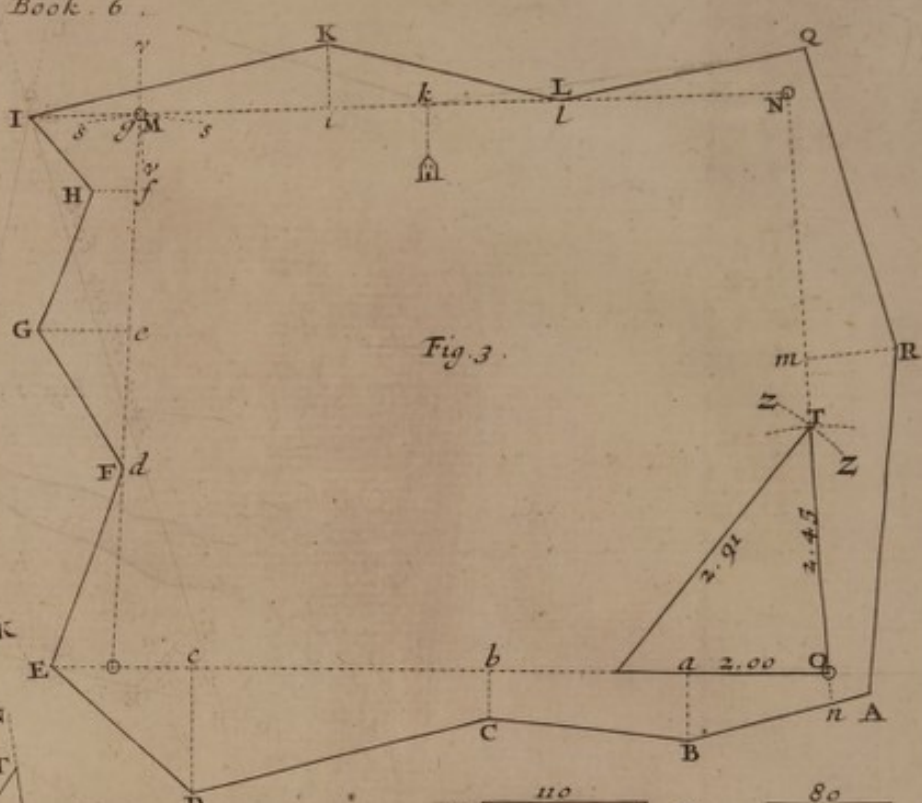
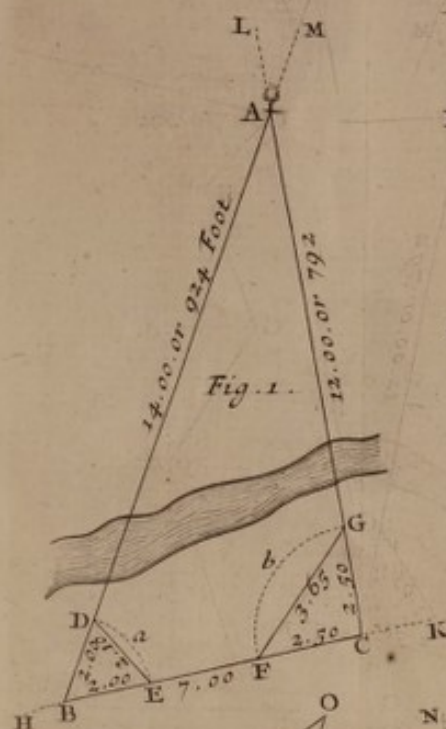
Both which Errors, I thus detect. Let there be a Piece of Land of Four unequal Sides, as O P Q R: (Fig. 9.) Which Piece, if truly measured, will be found to contain 13017 Perches, that is, 81 Acres, 1 Rood, and 17 Perches.

Now, the Side P Q is 40 Perches, the Side O R (opposite to it,) is 164 Perches; these added together make 204 Perches, the half whereof is 102 Perches. Again; the Side P O is 220 Perches,

ches, and the opposite Side Q R 108 Perches, which added together make 328 Perches, the half whereof is 164 Perches. Now these two Halves 164 and 102 multiplied together, do make 16728 Perches greater than the true Content by 3711 Perches; Or 23 Acres and 31 Perches: And thus is the First of these Errors detected: Now for the Second.

A Length measured from the Middle of the Side P Q, to the Middle of the opposite Side O R, will be found to contain 156 Perches: And the Length measured from the Middle of the Side P O, to the Middle of the opposite Side Q R, will be found to be 96 Perches: These multiplied into each other, do produce 14976 Perches for the Content, which is more than the true Content by 1959 Perches, or 12 Acres and a Quarter; yet less than the former erroneous Way by almost half: But by both these Ways, it always makes the Content of the Ground greater than it should be, and therefore ought to be rejected.

Thee End of the Sixth Book.





The COMPLEAT
SURVEYOR.

The Seventh BOOK.

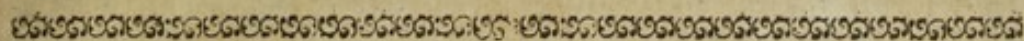
The ARGUMENT.

HAVING in the foregoing Books largely treated of the Surveying of all manner of Grounds, whether Wood-Land, Champion, or other Grounds, either Plain, or Mountainous, divers Ways, and by several Instruments, I conceived it very necessary (to the compleating of this Treatise) to say something concerning other kinds of Mensurations, and could think of none more convenient, than such as concern Building, and Materials thereunto belonging; considering that Gentlemen and Others, have continual occasion either to buy or sell Timber, Stone, and other Necessaries for that purpose; and how that some in the purcha-
A sing,

sing, and others in the selling of such Materials, are daily abused; partly out of ill Customs (too frequently in use) but principally for the want of Geometrical Knowledge in such as undertake for themselves, or are intrusted by others, in such Employments. For, Errors in many Cases are committed insensibly; and the Undertaker, for want of Skill in Geometry, knows not whence such Errors do arise, nor how to rectify or amend the same when they are introduced. I have therefore, in this Seventh Book, laid down such plain, easy, and infallible Rules (all grounded upon firm Geometrical Principles) for the Mensuration of Superficies and Solids, as Board, Glafs, Pavement, Wainfcot, Plaistering, Painting, Brick-work, &c. Likewise of Solids, as Stone, Timber growing, or squared, &c. And for the Ease and Benefit of such as have not Skill, or at least Leisure to pry far into this kind of Learning, I have for their Sakes (besides the Ways and Means whereby these Mensurations are to be performed) calculated Tables wherein all (or the most part) of the fore-mentioned Particulars are ready cast up to Hand, so that if you have but a Rod, or Rule to take your Dimensions with, you may come very near the Truth of the Thing you desire to know. There are divers other things promiscuously inserted in this Seventh Book which are not here enumerated, but those I leave to the Scrutiny of the Peruser.

O F

M E A S U R I N G.

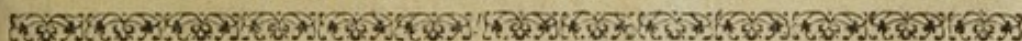


C H A P. I.

Of Superficial Measures in general; But more particularly of the Menfuration of Board, Glafs, Pavement, Wainfcot, Plaiftering, Painting, Tiling, &c.

1. **B**oard, Glafs, and fome other forts of Superficies, as *Pavement of Marble*, or *Purbeck Stone* is commonly meafur'd by the *Foot Square*, that is, 12 Inches every way, which is in all 144 Inches.
2. *Wainfcoting, Plaiftering, and Painting*, are meafured by the *Yard Square*, that is 3 Foot every way, which is in all 9 fquare Feet.
3. *Tiling, Flooring, and Roofing* by the *Square of Ten*; that is ten Foot every way, in all, (or in each *Square*) 100 fquare Feet.
4. *Brick-work* is meafured by the *Rod Square* of 16 Foot and an half, each *Rod* containing 272 and a quarter of *square Feet*.

Now to fhew the manner of meafuring any of the above-mentioned, by help of the *Table of Logarithms* in the third Book, as alfo by the *Line of Numbers*, it were moft fuitable to have your *Rule* by which you meafure, whether it be *Foot, Yard, Rod, or Perch*, divided into 10, 100, or 1000 Parts, according to the length thereof, that way of divifion being moft agreeable both to the *Tables*, and alfo to the divifions of the *Line of Numbers*. Thefe things being premifed, I fhall now come to give *Examples* in each of thefe forts of Works.



C H A P. II.

Of Foot Measure.

1. *A Board being 1 Foot and 25 parts broad, and 16 Foot and a half, which is five tenths of a Foot long, how many fquare Feet are contained therein?*

I Might here fhew how to perform this, and all fuch-like Conclufions, as I have before mentioned, by the help of the *Table of*
of

of *Logarithms* in the third Book, but the *Tables* there being so short, going only to 1000, they are unfit for this Business, without many Cautions to be observed in the Use of them; which, in this place, to enumerate would be both tedious and troublesome to the Learner; especially when the Dimensions consist of *whole Feet* and *parts of Feet*, or *whole Yards* and *parts of Yards*, and the like; but when they consist of *Integers* or whole Numbers only, and when the Product doth not exceed 1000, then the *Tables* will exactly and easily perform the *Work*, as in this *Example*.

II. If a Free-Stone Pavement should contain 52 Foot in length, and 16 Foot in breadth, how many square Feet are contained in that Pavement?

By the Logarithms thus.

The Logarithm of 52 is	1,716003
The Logarithm of 16 is	1,204120
Their Sum is	<u>2,920123</u>

Which is the *Logarithm* of 832, and so many Square Feet is contained in that Pavement.

But if the Pavement had been 52 Foot and 5 parts long, and 16 Foot and 7 parts broad, then you could not come to so near an Exactness by these short *Tables*, because the sum of the two *Logarithms* cannot be their sum. And indeed in the setting down of the numbers of the *Characteristick* of the *Logarithms* should be varied; but this, with some other Cautions, in the use of *Logarithms*, are not convenient for this Place. Yet, for *Example* sake, is the manner of working by the *Tables*.

The Logarithm of 52, 5 is	1,720159
The Logarithm of 16, 7 is	1,222716
Their Sum is	<u>2,942875</u>

The nearest Number answering to this *Logarithm* in the Table is 877, but that is something too much, for the real Content of the

52, 5	Pavement is but 176 Foot and 75 parts of a
16, 7	Foot, which is three quarters of a Foot, as by
<u>3675</u>	the <i>Arithmetical Work</i> in the Margin doth ap-
3150	pear; for 52, 5 being multiplied by 16, 7 gi-
525	veeth in the Product 876, 75, which is 876
<u>87675</u>	whole square Feet, and 75 parts, or three quar-
	ters of a Foot.

And for this Reason, the Table being something troublesome to such, who are not acquainted with the use of larger *Tables* of this Nature, I shall forbear to make farther Use of them in this kind, but

do all by the help of the *Line of Numbers*, which performeth all manner of *Mensurations* of this Nature, very expeditiously and exactly, as I have already made appear in my Treatise entituled, *The Use of the line of Proportion made easy*; and shall shew some farther *Uses* thereof in a second Part to the same Book, now almost ready for the Press; and as the *first Part* hath found good acceptance in the World, so I doubt not but the *second Part* thereof will be as well received, for that it shall be furnished with variety of *Examples* continually in *Use* and *Practice* with (almost) all manner of *Artificers*, especially such as any way relate to *Building*, or in buying or selling *Materials* thereunto belonging But now to return to our intended Business.

III. *A Board being 1 Foot 25 parts broad, and 16 Foot and 5 parts (which is half a Foot) long, how many square Feet are contained therein?*

As 1, is to 1, 25 the breadth,
So is 16, 5 the length, to 20, 62 the Content.

By the Line of Numbers.

Extend the Compasses from 1, to 1, 25. The same Extent will reach from 16, 5 to 20, 62 the Content. Or, if you extend the Compasses from 1, to 16, 5, the same extent will reach from 1, 25, to 20, 62, as before.

IV. *If a Plank be 3 Foot, and 62 parts broad, and 23 Foot 75 parts long, how many square Feet doth it contain?*

As 1, is to 3, 62, the breadth,
So is 23, 75 the length, to 85, 97, the Content.

By the Line of Numbers.

Extend the Compasses from 1, to 3, 62. The same shall reach from 23, 75 to 85, 97, which is the quantity of Feet contained in that *Plank*, and is within 3 parts of an hundredth 86 Foot, and may be so called.

Or, if you extend the Compasses from 1, to 23, 75, the same will reach from 3, 62, to 85, 97, as before.

V. If a Board or Plank be 4 Foot and 50 parts broad at one end, and 3 Foot 20 parts broad at the other end, and 27 Foot 12 parts long, how many Foot is contained therein?

Because the Breadths at either end are unequal, you shall therefore add both Ends together, and take the half thereof for a *mean breadth*: Thus 4, 50 and 3, 20 being added together, do make 7, 70, the half whereof is 3, 85, which is a *mean breadth*. Then,

As 1, is to 3, 85, the *mean breadth*,
So is 27, 12 the *length*, to 104, 41 the *content*.

By the Line of Numbers.

In this Case, if you extend your Compasses from 1, to 3, 85, the other Foot being placed in 27, 12 will reach beyond the Line. Wherefore (in such Cases)

Extend the Compasses from 1, in the middle of the Line, to 3, 85 downwards, towards the beginning of the Line, then will that same Extent reach from 27, 12 (downwards also) to 104, 41, which is the Content of the *Plank* or *Board*.

VI. If a Pane of Glass be 1 Foot 63 parts broad, and 2 Foot 8 parts long, how many Foot are there in that Pane?

As 1, is to 1, 63,
So is 2, 8, to 4, 56, the *Content*.

By the Line of Numbers.

Extend the Compasses from 1, to 1, 63. The same extent will reach from 2, 8 to 4, 56. Or extend the Compasses from 1, to 2, 8 the same will reach from 1, 63 to 4, 56 the Content, as before, which is 4 Foot and an half and three quarters of an Inch, in common Measure.

If many *Panes* of *Glass* standing in the same range, that is, having all one height; with a *Line* or *String*, take all the breadths together in one sum, and take that sum for the length, and the height for the breadth. And then work as in the Example following.

Lib. VII. Of MEASURING.

7

VII. *Several Panes of Glafs of different breadth, containing in length 21 Foot 5 parts, and being 3 Foot 75 parts high, how many Foot of Glafs in all?*

As 1, is to 3,75, the common height,
So is 21, 5 all the breadths together
To 80, 62 the Content in Feet.

By the Line of Numbers.

Extend the Compaffes from 1 to 3,75. The fame extent will reach from 21, 5 to 80, 62 --- Or, extend the Compaffes from 1 to 21, 5, the fame will reach from 3, 75 to 80, 62 as before, which is 82 Foot, and fomewhat above half a Foot, and fo many Foot are in all the Panes.

VIII. *There is a Yard paved with Free-ftone, being in length 57 Foot and 5 parts, and in breadth 26 and 25 parts, how many Foot are in that Yard.*

As 1 is to 26, 25 parts, the breadth,
So is 57, 5 the length, to 1509, 37, the Content.

By the Line of Numbers.

Extend the Compaffes from 1 in the middle of the Line downwards, to 26, 25. The fame Extent will reach from 57, 5 downwards, to 1509, 37 the Content, which is both 1509 Foot, and about 5 Inches.

IX. *A Marble Foot-pace, being 6 Foot 93 parts long, and 1 Foot 36 parts broad, how many Foot therein?*

As 1 is to 1, 36 the breadth,
So is 6, 93 the length, to 9, 42 the quantity.

By the Line of Numbers.

Extend the Compaffes from 1, to 1, 36. The fame extent will reach from 6, 93 to 9, 42 the Content; fo that there is 9 Foot and 5 Inches in that *Foot-pace*.

¶ Let thefe *Examples* fuffice for things meafured by the Foot fquare, wherein, if the thing to be meafured be broader at one End than at the other, obferve the Direction given in the 3d Section of this Chapter. And now I will proceed to *Yard Measure*, as to things meafured by the *Yard Square*, as *Wain-*
fcot,

scot, Plaistering, Painting, and other Hangings. But first (because it is customary for Men to sell parts, or a certain number of Feet of Board,) I will here shew you first, how by having the breadth of any Board or the like, given in *Foot-measure*, to find how much thereof in length will make a Foot square, for which take this Example.

X. *A Board or any other Superficies, being 72 parts of a Foot broad, how much thereof in length will make a square Foot?*

For the effecting hereof, the Proportion is,
 As 72 Parts, the *breadth* in Foot-measure,
 Is to 10, or 100, so is 1, in the middle of the Line,
 to 1, 39 the *length* of so much of that Board
 as will make a square Foot.

By the Line of Numbers.

Extend the Compasses from 72 Parts, the *breadth*, to 1, in the middle of the Line, the same Extent will reach upwards from the same 1, to 1 Foot 39 parts, and so much in *length* will make a Foot square of that Board.

¶ And now because this way of Measuring is so customary, I will here insert a Table, by which, (having the breadth of of any Board, or other Superficies given in Inches) you may find how much in length thereof will make a square Foot, and that from one Inch broad, to 36 Inches, or 3 Foot broad.

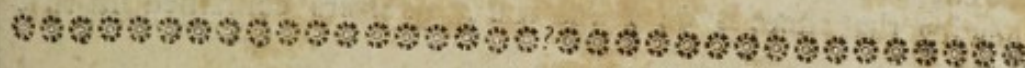
A Table

A Table shewing how much in length of any Board, Plank, Pane of Glass, &c. will make a Foot square; the breadth thereof being given in Feet and Inches, from one Inch to three Foot broad.

F. Inch	F. Inc. 10 p. of Inc.	F. Inch	F. Inc. 10 p. of Inc.	F. Inch	F. Inc. 10 p. of Inc.
0	12 0 0	1	0 0	11	0 0
1	6 0 0	1	11 8	1	0 8
2	4 0 0	2	10 3	2	0 5
3	3 0 0	3	9 6	3	0 5
4	2 4 8	4	9 0	4	0 5
5	2 0 0	5	8 5	5	0 5
6	1 8 6	6	8 0	6	0 4
7	1 6 0	7	7 6	7	0 4
8	1 4 0	8	7 2	8	0 4
9	1 2 4	9	6 8	9	0 4
10	1 1 1	10	6 5	10	0 4
11	1 0 0	11	6 2	11	0 4
12	0 0				0 1

The Use of the TABLE.

Suppose a Board be 9 Inches broad, look in the Table for 9 Inches, and right against it you shall find 1 Foot and four Inches, and so much in length of the Board will make a square Foot. So likewise, if a Board or Pane of Glass or Marble Foot-pace, be 1 Foot and 9 Inches broad, then 6 Inches and 8 tenth parts of an Inch will make a Foot square.



CHAP. II.

Of Yard Measure.

IF the Yard with which you measure your Work be divided into 100 equal Parts, as your Foot before was, then will the Proportions be the same as in Foot-Measure, and the Work upon the Line of Numbers the same also; for the Compasses being extended from 1, to the breadth of the thing to be measured, the same extent of the Compasses shall reach from the Length thereof, to the Quantity of Yards therein contain'd: But if you measure by Feet and parts of a Foot, as before in Board-Measure, and would have your Result or Content in Yards, then the Proportion is

C

As

As 9 is to the Breadth,
So is the Length, to the Content in Yards.
Examples shall make this plain.

- I. *A Piece of Wainscot being 8 Yards, and 82 parts of a Yard deep, and 10 Yards and 73 parts broad, how many square Yards are contained therein?*

As 1 is to 8, 82 depth,
So is 10, 73 the breadth,
To 94 Yards, 74 hundred parts of a Yard.

By the Line of Numbers.

Extend the Compasses from 1, to 8, 82, the depth. The same Extent will reach from 10, 73 the breadth, to 94, 74 the Content; so that there is 94 Yards and 3 Quarters contained in this piece of Wainscot.

But if the Dimensions of this piece of Wainscot had been taken in Foot-Measure, the breadth would have been 26 Foot and 50 parts, and the depth 32 Foot and 20 parts, and then the Proportion would have been,

As 9 (the number of square Feet in one Yard)
is to 26, 50 (the depth in Foot-Measure)
So is 32, 20 (the breadth in Foot-Measure)
To 94, 74, the Content in square Yards.

By the Line of Numbers.

Extend the Compasses from 9, to 26, 50 the depth; the same Extent will reach from 32 20 the breadth, to 94, 74 as before, shewing that there is 94 Yards and 3 quarters contained in that Piece.

- II. *A Cieling of a Room being 97 Foot and 32 parts broad, and 120 Foot long, how many Yards of Plastering are contained in that Cieling?*

As 9 is to 97, 32 Feet,
So is 120 Feet to 1298 Yards.

By the Line of Numbers.

Extend the Compasses from 9 to 97, 32: The same Extent will reach from 120, to 1298, and so many Yards are contained in that Cieling.

III. *A Room being 8 Foot 50 parts high, and 92 Foot about, how many Yards of Painting is there in this Room?*

Extend the Compasses from 9, to 92: The same Extent will reach from 8, 50 to 868, 8, that is to 868 Yards, and 8 Foot. Or if by this manner of Working the Compasses open to too large an Extent you may extend them from 9, to 8, 50 downwards, and the Extent will reach from 92 downwards to 868, 8, as before.

IV. *A Piece of Tapestry being 13 Foot and 25 parts long, and 7 Foot 36 parts broad, how many Yards therein?*

As 9, to 13 25,
So is 7, 36 to 10, 70 Yards.

Extend the Compasses from 9, to 13 25 parts: The same Extent will reach from 7 36, parts to 10, 70; so that there is 10 Yards and 7 Foot contained in that piece of Tapestry.

¶ Having given these *Examples* in *Yard-measure*, I will take the like Course as I did in *Foot-measure*, namely to add a *Table* by which you may know how many *Yards* are contained in any piece of *Work*, having the length and breadth thereof given in Feet, from 10 Foot broad to 30 Foot long.

A Table

A Table shewing how many square Yards are contained in any Piece of Work, the length and breadth being given in Feet.

The Breadth of the Plaistering, or other Work in Feet.

The Length of the Work in Feet.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15																
	YF	YF	YF	YF	YF	YF	YF	YF	YF	YF	YF	YF	YF	YF	YF																
1	0	1	0	2	0	3	0	4	0	5	0	7	0	8	1	0															
2	0	2	0	4	0	6	0	8	1	1	1	3	1	5	1	7	2	0	2	2	4	2	6	2	8	3	1	3	3		
3	0	3	0	6	1	0	1	3	1	6	2	0	2	3	2	6	3	0	3	3	6	4	3	4	3	4	6	5	0	0	
4	0	4	0	8	1	3	1	7	2	2	2	6	3	1	3	5	4	0	4	4	8	5	3	5	7	6	2	6	6	6	
5	0	5	1	1	1	6	2	2	7	3	3	3	8	4	4	5	0	5	5	6	1	6	7	2	7	7	8	3			
6	0	6	1	3	2	0	2	6	3	3	4	0	4	6	5	3	6	0	6	7	3	8	0	8	6	9	3	10	0	0	
7	0	7	1	5	2	3	3	1	3	8	4	6	5	4	6	2	7	0	7	8	5	9	3	10	1	10	8	11	6		
8	0	8	1	7	2	6	3	5	4	4	5	3	6	2	7	1	8	0	8	9	7	10	6	11	5	12	4	13	3		
9	0	1	2	0	3	0	4	0	5	0	6	0	7	0	8	0	9	0	10	0	11	0	12	0	13	0	14	0	15	0	
10	1	0	2	3	3	4	4	5	5	6	6	7	7	8	8	10	0	11	1	12	2	13	3	14	4	15	5	16	6		
11	1	2	2	4	3	6	4	8	6	1	7	3	8	5	9	7	11	0	12	2	13	4	14	6	16	8	17	1	18	3	
12	1	3	2	6	4	0	5	3	6	6	8	0	9	3	10	6	12	0	13	3	14	6	16	0	18	3	18	6	20	0	
13	1	4	2	8	4	3	5	7	7	2	8	6	10	1	11	5	13	0	14	4	15	8	17	3	19	7	20	2	21	6	
14	1	5	3	1	4	6	6	2	7	7	9	3	10	8	12	4	14	0	15	5	17	1	18	6	21	2	21	7	23	3	
15	1	6	3	3	5	0	6	6	8	3	10	0	11	6	13	3	15	0	16	6	18	3	20	0	22	6	23	3	25	0	
16	1	7	3	5	5	3	7	1	8	10	6	12	4	14	2	16	0	17	7	19	5	21	3	24	1	24	8	26	6		
17	1	8	3	7	5	6	7	5	9	4	11	3	13	2	15	1	17	0	18	8	20	7	22	6	25	5	26	4	28	3	
18	2	0	4	0	6	0	8	0	1	00	12	0	14	0	16	0	18	0	20	0	22	0	24	0	26	0	28	0	30	0	
19	2	1	4	2	6	3	8	4	1	05	12	6	14	7	16	8	19	0	21	1	23	2	25	3	27	4	29	5	31	6	
20	2	2	4	4	6	6	8	8	1	11	13	3	15	5	17	7	20	0	22	2	24	4	26	6	28	8	31	1	33	3	
21	2	3	4	6	7	0	9	3	11	6	14	0	16	3	18	6	21	0	23	3	25	6	28	0	30	3	32	6	35	0	
22	2	4	4	8	7	3	9	7	12	2	14	6	17	1	19	5	22	0	24	4	26	8	29	3	31	7	34	2	36	6	
23	2	5	5	1	7	6	10	2	12	7	15	3	17	8	20	4	23	0	25	5	28	1	30	6	33	2	35	7	38	3	
24	2	6	5	3	8	0	10	6	13	3	16	0	18	6	21	3	24	0	26	6	29	3	30	0	34	6	37	3	40	0	
25	2	7	5	5	8	3	11	1	13	8	16	6	19	4	22	2	25	0	27	7	30	5	33	3	36	1	38	8	41	6	
26	2	8	5	7	8	6	11	5	14	4	17	3	20	2	23	1	26	0	28	8	31	7	34	6	37	5	40	4	43	3	
27	3	0	6	0	9	0	12	0	15	0	18	0	21	0	24	0	27	0	30	0	33	0	36	0	39	0	42	0	45	0	
28	3	1	6	2	9	3	12	4	15	5	18	6	21	7	24	8	28	0	31	1	34	2	37	3	40	4	43	5	46	6	
29	3	2	6	4	9	6	12	8	16	1	19	3	22	5	25	7	20	0	32	2	35	4	38	6	41	8	45	1	48	3	
30	3	3	6	6	10	0	13	3	16	6	20	0	23	3	26	6	30	0	33	3	36	6	40	0	43	3	46	6	50	0	

The Content of the Work in square Yards and odd Feet.

The Content of the Work in square Yards and odd Feet.

The

The Use of the Table.

In a Cieling 26 Foot long and 15 Foot broad, how many Yards are contained?

Seek 15 in the head of the Table, which you shall find over the last Column,) and under it, just against 26, you shall find 43 Yards and 3 Foot, and so many Yards are contained in that Cieling.

II. *A Joyner bath Wainscoted a Room 7 Foot high, and 29 Foot about, how many Yards are therein contained?*

Seek 7 in the head of the Table, and 29 in the first Column next your left Hand, and just against 29, and under 7 in the head of the Table, you shall find 22 Yards and 5 Foot, and so many Yards doth the Room contain.

If the Work, whose content you desire to know, be too large for the Lengths and Breadths in this Table, you may take the half or quarter thereof, and so double or quadruple the Number found in the Table accordingly.

CHAP. III.

Of Measure by the Square.

ALL manner of Tiling, Flooring, and Roofing is usually measur'd by the Square of ten Foot; so that 10 times 10, being 100, is counted as a Square Tiling; so that a Square of Roofing, or Flooring contains just 100 square Feet. In this kind of Measure you see the Rod itself is divided into 10 Foot, and therefore the Proportion will be,

As 1, is to the length in Feet,
So is the breadth in Feet to the Content in Feet,
every 100 being a Square.

D

I. The

- I. *The Tiling on the Roof of the House (both sides being taken) the breadth contains 26 Foot 50 parts, and the length of the House 32 Foot, 25 parts long, how many Square of Tiling is there in this Roof?*

As 1 is to 26, 50 the breadth,
So is 32, 25 the length, to 854, 62, the Content.

By the Line of Numbers.

Extend the Compasses from 1, to 26, 50. The same Extent will reach from 32, 25 to 854, 62; which is 854 Foot, and 62 hundred parts of a Foot, which we reject as superfluous in this Case: So that the 854 foot is 8 Square, and the 54 foot is half a Square, and 4 foot over. So that in this Roof is contained 8 Square, 2 Quarters, and 8 Foot.

- II. *A Barn, whose length is 123 Foot, and the length of the Rafter (both sides being taken) 62 Foot, how many Square of Roofing is there in this Barn?*

As 1, is to 62 foot (the breadth)
So is 123 Foot (the length)
To 7626, the Content in feet.

By the Line of Numbers.

Extend the Compasses from 1, to 62. The same extent will reach the same way from, 123, to 7626 foot, which is the Content, that is 76 Square, and 26 foot, which is 1 foot above a quarter of a Square. So that the Roof contains 76 Square, 1 Quarter and 1 foot.

But because it is something troublesome in very great Numbers, to give the Estimate upon the Line to so many Places (as heretofore) it will be better to count the length and breadth of the Roof by Rods and parts of a Rod: So in this Example, the length of the Roof will be 12 Rod and three parts, and the breadth 6 Rod and 2 parts: Then,

As 1, is to 21 Rod 3 parts,
So is 6 Rod 2 parts
To 76 Sq. 1 Quarter, and 1 foot. For,

Extend the Compasses from 1, to 12 Rod 3 parts, the same will reach from 6 Rod 2 parts, to 76 Square and somewhat above a Quarter; that is, 27 Rod and 9 foot.

III. A Floor being 279 Foot (that is, 27 Rod and 9 Foot) long, and 132 Foot (or 13 Rod 2 Foot) broad, how many Square is contained in that Floor?

As 1, is to 27, 9 parts,
So is 13, 2 parts, to
368 Rod, and 28 parts.

Extend the Compasses from 1 to 27 Rod 9 parts. The same Extent will reach the same way from 13 Rod 2 parts, to 368 Rod, and something above a Quarter, for it will reach to 368 Rod and 28 parts.

¶ And thus have you Examples in *Tiling, Roofing and Flooring*; and as in the other two sorts of Measures before, so in this also, I will give you a Table ready computed, serving for any Work by the *Square*, from 10 foot to 20 foot broad, and and from 10 foot to 40 foot long.

A Table

A Table shewing what number of Squares are contained in any piece of Work, from 10 Foot to 20 Foot broad, and from 10 to 40 Foot long.

The Breadth of the Work in Feet.																								
Fe	10		11		12		13		14		15		16		17		18		19		20			
	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.	Sq.F.		
10	1	0	1	10	1	20	1	30	1	40	1	50	1	60	1	70	1	80	1	90	2	0		
11	1	10	1	21	1	32	1	43	1	54	1	65	1	76	1	87	1	98	2	9	2	20		
12	1	20	1	32	1	44	1	56	1	68	1	80	1	92	2	4	2	16	2	28	2	40		
13	1	30	1	43	1	56	1	69	1	82	1	95	2	8	2	21	2	34	2	47	2	60		
14	1	40	1	54	1	68	1	82	1	96	2	10	2	24	2	38	2	52	2	66	2	80		
15	1	50	1	65	1	80	1	95	2	10	2	25	2	40	2	55	2	70	2	85	3	0		
16	1	60	1	76	1	92	2	8	2	24	2	40	2	56	2	72	2	88	3	4	3	20		
17	1	70	1	87	2	4	2	21	2	38	2	55	2	72	2	89	3	6	3	23	3	40		
18	1	80	1	98	2	16	2	34	2	52	2	70	2	88	3	06	3	24	3	42	3	60		
19	1	90	2	9	2	28	2	47	2	66	2	85	3	4	3	23	3	42	3	61	3	80		
20	2	0	2	20	2	40	2	60	2	80	3	0	3	20	3	40	3	60	3	80	4	0		
21	2	10	2	31	2	52	2	73	2	94	3	15	3	36	3	57	3	78	3	99	4	20		
22	2	20	2	42	2	64	2	86	3	8	3	30	3	52	3	74	3	96	4	18	4	40		
23	2	30	2	53	2	76	2	99	3	22	3	45	3	68	3	91	4	14	4	37	4	60		
24	2	40	2	64	2	88	3	12	3	36	3	60	3	84	4	8	4	32	4	56	4	80		
25	2	50	2	75	3	0	3	25	3	50	3	75	4	0	4	25	4	50	4	75	5	0		
26	2	60	2	86	3	12	3	38	3	64	3	90	4	16	4	42	4	68	4	94	5	20		
27	2	70	2	97	3	24	3	51	3	78	4	5	4	32	4	59	4	86	5	13	5	40		
28	2	80	3	8	3	36	3	64	3	92	4	20	4	48	4	76	5	4	5	32	5	60		
29	2	90	3	19	3	48	3	77	4	06	4	35	4	64	4	93	5	22	5	51	5	80		
30	3	0	3	30	3	60	3	90	4	20	4	50	4	80	5	10	5	40	5	70	6	0		
31	3	10	3	41	3	72	4	03	4	34	4	65	4	96	5	27	5	58	5	89	6	20		
32	3	20	3	52	3	84	4	16	4	48	4	80	5	12	5	44	5	76	6	8	40			
33	3	30	3	63	3	96	4	29	4	62	4	95	5	28	5	61	5	94	6	27	6	60		
34	3	40	3	74	4	8	3	42	4	76	5	10	5	44	5	78	6	12	6	46	6	80		
35	3	50	3	85	4	20	4	55	4	90	5	25	5	60	5	95	6	30	6	65	7	0		
36	3	60	3	96	4	32	4	68	5	4	5	40	5	76	6	12	6	48	6	84	7	20		
37	3	70	4	7	4	44	4	81	5	18	5	55	5	92	6	29	6	66	7	3	40			
38	3	80	4	18	4	59	4	94	5	30	5	70	6	8	6	46	6	84	7	22	7	60		
39	3	90	4	29	4	68	5	7	5	46	5	85	6	24	6	63	7	2	7	41	7	80		
40	4	0	4	40	4	80	5	20	5	60	6	0	6	40	6	80	7	20	7	60	7	0		

The Length of the Work in Feet.

The Content of the Work in Squares.

The Content of the Work in Squares.

The

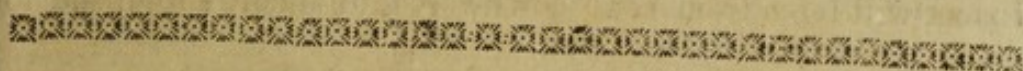
The Use of the Table.

I. *If any piece of Work be 13 Foot broad, and 32 Foot long, how many Squares are there contained therein?*

Look 13 in the top of the Table, and right against 32, in the first Column towards the left Hand, you shall find 4 Square and 16 Foot, and so much is contained therein.

II. *If a piece of Work be 19 Foot one way, and 37 Foot the other way, how many Squares are there contained therein?*

Look 19 at the top of the Table, and underneath it just against 37, in the side, you shall find 7 Square and 3 Foot, and so much is contained therein.



CHAP. IV.

Of Measures by the Rod.

HAVING dealt with the Carpenter, Joyner, Mason, Glasier, Painter, Plasterer, &c. we now come to have to do with the Bricklayer, whose Measure differs from all the rest, for they do measure by the Rod Square, each Rod containing 16 Foot and an half in length; so that one of these Rods in length, and one in breadth, do make a Rod Square, which contains 272 and a quarter square Feet. Now if you have a Rod of 16 Foot and a half, divided into 10 or 100 Parts, then your length and breadth being given in Rods, and parts of a Rod, you may by the *Line of Numbers* work as if they were Feet, as before: But if you measure your length and breadth by Feet and parts of a Foot, then your Proportion will be,

As 272 and a quarter is to 1,
So is the superficial measure of the Wall in Feet,
To the Content of the Wall in Rods.

Example.

Suppose a Wall upon the flat to contain 2178 superficial Feet: Then, the extent of the Compasses from 272 $\frac{1}{4}$, downwards to 1, will reach from 2178, downwards to 8. And so many Rods are contained in that Wall.

- I. *If a Brick-Wall be 90 Foot long, and 12 Foot high, how many Rod of Brick-work is contained therein?*

The Proportion is,

1. As 1, is to 12 Foot the *Height*,
So is 90 Foot the *Length*, to 1080 foot, the Content in Feet.

Then,

2. As $272\frac{1}{4}$ is to 1,
So is 1089 foot, the Content in Feet,
To almost 4, the number of Rods contained in that Wall.

1. Extend the Compasses from 1, to 12 (the height of the Wall.)
The same Extent will reach the same way, from 90 (the length of the Wall) to 1080.

Then,

2, Extend the Compasses from $272\frac{1}{4}$, downwards to 1. The same Extent will reach from 1080 downwards, to almost 4 Rod, and so much is contained in that Wall.

- II. *If a Wall or side of a House be 24 Foot long, and 37 Foot high, how many Rod of Work is contained in it?*

1. As 1 is to 24 foot the *Length*,
So is 37 foot the *Height*, to 888 foot, the Content in feet.

2. As $272\frac{1}{4}$, is to 1,
So is 888, to 3 Rod and a Quarter.

For,

1. Extend the Compasses from 1, to 24. The same Extent will reach from 37, to 888, the Content in feet.

2. Extend the Compasses from $272\frac{1}{4}$, downwards to 1. The same Extent will reach from 884, to 3, 25 parts, that is 3 Rod, and a Quarter, and so many Rod of Brick-work is contained in that Wall: And so let these two serve for Examples for the measuring of Brick-work.

But besides this way of measuring of their Brickwork by the Rod, there is another thing to be considered, *viz.* the Thickness of the Wall, for all Walls of the same length and height do not contain the same quantity of Rods, for the thicker the Wall is the more Rods will be contained therein, their Standard for thickness being one Brick and a half; so that if a Wall be thicker than one Brick and half, a Square Rod upon the Superficies of the Wall will contain above a Rod, and a Rod upon the Superficies of a Wall that is less than a Brick and a half thick, will contain

tain less than a Rod when it is reduced to the thickness of one Brick and half, as all Walls (of what thickness soever) must be; so that every Rod upon the Superficies of a Wall that is 3 Bricks thick, will contain 2 Rod, because 3 Bricks is twice as thick as a Brick and half. And now the manner how to reduce any Wall of what thickness soever I shall now come to shew, and this is the proportion.

As 3, is to the number of half Bricks that any Wall is in thickness,
So is the number of Feet contained on the superficies of that Wall,
To the number of Rods, contained in the Wall; it being reduced to one Brick and half thick.

III. *Suppose a Wall of 4 Bricks thick, should contain upon the Superficies thereof, 762 Foot, and you would know how many it would contain, if it were reduced to a Brick and half; say,*

As 3 is to 8, the number of Half-Bricks
So is 762, the superficial Feet on the out-side of the Wall,
To 2032, the number of Feet; it being reduced to the thickness of a Brick and half.

By the Line of Numbers.

Extend the Compasses from 3 to 8. The same Extent will reach from 762, to 2032, the Quantity of Feet contain'd in the Wall when it is reduced to the Thickness of one Brick and half.

IV. *If a Wall of 8 Bricks thick should contain upon the Superficies thereof 75 Foot, how many Foot would it contain when reduced to one Brick and half thick? Say,*

As 3, is to 16, the half Bricks in thickness,
So is 75, the Content on the Superficies of the Wall,
To 400 foot: And so many foot will it contain when reduced to Brick and half.

¶ And thus have you the manner of measuring of Brick-work, and also the way of reducing it from any thickness to the standard thickness of one Brick and half, and now, as to the rest, I will give you a Table by which you may know how many feet and inches in length will make a Rod of Brick-work at any height, from 1 foot high to 30 foot high.

The Use of the Table.

A Table shewing how much in length will make a Rod square of any Brick-wall, from a Foot high to 30 Foot high.

Feet.	Feet	Inch.
2	272	3
1	126	1
3	90	9
4	68	0
5	54	5
6	45	4
7	38	1
8	34	0
9	30	3
10	27	2
11	24	4
12	22	8
13	20	11
14	19	5
15	18	2
16	17	0
17	16	0
18	15	2
19	14	4
20	13	8
21	13	0
22	12	4
23	11	10
24	11	5
25	10	11
26	10	6
27	10	1
28	9	9
29	9	5
30	9	1

1. *If a Brick-wall be 7 Foot high, how much thereof in Length must go to make a Rod Square?*

Look in the first Column of the Table for 7 Foot, which is the height of the Wall, and right against 7 Foot you shall find 38 Foot and 1 Inch, and so much in Length will make a Rod.

Again, If a Wall be 26 Foot high, how much in length will make a square Rod?

Seek 26 in the first Column, and right against it in the second Column you shall find 10 Foot 6 Inches, and so much in length will make a square Rod.

And here Note, that this Table supposes the Wall to be Brick and half thick; if it be thicker or thinner it must be reduced as is before taught.

CHAP. V.

Of Solid Measure, and particularly of the Mensuration of Stone, Timber, &c.

Timber and Stone are most commonly measured by the Foot Solid, that is to say, 12 Inches in Length, and 12 Inches in Depth, and 12 Inches in Thickness, make a Foot Solid; so that a Foot of Solid Stone or Timber, contains 1728 solid inches; for 12 inches in length, and 12 inches in breadth, being multiplied together, produce 144 square inches, which is a foot of Board, and 12 times 144 produce 1728, which is a solid foot of Timber or Stone.

Now for the mensuration of these Solids, there is no Instrument comparable to the *Line of Numbers*, both for speed and exactness: So that measuring the length, breadth and depth of any piece of Stone and Timber by a Foot Rule divided into 100 Parts, the Content or Quantity may be obtained by the Precepts following; of which I shall treat

I. *Of squared Timber or Stone.*

By squared Timber or Stone, I mean such whose Sides are strait and parallel. As,

I. *If a Stone or piece of Timber, be 1 Foot 16 Parts broad, and 2 Foot 25 parts deep, and 16 Foot 50 parts long, how many solid Foot of Timber is there in that Piece?*

The Proportion is,

1. As 1, is to 1, 16 Parts the breadth,
So is 2, 25 Parts the depth, to 2 Foot 61 Parts, the superficial Content of the end of the Piece. Then

2. As 1, is to 2, 61 Parts, the Content at the end of the Piece,
So is 16, 50 Parts, the length of the Piece, to 43, 06 Parts,
The Content of the Piece in solid Feet.

By the Line of Numbers.

1. Extend the Compasses from 1, to 1, 16 the breadth: The same Extent will reach from 2, 25 the depth, to 2 Foot 61 Parts, the Quantity of the Piece at the end.

F

2. Extend

2. Extend the Compasses from 1 to 2, 61, the same Extent will reach from 16, 50 the length of the Piece, to 43, 06 the Content of the Piece, which is 43 foot, and 06 hundred parts of a foot, which parts are not to be regarded.

II. *If a piece of Timber or Stone, be 0, 75 Parts broad, and 1, 55 parts deep, and 20 Foot long, how much is therein contained?*

1. As 1, is to 0, 75 Parts,

So is 1, 55 parts, to 1, 16 parts the content at the end.

2. As 1, is to 1, 16 parts, the Content at the end,

So is 20 foot the length, to 23, 25 Parts, the solid Content.

By the Line of Numbers.

Extend the Compasses from 1, to 0, 75 downwards, (because 0, 75 parts is less than one foot). The same Extent will reach from 1, 55 (downwards also) to 1, 16, which is the Content of the end of the Piece. Then

2. Extend the Compasses from 1, to 1, 16. The same Extent will reach from 20, the length, to 23 foot, 25 parts, the solid Content of the Piece, which is 23 foot and one quarter of a foot.

III. *Let a Piece be 0, 25 parts broad, and 0, 62 parts deep, and 32 Foot long, how many Foot solid is contained therein?*

1. As 1, is to 0, 25 parts,

So is 0, 62 parts, to 155 parts.

2. As 1 is to 155 parts,

So is 32 the length, to 4, 96 parts the solid content.

By the Line of Numbers.

1. Extend the Compasses (downwards) from 1, to 0, 25 parts. The same Extent will reach (downwards also) from 0, 62 parts, to 155 parts. Then,

2. Extend the Compasses from 1, to 0, 155 parts, the same will reach from 32 foot, the length, to 4 foot 96 parts, which is almost 5 foot, and may be so called. And thus much for squared Stone or Timber.

¶ But before I proceed I must needs detect one grand and too common an Error; for most Artificers, when they meet with squared Timber whose breadth and depth are unequal, they usu-

usually add the breadth and depth together, and take the Half for a *mean Square*, and so proceed. This indeed, tho' it be always an Error, yet it is not so great when the difference of the breadth and depth is not much; but if the Difference be great, the Error is very obnoxious either to Buyer or Seller. I will instance in one Example?

IV. Let a Piece of Timber be 2 Foot 24 parts broad, and 1 Foot 30 parts deep, and 26 Foot long, how many Foot are contained therein.

First for the true Way.

1. As 1, is to 2, 24 parts the breadth,
So is 1, 30 parts the depth, to 2, 92 parts, the Content at the End:
2. As 1, is to 2, 92,
So is 26 the length, to 56, 07, the Content, which is
56 Foot, and about an Inch.

Now for the customary false Way.

The breadth of the Piece is	2, 24
The depth thereof is	1, 30
Their Sum is	3, 54
The half Sum is	1, 77

And this 1, 77 Parts they take for a true Square, which is egregiously false; For, now come to the *Line of Numbers*, and say,

1. As 1, is to 1, 77 parts, so is 1, 77 parts to 3, 13 parts.
2. As 1 is to 3, 13 parts, so is 26 the Length, to 81, 45 parts, that is, to 81 foot and almost half a foot; whereas, by the true Way, it contains but 56 foot, and 07 parts. The difference in this Piece being 25 foot, and above one third part of a foot, which is above half a Load of Timber; and Timber being at 50 s. or 3 l. per Load, here is 25 or 30 s. lost by the Buyer, and gained by the Seller; a considerable Fallacy, to buy *One Load*, and pay for above a *Load and a half*. But if People will be deceiv'd, let them be deceiv'd. And thus I shall conclude with squared Timber, equal at both Ends: Only I will first give you a Table shewing how much in length will make a solid Foot of Timber, the side of the Square at the end thereof being given in Feet and Inches, from 1 Inch square to 3 Foot, or 36 Inches the Square.

A Table shewing how much in length will make a Solid Foot of squared Timber, the side of the Square at the end thereof being known.

F. Inch F In. 10 p.				F. Inch F. In. 10 p.				F. Inch F. In. 10 p.			
The side of the Square.	O	0		The side of the Square	I	0	1	The side of the Square.	II	0	3
	1				1	0	18		1	0	2
	2				2	0	8		2	0	2
	3				3	0	7		3	0	2
	4				4	0	6		4	0	2
	5				5	0	5		5	0	2
	6	4	0		6	0	5		6	0	1
	7	2	11		7	0	4		7	0	1
	8	2	3		8	0	4		8	0	1
	9	1	9		9	0	3		9	0	1
	10	1	3		10	0	3		10	0	1
I	11	1	2	II	11	0	3	III	11	0	1
	0	1	0		0	0	3		0	0	1

The Use of the TABLE.

If your Timber or Stone have all the sides equal at the end, then find the length of one of them in this Table, and against that Number you shall have the length of a Foot. Thus, if the side of the Square be 1 foot 10 inches, look this Number in the Table, and right against it you shall find 3 inches and 5 tenth parts of an inch, which is half an inch; which shews that 3 inches and an half in length, will make a Foot Solid of that piece of Timber.

But if the sides of the Square at the end of the Piece be unequal, that is to say one longer than another, you may find the true Square by help of your Line of Numbers thus. Divide the Distance upon the Line between the two unequal Sides, into two equal Parts, and the Compasses shall rest upon the true Square, and with that Number you must enter the Table.

CHAP. VI.

Of un-equal sided (but squared) Timber or Stone.

THose pieces of Timber or Stone, whose sides are neither equal nor parallel (only the two ends are suppos'd parallel,) I call *un-equal sided squared Stone or Timber*, which is bigger at one end than at the other, and in this form do most *Timber-Trees* grow, and being fell'd, are so hewn and brought to *Square*.

The usual way to measure such Timber is to take a Square about the middle of the Piece, and not at either end, and this middle they take for a *mean Square*, and work with it as if the Piece would bear the *Square* throughout; but in this there is a great Error, for the Content of the Piece thus found, will be ever less than the Truth, as the former Error made the Piece more.

But to pass by this (too customary way) I will here deliver the Geometrical true way, which is demonstrable. And that is this.

1. Find the Content of the Piece at both Ends, and multiply the one Area or Content by the other. 2. Out of this Product of the two Area's extract the Square Root. 3. Add this Root, and the two Areas of the two Bases all three into one Sum. 4. Multiply this Sum by one third part of the length of the Piece, and that Product shall give you the Content thereof in solid Feet.

Examples.

1. There is a piece of Timber, whose breadth at the greater end is 1 Foot and 75 parts, and its depth 1, 32. The breadth at the little end is 1, 2 Parts, and the depth 0, 91 Parts. And the length thereof is 12 Foot, 60 parts how many Solid Feet are contained in this Piece?

By the Line of Numbers.

- | | |
|---------------------------------------|---------------------------------------|
| 1. As 1 is to 1, 32 parts, the depth, | } Of the greater
end of the Piece. |
| So is 1, 75 parts, the breadth, | |
| To 2, 31 parts, the Content, or Area | |

2. As 1, is to 0,91 parts, the *depth*,
 So is 1, 20 parts, the *breadth*,
 To 1, 09 parts, the *Area* or *Content* } Of the lesser end
 of the Piece.

3. As 1, is to 2,31 parts, the *Area of the greater end*,
 So is 1, 09 parts, the *Area of the lesser end*,
 To 9, 522 the *Product* of the two *Areas*.

4. To find the square Root of this Number, you must divide the space between 2, 522 the *Product*, and 1, upon your *Line of Numbers*, and the *Compass's* point will rest upon 1, 588.

4. Add this Root 1, 588, and

The *Product* of the $\left\{ \begin{array}{l} 1, 092 \\ 2, 310 \end{array} \right\}$ two Ends together;

The Sum is, 4, 998. Then say,

5. As 1, is to 4, 2 parts, the *third part of the length of the Piece*,
 So is 4, 99 parts, the *Sum* before found,
 To 20, 95 parts, the *solid Content of the Piece*.

The Operation.

1. Extend the *Compasses* from 1, to 1,32. The same will reach from 1, 75 to 2, 31, the *Area of the greater End*.

2. Extend the *Compasses* from 1, downwards to 0, 91, the same will reach downwards from 1, 20 to 1, 09, the *Area of the lesser End*.

3. Extend the *Compasses* from 1, to 2, 31, the *greater Area*. The same Extent will reach from 1, 09, the *lesser Area*, to 2, 522.

4. Divide the Distance between 1, and 2, 522 upon the *Line*, into two equal parts, and the *Compass's* point will rest upon 1, 588, the *square Root*; which added to

The two *Products* $\left\{ \begin{array}{l} 1, 092 \\ 2, 310 \end{array} \right\}$

The Sum will be 4, 998

5. Extend the *Compasses* from 1, to 4, 20 parts, the *third part of the length of the Piece*. The same Extent shall reach from 4, 99 the *Sum*, to 20, 95 the *Content of the Piece*. So that this Piece of Timber contains 20 Foot 3 quarters, and 20 hundred parts of a Foot.

III. If a piece of tapering Timber being exactly square at each end, the side of the greater End being 1 Foot 50 parts, and the side of the lesser End 0, 5 parts, and the length 30 Foot, how many solid Foot in that piece of Timber?

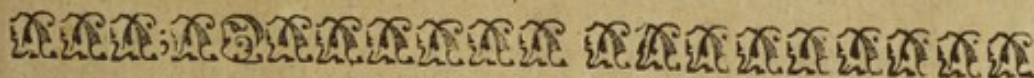
In this Example I will only set down the Proportion, and leave the Practice to the Reader.

1. As 1, is to 0, 5 parts,
So is 0, 5 parts, to 0, 25 parts, *the Area of the lesser End.*
2. As 1, is to 1, 5 parts,
So is 1, 5 parts to 2, 25, *the Area of the greater End.*
3. As 1, is to 0, 25 parts,
So is 2, 25 to 5625 parts.

. 75 2. 25 . 25 3. 25	The half Distance between 5625, and 1, is 75, the square Root of 5625, which added to the <i>Area</i> of the two Ends, viz. To 2, 25 and 0, 25 make 3, 25, as in the Margin. Then
--	---

4. As 1, is to 3, 25, the Sum before found,
So is 10, *one third part of the Length,*
To 32, 50, the *solid Content of the Piece;*
That is, 32 Foot and an half.

And so let these Examples suffice in the measuring tapering Timber.



C H A P. VII.

Of the mensuration of round Timber.

AS there are grand customary Errors continually committed in the mensuration of unequal-sided and in tapering Timber, so there is one also in the measuring of round Timber, which transcendeth them all; and that is this: In Timber-Trees they usually girt the Tree about the middle of the Trunk thereof, with a Line, and take one fourth Part of that Girt for the side of a Square, and with this they find the Content of the Tree, as if it were a Square, whose side is equal to a fourth part of that Girt; but this is egregiously false, for it always gives the Content of the Tree to be near,

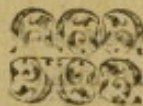
near, and most commonly above one fifth part less than the true Content. But for the maintaining of this ill Custom they plead,

The *Overplus Measure* may well be allow'd, because the *Chips* cut off, are of little Value, and will not near countervail the Labour of bringing the Timber to a Square, to which Form it must be brought before it be fit for Use.

To this I answer, that altho' the Chips in small Timber-sticks be but of small Value, yet in great Trees there be large *Slabs*, and so the Labour of hewing is not lost and only the Chips allowed; but notwithstanding I do not say, that Timber standing ought to be measured falsely, but truly, and if any allowance be to be made, let it be in the *Price*, and not in the *Quantity*; and as the *Quantity* will be one fifth part more than in reality it is, so a fifth part might rather be abated in the *Price*. Besides this, if Timber be thus measured and bought when it is round, I say, that a Tree, when it is hewed, and brought to such a Square as Timber is usually brought to, and measured as it then is hewed, that Timber-thick shall then hold out more Measure than when it was bought round.

Divers other Errors in the mensuration of solid Bodies have crept in for lack of Art, and the Ignorant being possessed thereof do plead Prescription and Custom, whereas Custom cannot establish a Law upon a bad Foundation and false Ground, neither can Error prevail against Truth, nor Ignorance convince Reason supported by Art upon Demonstration: But leaving these and them (who are wedded) to their ill Customs, I will proceed to shew the true and exact way of measuring of round Timber.

As in squared Timber the Ends thereof were either *equal* or *unequal*, that is, greater at one End than at the other, and so were parts of Pyramids: So in round Timber either the Circles at both Ends of the Piece are either *equal*, and so are *Cylinders*, or else are *unequal*, and so are *defected Cones*. And how to measure either of them I shall now shew, beginning with



CHAP. VIII.

Of Round Timber whose Ends are Equal.

BEfore Round Timber can be measured, the *Area*, or *Content* of the Circle or Circles at the Ends thereof must first be found; Wherefore, before I come to measure Round Timber I must add these necessary *Problems* concerning the *Circle*.

I. *The Circumference of a Circle being given, to find the length of the Diameter.*

Let the *Circumference* be 3 foot 25 parts, and let the *Diameter* be required.

As 22, is to 7,

So is the *Circumference* 3, 25

To 1, 03 parts, the length of the *Diameter*.

By the Line of Numbers.

Extend the Compasses from 22 downwards, to 7. The same Extent will reach from 3, 25 parts downwards, to 1, 03 the length of the *Diameter*.

II. *The Diameter being given, to find the Circumference, let the Diameter be 2, 50 parts and the Circumference required.*

As 7, is to 22,

So is 2, 50 the *Diameter*, to 7, 85 parts the *Circumference*.

By the Line of Numbers.

Extend the Compasses from 7, to 22, the same will reach from 2, 50 parts, to 7, 85 parts for the *Circumference*.

III. *The Diameter of a Circle being given, to find the Area or Content thereof.*

Let the Diameter of a Circle be 2, 5 parts, and let it be requir'd to find the Area.

As 28, is to 22,
So is 6, 25 (which is the Square of the Diameter)
To 4, 91, the Area of the Circle.

By the Line of Numbers.

1. Take in your Compasses the Distance from 1, to the 2, 5 parts, the Diameter given, and turn the Compasses about upon that Point, so shall the other Point fall upon 6, 25 parts, which is the Square of the Diameter 2, 5.

2. Extend the Compasses from 28 downwards to 22. The same Extent will reach from 6, 25 the Square, to 4, 91 parts, the Area or Content of the Circle.

IV. *The Circumference of a Circle being given, to find the Area.*

Let the Circumference of the given Circle be 7, 85 parts, and let the Area be required.

As 88, is to 7,
So is 61, 62 parts (the Square of the Circumference)
To 4, 91 parts, the Area, as before.

By the Line of Numbers.

1. Take the Distance from 1 (downwards) to 7, 85, the Circumference given, and upon that Point turn the Compasses downwards, so will the Compass Point rest upon 61, 62 parts.

2. Extend the Compasses from 88 downwards to 7, the same will reach from 61, 62 parts the Square of the Circumference) to 4, 91 Parts, the Area or Content of the Circle.

But

But now, before I shew how to measure tapering Timber, I will, (as in the rest before) give you a Table by which, having the Girt of any Timber-Tree in Inches, you may know how much in Length thereof will make a Solid Foot.

In. 10 p.			In. 10 p.			In. 10 p.		
12	150	8	42	12	3	72	4	2
13	128	5	43	11	7	73	4	1
14	110	8	44	11	2	74	3	9
15	94	3	45	10	7	75	3	8
16	84	8	46	10	3	76	3	7
17	75	1	47	9	8	77	3	6
18	67	0	48	9	6	78	3	6
19	60	1	49	9	2	79	3	5
20	54	3	50	8	7	80	3	4
21	49	2	51	8	0	81	3	3
22	48	9	52	7	3	82	3	2
23	40	9	53	7	7	83	3	2
24	37	7	54	7	4	84	3	1
25	34	7	55	7	1	85	3	0
26	32	1	56	6	9	86	2	9
27	29	8	57	6	7	87	2	9
28	27	7	58	6	5	88	2	8
29	25	8	59	6	2	89	2	7
30	24	1	60	6	0	90	2	7
31	22	6	61	5	6	91	2	6
32	21	2	62	5	5	92	2	6
33	19	9	63	5	5	93	2	5
34	18	8	64	5	3	94	2	4
35	17	7	65	5	1	95	2	4
36	16	7	66	4	9	96	2	3
37	15	9	67	4	8	97	2	3
38	15	4	68	4	7	98	2	2
39	14	3	69	4	6	99	2	2
40	13	6	70	4	4	100	2	2
41	12	9	71	4	3			

The Use of the Table.

Find the Girt or Compass of the Tree in Inches in the Column of Inches, and right against it you shall find how many Inches and 10th parts of Inches will go to make a Foot Solid.

Example. If a Tree be 57 Inches about, look for 57 Inches in the Column of Inches, and against it you shall find 6 Inches and 7 10th parts of an Inch, which is almost three quarters of an Inch, and so much in Length will make a Foot Solid.

CHAP. IX.

Of Round Timber whose Ends are unequal.

- I. *A round Piece of Timber, whose Girt or Circumference is 7 Foot 85 Parts, and 15 Foot Long, how many Solid Foot is therein contained.*

BY the last Problem before-going, you found the Area of a Circle, whose Circumference was (as this is) 7,85 parts, to be 4,91, that is 4 Foot 91 parts of a Foot. Now the length of the Tree or Piece being 15 Foot, say,

As 1, is to 4,91 (the Area at the end)
So is 15 the length, to 73,65 parts the Solid Content.

By the Line of Numbers.

Extend the Compasses from 1, to 4,91, the Area at the End. The same will reach from 15 (the length of the Piece) to 73 foot 65 parts, which is half a foot, and 15 hundred parts of a foot.

- II. *A piece of round tapering Timber, the Circumference (or Girt) at the greater end is 7,85 parts, as in the last, and the Girt at the lesser end 5,5, and the Piece is 18 foot long, how many Solid Feet is contained in this Piece?*

1. By the 4th before going, find the Area at either End, so shall you find the Area of the greater End to be 4,91, and of the lesser, 2,27. Then say,

1. As 1, is to 2,27 parts, the Area of the lesser End,
So is 4,91 parts, the Area of the greater End,
To 11,14 parts, the Product of the two Areas.

By the Line of Numbers.

1. Extend the Compasses from 1, to 2,27. The same Extent will reach from 4,91, to 11,14, which is the Product of the Areas of the two Ends.

2. Divide the space between 1, and 11,14 upon the Line, into two equal parts, and the Compasses will fall upon 3,40, which is the Square Root of the Product of the two Areas: Add this Root and the Area of the two Ends, all three into one Sum as is done in the Margin, which Sum will be 10,58, and then,

$$\begin{array}{r} 2, 27 \\ 3, 40 \\ \hline 4, 91 \\ \hline 10, 58 \end{array}$$

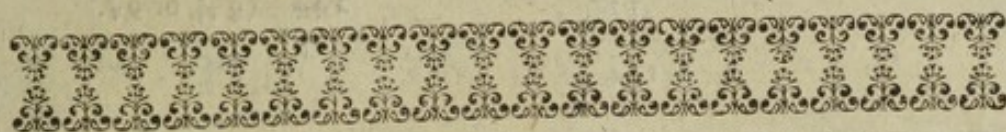
As 1, is to 6 (which is one third part of the Length)
So is 10,58 parts, to 63,84, the Solid Content.

Therefore

Therefore

Extend the Compasses from 1. to 6. the same Extent shall reach from 10. 58 Parts, to 63. 48 Parts the *Solid Content* of the Piece; so that this Piece of *Tapering round Timber* doth contain 63 *Foot* and an half, wanting only two hundred Parts, which is not to be mention'd; and let this suffice for the Mensuration of Solids.

I might make a farther Progress herein, as to shew the manner how to measure Prisms, Pyramids, Cones and Frustums of either of these, whether upright or schalene, as also of Regular Bodies, with divers other Curiosities in Solid Geometry; but this Book was not intended for Curiosity, but Profit, and therefore I have inserted only such as are pertinent to my intended Design.



CONCLUSION.

IN this *Book* throughout, before I shew how to work upon the *Line of Numbers*, I do lay down the *Analogy* or *Proportion* by which the *Problem* is to be wrought; by which (if you have not a Rule with the Line of Numbers upon it, or want Compasses) you may work the same with the Pen, arithmetically, for the Proportions are no other than Questions stated in the *Golden Rule*, as thus:

If a Board be 1 Foot 25 Parts broad, and 16 Foot 5 Parts long, how many Square Foot are contained in this Board?

As 1. is to 1. 25, So is 16. 5, to what?

. 1. 25

825

330

165

The Answer will be 20 | 625. Which is 20 Foot, 62 Parts, which is half a Foot, and half a quarter of a Foot.

For if you multiply the second Number by the third, *viz.* 16. 5 by 1. 25, the Product will be 20. 625, which should be divided by the first Number; but being it is an Unite, it neither multiplies nor divides, and therefore the Number 20. 625 is the Number that answers the Question, and is the Content of the Board, *viz.* 20 Foot and an half, and half a quarter. Again,

Take another Example.

If a Board that is 12 Inches broad doth require 12 Inches in length to make a Foot Square, how much in length will make a Square Foot when the Board is 1 Foot and 3 Inches broad?

Set the Numbers thus:

broad	long	broad
If 12 In. require	12 In. what shall	15 In. require?
	12	
	24	
	12	
	144	
		5(9
		144 (9 $\frac{2}{3}$, or 9 $\frac{2}{3}$.
		18

This Question is resolved by *reciprocal Proportion*, or the *backer Rule of Three*, which is easily discover'd; for 15 Inches being more than 12, it must needs require less length than 12 Inches to make a Foot; wherefore multiply the first and second Terms together, *viz.* 12 by 12, they produce 144, which divide by 15 the breadth given (the third Number in the Proportion) the Quotient will be 9 and $\frac{2}{3}$, or $\frac{2}{3}$ of an Inch; so that 9 Inches and $\frac{2}{3}$ will make a Foot Square.

In like manner, If a Board or Pane of Glass, or the like, be 18 Inches broad, then 8 in length will make a Foot, as appears by the Work following.

If 12 require 12, what 18?

12	
24	
12	6
144	144 (8 In.
	18

Now you are to take Notice, That all the *Examples* in this *Book*, suppose the *Foot* or *Yard* to be divided into 10 or 100 Parts, which is called *Decimal Division*; so all the *Proportions* are laid down in *Decimal Numbers*, and must be wrought by *Decimal Arithmetick*, concerning which there is ample Satisfaction to be had in my *Book* treating both of *Vulgar*, *Decimal*, and *Instrumental ARITHMETICK*.

The End of the Seventh Book.



The COMPLEAT
SURVEYOR.

The Eighth Book.

The ARGUMENT.



FOR farther Illustration of the Table of Sines and Tangents in the Third Book, and also of the proportional Lines upon the Index of your Table mention'd in the Second Book, I have in this Eighth Book applied them to the making of Sun-Dials, as a thing I conceive both useful and necessary, as well for a Surveyor, as other Persons, who may have occasion for the same. But I intend not here to make an entire Treatise of the whole Art of DIALLING, (having lately done that already, both Arithmetically,

tically, Geometrically, and Instrumentally, in a particular Treatise lately by me published) but to shew you the Use of the foremention'd Tables and Lines in the Calculation of the Requisites and Hour-Distances for all manner of Horizontal and upright Dials, whether direct or declining, and that in any Latitude or Part of the World. Which upright and Horizontal Dials, of all others, are the most useful and necessary, they serving not only for the making of some one single Dial, but to adorn and furnish divers Regular or Polyhedronick Bodies cut in Wood or Stone, which the Precepts in this following Book will be a sufficient Tutor to direct unto; omitting to say any thing concerning Reclining and Inclining Dials, which do decline, and that for the Reason before given. To this Book I have added also (for the Satisfaction of such as delight therein) several other Ways, Rules and Tables, to find the Hour of the Night by the Moon and Stars, as well as by the Sun in the Day-time: And with these, and some other things of the like Nature, I do conclude this Eighth Book.





O F
D I A L L I N G.

C H A P. I.



BEFORE I come to shew how the Hour-Lines are to be described upon any Dial-Plain, it will be requisite to know first, how such Plain, upon which you intend to describe or draw a Dial, is situate in respect of the four Cardinal Points of the *World* (or rather of your particular *Horizon*) that is, whether the Dial-Plain do directly behold either the East, West, North or South Points, or not; for if they do behold either of the forementioned Points, they are called direct East, West, North or South Dials; but if they do not behold any of these Points directly, they are then said to decline. So a Dial-Plain lying between the $\left\{ \begin{smallmatrix} \text{South} \\ \text{North} \end{smallmatrix} \right\}$ Points and the East, is said to be a $\left\{ \begin{smallmatrix} \text{South} \\ \text{North} \end{smallmatrix} \right\}$ Plain declining Eastward, so many Degrees as the Plain leaneth from the East or West. Also a Dial-Plain lying between the $\left\{ \begin{smallmatrix} \text{South} \\ \text{North} \end{smallmatrix} \right\}$ Points and the West, is denominated to be a $\left\{ \begin{smallmatrix} \text{South} \\ \text{North} \end{smallmatrix} \right\}$ Plain declining Westward, so many Degrees as the Plain deviates from the West or East. Now to find the true Situation of any Plain, there are several ways. The most easy and common way is by the magnetical Needle, such as is in the Box of your Plain Table. For if you apply the side of

your Box to the Dial-Plain, holding it level, the Needle will shew you how many Degrees the Plain deviates or declines from the true North, South, East or West Points. This is so plain, that an Example to be given thereof were needless: and besides, the way itself is uncertain, in regard the Needle hath some Variation, and so points not at all times to the true North Point; and therefore is not to be used but in case of Necessity, when you cannot have the Benefit of the Sun's shining.

The best and most absolute way to attain this Declination therefore is by the Sun; for by finding of the Sun's *Azimuth* at any time, the Declination of any Wall may be attained. And therefore I shall first shew you how to find the Sun's *Azimuth* at any time when the Sun shineth, and that two several ways: *viz.* one Geometrically, by help of your Line of Chords; the other Arithmetically, by help of the Table of Sines. And because the Sun's Declination is requisite to be known before you can compute the *Azimuth*, I have here added a Table shewing the Sun's Declination for every Day in the Year; and following the same, another Table shewing the Latitude of all the principal Cities and Towns in *England, Scotland* and *Ireland*, alphabetically disposed; so that when you are required to make a Dial in any of these Kingdoms, you need not be to seek for the Latitude of your Place wheresoever you be.



A Table

A Table shewing the Sun's Declination for every Day of the Year, serving for the more ready finding of the Sun's Azimuth.

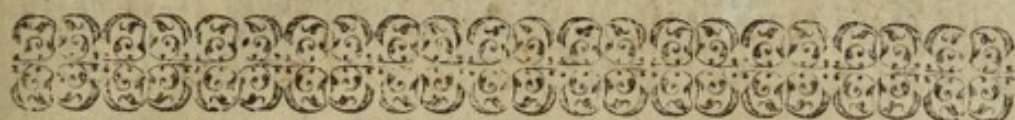
A Table of the Sun's Declination.

Days.	Janu.	Febr.	March.	April	May	June	July	Aug.	Sept.	Octo.	Nov.	Dec.
d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.
1	21 44	13 46	3 24	8 36	18 5	23 12	22 8	15 12	4 24	7 15	17 40	23 9
2	21 33	13 26	3 0	8 58	18 20	23 16	22 0	14 54	4 2	7 38	17 56	23 13
3	21 23	13 5	2 37	9 20	18 35	23 19	21 51	14 36	3 38	8 0	18 12	23 17
4	21 13	12 45	2 13	9 42	18 50	23 22	21 42	14 17	3 15	8 22	18 28	23 20
5	21 2	12 25	1 49	10 3	19 4	23 25	21 32	13 58	2 52	8 45	18 45	23 23
6	20 50	12 4	1 25	10 24	19 18	23 27	21 22	13 39	2 29	9 7	18 58	23 26
7	20 38	11 43	1 10	10 45	19 31	23 29	21 12	13 20	2 5	9 29	19 13	23 28
8	20 26	11 21	0 38	11 0	19 44	23 30	21 2	13 1	42	9 51	19 27	23 30
9	20 13	11 0	0 14	11 27	19 57	23 31	20 51	12 41	1 19	10 13	19 41	23 31
10	20 0	10 38	0 10	11 47	20 10	23 32	20 40	12 21	0 55	10 35	19 55	23 31
11	19 46	10 16	0 33	12 7	20 22	23 31	20 28	12 10	0 32	10 56	20 8	23 31
12	19 32	9 54	0 57	12 28	20 34	23 31	20 16	11 41	0 8	11 18	20 21	23 31
13	19 18	9 32	1 21	12 48	20 45	23 30	20 4	11 21	0 16	11 39	20 34	23 29
14	19 3	9 10	1 44	13 7	20 56	23 29	19 51	11 0	39	12 0	20 46	23 27
15	18 48	8 48	2 8	13 27	21 7	23 28	19 38	10 39	1 3	12 21	20 58	23 25
16	18 33	8 25	2 31	13 46	21 17	23 26	19 25	10 18	1 26	12 41	21 9	23 22
17	18 17	8 3	2 54	14 5	21 27	23 19	12 9	9 57	1 50	13 2	21 20	23 19
18	18 2	7 40	3 18	14 24	21 37	23 10	18 58	9 36	2 13	13 22	21 31	23 16
19	17 45	7 17	3 41	14 42	21 46	23 17	18 43	9 15	2 37	13 42	21 41	23 12
20	17 28	6 54	4 5	15 1	21 55	23 14	18 29	8 53	3 0	14 2	21 50	23 7
21	17 11	6 31	4 28	15 19	22 4	23 10	18 14	8 31	3 23	14 21	22 0	23 2
22	16 54	6 8	4 51	15 37	22 12	23 6	17 59	8 9	3 47	14 41	22 9	23 57
23	16 36	5 45	5 14	15 54	22 20	23 1	17 44	7 47	4 10	15 0	22 17	22 51
24	16 18	5 21	5 37	16 12	22 27	23 5	17 28	7 25	4 33	15 19	22 15	22 44
25	16 0	4 58	6 0	16 29	22 34	23 10	17 12	7 3	4 57	15 37	22 33	22 37
26	15 42	4 34	6 22	16 46	22 41	23 14	16 56	6 41	5 20	15 55	22 40	22 30
27	15 23	4 11	6 45	17 2	22 47	23 17	16 39	6 18	5 43	16 13	22 46	22 22
28	15 4	3 47	7 7	17 18	22 53	23 16	22 31	5 56	6 16	16 31	22 52	22 14
29	14 45		7 30	17 34	22 58	23 16	22 6	5 33	6 29	16 49	22 58	22 5
30	14 26		7 52	17 50	23 3	23 16	15 48	5 10	6 52	17 6	23 4	22 56
31	14 6		8 14		23 8	23 15	30 4	4 47		17 23		21

A Table

A Table of the Names and Latitudes of the Principal Cities, Towns, and Islands in and about Great Britain and Ireland.

ENGLAND.			D.	M.				D.	M.
B	Edford		52	8	Flint			53	17
	Berwick		55	54	Landaffe			51	35
Bristol			51	27	Monmouth			51	51
Buckingham			52	0	Montgomery			51	56
Cambridge			52	12	Pembroke			51	46
Canterbury			51	17	Radnor			52	19
Carlisle			55	0	St. Davids			52	0
Chichester			50	48	ISLANDS.			D.	M.
Chester			53	16	G	Armfey		49	30
Colchester			51	58		Jerfey		49	12
Derby			52	58	Lundy			51	22
Dorchester			50	40	Man			54	24
Durham			54	50	Portland			50	30
Excester			50	43	Wight			50	39
Gilford			51	12	SCOTLAND.			D.	M.
Glocester			51	53	A	Berdeem		57	32
Hartford			41	49		Dumblain		26	21
Hereford			52	7	Dunkel			56	48
Huntington			52	19	Edenburgh			55	56
Ipswich			52	8	Glasgow			55	52
Kendal			54	23	Kinfaile			57	44
Lancaster			54	10	Orkney			60	6
Leicester			52	40	St. Andrews			56	39
Lincoln			53	14	Skyrasslin			58	36
London			51	32	Sterling			56	12
Northampton			52	14	IRELAND.			D.	M.
Norwich			52	42	A	Ntrim		54	38
Nottingham			53	0		Arglas		54	10
Oxford			51	46	Armagh			54	14
Reading			51	28	Caterlaugh			52	41
Salisbury			51	4	Clare			52	34
Shrewsbury			52	47	Cork			51	53
Stafford			52	52	Droghedagh			53	38
Stamford			52	38	Dublin			53	13
Truro			50	30	Dundalk			53	52
Warwick			52	20	Galloway			53	2
Winchester			51	3	Youghall			51	53
Worcester			52	14	Kenny			52	27
York			53	58	Kildare			53	0
WALES.			D.	M.	Kings Town			53	0
A	Nglefey		53	28	Knockfergus			54	37
	Barmonth		52	50	Kingfale			51	41
Brecnock			52	1	Limerick			52	30
Cardigan			52	12	Queens Town			52	52
Carmarthen			51	26	Waterford			52	9
Carnarvan			53	16	Wexford			52	18
Denbigh			53	13					



C H A P. II.

To find the Sun's Azimuth Geometrically.

HAVING the Latitude of your Place, and the Declination of the Sun; and the Sun's Altitude given, you may find the Sun's *Azimuth*. So the Latitude of the Place being 51 deg. 30 min. the Declination of the Sun 17 deg. 56 min. North, and the Sun's Altitude 35 deg. the *Azimuth* may be found Geometrically as followeth.

First, Describe with 60 deg. of your Line of Chords the Semi-circle A D C, and upon B, the Centre, erect the Perpendicular B D.

Secondly, Take 51 deg. 30 min. the Latitude of the Place, out of your Line of Chords, set it from D to E, and draw the Line E B, representing the Equinoctial Circle.

Thirdly, Out of your Line of Chords take 17 deg. 56 min. the Sun's Declination, and because it is Northward, set that Distance upwards from E to F, (but if the Declination had been Southward, you must have set it downwards from E to R) and draw the Line F G parallel to B E, which represents the Sun's Parallel for that time.

Fourthly, From your Line of Chords take 35 deg. the Sun's Altitude, and set it from A to H, and from C to L, and draw the Line H K L for the Line of the Sun's Altitude.

Fifthly, Take in your Compasses the Length of the Line K L, or K H, and with that Distance upon the Centre B describe the Semi-circle M P N.

Sixthly, Upon the Point O (which is where the Parallel of Declination and the Parallel of the Sun's Declination intersect each other) erect the Perpendicular O P.

Seventhly, Lay a Ruler from B to P, and it will cut the Circle in Q, and draw the Line P Q.

Lastly, Take the Distance from C to Q, and measuring it upon your Line of Chords, you shall find it to contain 74 deg. and so much is the Sun's *Azimuth* or his Distance from the South part of the Meridian at the time of Observation.





C H A P. III.

*To find the Sun's Azimuth Arithmetically
by the Table of Sines.*

LET the Latitude, Declination and Altitude, be as before, *viz.*

	d.	m.		d.	m.
Latitude-----	51	30	} Complement	38	30
Declination 17	56			72	04
Altitude ----	35	00		55	00

Their Sum ----- 165 34

Half Sum --- 82 47

The Difference between the half Sum
and the Complement of the Sun's
Declination --- --- --- 10 43

First, You must add the Complement of the Latitude, the Complement of the Declination, and the Complement of the Sun's Altitude, all three into one Sum, and they make 165 deg. 34 min. the half whereof is 82 deg. 46 min. and the Difference between this half Sum 82 deg. 46 min. and 72 deg. 4 min. the Complement of the Sun's Declination is 10 deg. 43 min.

Being thus prepared, the Proportion to find the Sun's *Azimuth* by the Table of Sines will be as followeth :

* (1.) As the Radius or Sine of 90 deg. --- --- --- 10 000000

is to the Sine Complement of the Altitude 55 d. 9 913364

So is the Sine Complement of the Latitude 38 d. 30 m. 9 794149

to the Sine of 30 deg. 40 min. --- --- --- 19 707513

(2.) As the Sine of 30 deg. 40 min. --- --- --- 9 707513

is to the Sine of the half Sum 82 deg. 47 min. --- 9 996594

So is the Sine of the Difference 10 deg. 43 min. --- 9 267395

19 263989

to this Sine --- --- --- 9 556476

To which add the Radius or the Sine of 90 deg. 10 000000

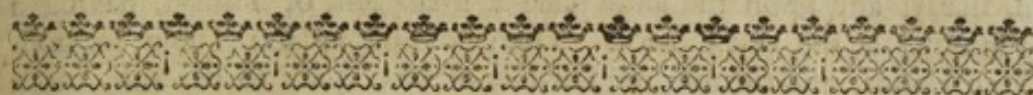
The Sum is --- 19 556476

Half this Sum is --- 9 778238

* By observing these two Analogies you may find the *Azimuth* by the Line of Sines on the Index of your Tables.

Which

Which is the Sine of 37 deg. neareſt, the double whereof is 74 deg. for the *Azimuth* from the South Part of the Meridian. And according to either of theſe ways you may find the Sun's *Azimuth* at any Time of the Day, and in any Part of the World. And now I ſhall ſhew you how by the help hereof.



C H A P. IV.

To find the Declination of any Wall or Plain.

THE Declination of a Plain is an Arch of the Horizon intercepted between the North or South Points of the Horizon, and a Line drawn perpendicular to the Plain upon which the Dial is to be made.

Or, it is that Arch of the Horizon which is comprehended between the Plain itſelf, and the Eaſt or Weſt Points of the Horizon.

To attain to the Quantity of this Declination, two Obſervations (the Sun ſhining) muſt be made, and both of them at the ſame Moment of Time, as near as may be. The one is the Horizontal Diſtance of the Sun from that Line which is perpendicular to the Plain: The ſecond is of the Sun's Altitude, whereby the Sun's *Azimuth* muſt be found, according as is taught in either of the two foregoing Sections.

I. *To find the Horizontal Diſtance.*

This ought to be performed by a Semicircle or Quadrant; but the Degrees upon the Frame of the Table will perform that Work, where better Helps are wanting.

Apply therefore that ſide of your Table which is next the Centre to the Wall on which you are to make your Dial, holding the Table as levell as you can; then hold a Thread and Plummert in your Hand, by the ſide of the Table, till the ſhadow of the Thread do directly paſs through the Centre of the Degrees of the Table; and then look how many Degrees and Parts of a Degree are cut by the ſhadow of a Thread, counting thoſe Degrees from 90, at the middle of the Table, either towards the Right or Left Hand; for the Number of thoſe Degrees is the Horizontal Diſtance ſought for, which ſet down, or keep in Memory.

II. To find the Sun's Altitude.

This is best performed by a Quadrant also; but where that is wanting, the Table will supply that Defect in this manner:

Stick a Pin up in the Centre of the Degrees of the Table perpendicularly, and upon the same hang a small Silk or Thread, having a Plummert at the end thereof. Then holding up the Table in both your Hands, and turning the left-side of your Body to the Sun, move the Table either upwards or downwards (as occasion shall offer) till the shadow of the Pin doth cast itself along a Line drawn through the Centre of the Table to the beginning of the Degrees, and so that the Thread and Plummert may hang at free liberty; so shall the Degrees that the Thread cutteth upon the Frame of the Table, counted from 90 deg. be the Degrees of the Sun's Altitude, which also keep or set down in writing. And here note, That you must take this Horizontal Distance and Altitude both of them as soon one after the other as possibly may be.

III. To find the Plain's Declination.

The *Horizontal Distance* and *Altitude* thus observed, will help you to the *Plain's Declination* by the *Rules* following: For,

By having the Sun's Altitude and the Sun's Declination for the Day (by the foregoing Table) you may find the Sun's *Azimuth*, as hath been taught in the former Sections. Then by comparing the Sun's *Azimuth* and the Horizontal Distance together, you may come to the *Plain's Declination*, thus;

When you make your Observation of the Sun's Horizontal Distance, mark whether the shadow of the Thread fall between the *South Point*, and 90 deg. of the Table. For,

1. If the shadow fall between them, the Sun's *Azimuth* and the Sun's *Horizontal Distance* added together shall be equal to the *Plain's Declination*: And in this case the Declination is toward the same Coast upon which the Sun then is; that is to say, Eastward if the Sun be East of the Meridian, or Westward if the Sun be West of the Meridian.

2. If the shadow of the Thread fall not between 90 deg. of the Table and the South Point, then the Difference between the Horizontal Distance and the *Azimuth* is the Plain's Declination. And if the *Azimuth* be the greater of the two, then the Declination is towards the same Coast whereon the Sun then is. But if the Horizontal Distance be the greater, then the Declination is towards the contrary Coast to that whereon the Sun is.

And here you are to note, That the Declination thus found is always accounted from the South, and that all Declinations are counted

counted from either North or South, towards either the East or the West, and must never exceed 90 deg. Therefore,

1. If the Declination do exceed 90 deg. you must subtract that Number from 180 deg. and the Remainder is the Plain's Declination from the North.

2. If the degrees of Declination do exceed 180, then the Excess above 180 deg. gives the Plain's Declination from the North, and towards that Coast which is contrary to the Coast whereon the Sun is.

Having now taught you to find the Situation of a Plain in any Part of the World, and at any Time of the Year or Day, (although about Noon-tide be very bad for this Work; therefore I would advise no Person to take the Declination of any Wall or Dial-Plain after Ten of the Clock in the Forenoon, nor till after Two in the Afternoon, for fear of Errour; the Sun's Azimuth at that Time of the Day being swiftest, and the Increase of Altitude but very little) I shall now proceed to shew you how to describe Hour-Lines upon all the most usual sorts of Plains, upon which Dials are most generally made; and those are the Horizontal, the direct East, West, North and South Plains, whether direct or declining; and that both by the Tables of Sines and Tangents in the Third Book, and also by the Lines of Sines and Tangents upon the Index of your Table.

CHAP. V.

How to make an Horizontal Dial in any Latitude.

FOR the making of this Dial there is nothing required but the Latitude of the Place, which we will suppose to be *London*, in 51 deg. 30 min. of North Latitude.

The Arithmetical Calculation for this Dial.

1. *By the Tables of Sines and Tangents.*

The Latitude of the Place being known, 51 deg. 30 min. the Analogy or Proportion for finding of the true Hour-Distances upon the Plain will be this following, *viz.*

M

As

As the Radius or Sine of 90 deg.	----	----	----	10	00000
is to the Sine of the Latitude of the Place 51 d. 30 m.				9	89354
So is the Tangent of 15 deg. which is one Hour's	}	Distance in the Equinoctial	----	9	42805
				9	32159
to the Tangent of 11 deg. 50 min. which is the	}	true Distance of the Hour-Lines of 11 and 1 a	----	9	32159
Clock from 12					

And in this manner may all the rest of the Hour-Distances upon the Plain be found from 12 a Clock, by the continual Addition of 15 deg. for each Hour. So,

As the Sine of 90 deg.	----	10	00000
is to the Sine of 51 d. 30 m.	----	9	89354

So is the Tangent of	15 deg.---	9	42805	} The Equinoctial Distance of	{ 1 } Hours from the Meridian.
	30 -----	9	76143		
	45 -----	10	00000		
	60 -----	10	23856		
	75 -----	10	57914		

to the Tang. of	d. m.	11 50	9 32122	} The true Hour-Distance of the	{ 11 1 } of the Clock upon the Plain from the Meridian.
		24 20	9 65534		
		38 03	9 89359		
		53 35	10 13211		
		71 06	10 46549		

And according to this Analogy or Proportion all the Hour Distances upon the Plain from 12 a Clock are found, and may be put into such a Table as this following:

Hours from the Meridian.		True Hour-Distances upon the Plain.	
12		00 deg. 00 m.	
11	1	11	50
10	2	24	20
9	3	38	03
8	4	53	35
7	5	71	06
6		90	00

Now from this Table, by help of a Line of Chords, may the Hour-Lines be transferred to the Plain, as shall be shewed anon.

But first I will shew how the former Hour-Distances may be formed.

2. *By the Lines of Sines and Tangents upon the Index of your Table.*

The Hour-Distances by these Lines will be found more readily than by the Tables, and sufficiently exact. For this being

The ANALOGY.

As the Sine of 90

is to the Sine of the Latitude 51 deg. 30 min.

So is the Tangent of 15 deg. 30 deg. 45 deg. &c.

to the Tangent of 11 deg. 50 min. &c. as in the former Table.

Wherefore, if you extend the Compasses from the Sine of 90 deg. downwards to the Sine of the Latitude 51 deg. 30 min. the same Extent will reach from the Tangent of 15 deg. downwards to the Tangent of 11 deg. 50 min. the first Hour's Distance from 12, as in the Table.

Also (the Compasses not alter'd) will reach from the Tangent of 30 deg. downwards to the Tangent of 24 deg. 20 min. the second Hour's Distance, as in the Table. And so from 45 deg. to 38 deg. 3 min. and from 60 deg. to 53 deg. 35 min. and from 75 deg. to 71 deg. 6 min.

And thus with once opening of the Compasses you have found all the Hour-Distances belonging to this Plain.

And in the same manner as you do find the whole Hour's Distances, by the same way may you find the Distances of the Halves and Quarters, by allowing 3 deg. 45 min. for one Quarter of an Hour in the Equinoctial, 7 deg. 30 min. for half an Hour, 11 deg. 15 min. for three Quarters, and 15 deg. for an Hour. So,

Extending the Compasses from the Sine of 90 deg. to the Sine of 51 deg. 30 min. (as before) the same Extent will reach from the Tangent of 3 deg. 45 min. to the Tangent of 2 deg. 56 min. which is the first Quarter of an Hour's Distance from 12 a Clock; and from 7 deg. 30 min. to 5 deg. 52 min. the first Half-hour's Distance from 12 a Clock; and from 11 deg. 15 min. to 8 deg. 51 min. three Quarters of an Hour's Distance from 12; and so all the rest, as in the Table following.

CAUTION.

When you come to use the Line of Tangents beyond 45 deg. you must then account 40 deg. to be 50 deg. and 30 deg. to be 60, &c. as they are usually numbred upon the Lines themselves.

Or if you find this to be inconvenient, you may, when you come to the Tangent of 60 deg. (as at 8 and 4 of the Clock) you may then use Cross-work, by extending the Compasses from the Sine of 90 deg. to the Tangent of 60 deg. The same Extent will reach from the Sine of 51 deg. 30 min. to the Tangent of 53 deg. 35 min. as before.

Now having thus attained the true Hour-Distances upon the Plain, it resteth to shew you

The

The Hour-Distances for a South or North Dial.

Hours.	Hour-Distances at the Equinoct.		True Hour-Distances upon the Plain.	
	d.	m.	d.	m.
XII	00	00	00	00
a quart.	5	45	2	56
half.	7	30	5	52
3 quart.	11	15	8	51
XI I	15	0	11	50
a quart.	18	45	14	52
half.	22	30	17	57
3 quart.	26	15	21	6
X II	30	0	24	20
a quart.	33	45	27	56
half.	37	30	31	0
3 quart.	41	15	34	28
IX III	45	0	38	3
a quart.	48	45	41	45
half.	52	30	45	34
3 quart.	56	15	49	30
VIII IV	60	0	53	35
a quart.	63	45	57	47
half.	67	30	62	6
3 quart.	71	15	66	33
VII V	75	0	71	6
a quart.	78	45	75	45
half.	82	30	80	25
3 quart.	86	15	85	13
VI	90	0	90	0

The Geometrical Construction of this DIAL.

FIG. I. 1. About the middle of the Plain upon which you design to draw your Dial, draw a right Line N S, representing the Meridian, or Hour-Line of XII, and cross it at right Angles with the Line E W, which shall be the Hour-Line of VI both in the Morning and in the Evening, E standing at VI in the Morning, and W at VI at Night. And where these two Lines intersect each other, which is at O, let it be the Centre of your Dial.

2. Upon O (as a Centre) with 60 deg. of your Line of Chords describe a Semicircle A 12 B: and because your Latitude is 51 deg. 30 min. take 51 deg. 30 min. from your Line of Chords, and set it (on either side of the Meridian) from XII to C, and draw the Line O C for the Axis or Stile of your Dial.

3. Laying your Table before you, take 11 deg. 50 min. (which is the first Hour's Distance upon the Plain) out of your Line of Chords, and set that Distance upon the Semicircle from 12 to 11, and draw the Lines O 11 and O 1 for the Hour-Lines of XI and I.

4. Take the second Hour's Distance, 24 deg. 20 min. out of your Line of Chords, and set it upon the Semicircle from 12 to 10, and from 12 to 2, and draw the Lines O 10 and O 2 for the Hour-Lines of XII and II.

5. Take 38 deg. 3 min. (the third Hour's Distance) out of your Chord, and set it from 12 to 9, and from 12 to 3, drawing the Lines O 9 and O 3 for the Hour-Lines of IX and III.

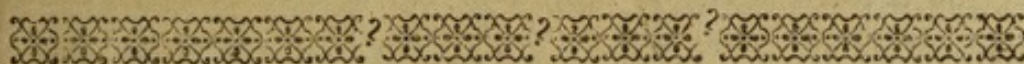
6. Take 53 deg. 35 min. and set it from 12 to 8, and from 12 to 4, and draw the Lines O 8 and O 4 for the Hour-Lines of VIII and IV.

7. Take 71 deg. 6 min. and set it from 12 to 7, and from 12 to 5, drawing the Lines O 7 and O 5 for the Hour-Lines of VII and V; and the Line E W is the Hour-Line of VI and VI, as was before express'd. And thus have you 12 Hour-Lines described upon your Plain, namely from 6 in the Morning to 6 at Night. But,

8. For the Hour-Lines before 6 in the Morning, or after 6 in the Evening, they may be supplied by continuing their opposite Hour-Lines

Lines beyond the Centre. So shall the Hour-Line of VII in the Morning become VII in the Evening, when it is extended beyond the Centre O; and VIII in the Morning become VIII in the Evening: And so of IV in the Evening will become IV in the Morning, and of V in the Evening V in the Morning.

Lastly, For the Stile of your Dial, it may be either an Iron Rod, or a Plate of Iron or Brass, which must be equal to the Angle 12 O C, namely 51 d. 30 m. equal to the Latitude of the Place; which being set perpendicularly upon the Meridian, or Hour-Line of XII, and its angular Point in the Centre O, it shall represent the Axis of the World, and be truly placed for the casting of its Shadow upon the true Hour at all Times of the Day.



C H A P. VI.

How to make a direct South or North DIAL in any Latitude.

FOR the making of these Dials there is nothing required to be given but the Latitude of the Place where they are to stand, which we will suppose to be (as before) *London*, whose Latitude is 51 d. 30 m. which known, we proceed to

The Arithmetical Calculation of these Dials.

1. *By the Table of Sines and Tangents.*

The Latitude of the Place being known, 51 d. 30 m. take the Complement thereof to 90 d. that is, Subtract 51 d. 30 m. from 90 d. the Remainder will be 38 d. 30 min. which is the Complement thereof. This being known, for finding of the Hour-Distances this is

The ANALOGY, OR PROPORTION.

As the Sine of 90 deg.	---	---	---	---	10	00000
is to the Sine of the Complement of the	}	---	---	---	9	79417
Latitude, viz. 38 d. 30 m.						
So is the Tangent of 15 deg. which is one	}	---	---	---	9	42805
Hour's Distance in the Equinoctial						
to the Tangent of 9 d. 28 m.	---	---	---	---	19	22222

Which 9 d. 28 m. is the true Hour-Distance of 11 and 1 of the Clock from the Meridian or Hour-Line of XII. And thus allowing 15 d. for one Hour, 30 d. for two Hours at the Equinoctial, all the Hour-Distances upon the Plain may be found, and will be as in the Table hereafter following.

2. *By the Lines of Sines and Tangents.*

The Hour-Distances by the Lines will be found more readily, as were those in the former Dial, namely, by once opening of the Compasses. For the Proportion being,

As the Sine of 90 d.

is to the Sine Comp. of the Latitude 38 d. 30 m.

So is the Tangent of 15 d. 30 d. 45 d. &c.

to the Tangent of 9 d. 28 m. &c.

Wherefore extend the Compasses from the Sine of 90 d. downwards to the Sine of 38 d. 30 m. the same Extent will reach from

The Hour-Distances for a South or North Dial.

Hours.	Hour-Distances at the Equinoct.		True Hour-Distances upon the Plain.	
	d.	m.	d.	m.
XII	00	00	00	00
a quart.	3	45	2	20
half.	7	30	4	41
3 quart.	11	15	7	3
XI I	15	0	9	28
a quart.	18	45	11	56
half.	22	30	14	27
3 quart.	26	15	17	4
X II	30	0	19	45
a quart.	33	45	22	35
half.	37	30	25	32
3 quart.	41	15	28	38
IX III	45	0	31	54
a quart.	48	45	35	22
half.	52	30	39	3
3 quart.	56	15	42	58
VIII IV	60	0	47	9
a quart.	63	45	51	36
half.	67	30	56	20
3 quart.	71	15	61	23
VII V	75	0	66	42
a quart.	78	45	72	17
half.	82	30	78	3
3 quart.	86	15	84	0
VI	90	0	90	0

the Tangent of 15 d. to the Tangent of 9 d. 28 m. and from the Tangent of 30 d. to the Tangent of 19 d. 45 m. and from the Tangent of 45 d. to the Tangent of 31 d. 54 m. from the Tangent of 60 d. to the Tangent of 47 d. 9 m. and from the Tangent of 75 d. to the Tangent of 66 d. 43 m.

And so from the respective Tangent of 3 d. 45 m. for a quarter, 7 d. 30 m. for half, and 11 d. 15 m. for 3 quarters of an hour at the Equinoctial, to the Tangent of 2 d. 20 m. 4 d. 41 m. 7 d. 3 m. &c. as in the Table. Which Table being thus collected, you may proceed to the drawing of the Hour-lines.

The Geometrical Construction of these DIALS.

FIG. II. 1. Upon your Dial Plain (about the middle thereof) draw a down-right line A B, which shall represent the Meridian, and be the Hour-line of XII; and towards the upper part thereof draw another line C D at right Angles thereunto, crossing each other in the Point E. The line C D shall be the Hour-lines of VI in the Morning and VI in the Evening also; and E shall be the Centre of the Dial.

2. Upon

2. Upon E with 60 d. of your Line of Chords describe a Semicircle C 12 D, and taking 38 d. 30 m. the Complement of the Latitude, set it from 12 to F on either side of the Line A B, and draw the Line E F for the Stile of your Dial.

3. Lay your Table before you, and from your Line of Chords take 9 d. 28 m. and set them upon the Semicircle from 12 to 11, and from 12 to 1, and draw the Lines E 11 and E 1, for the Hour-lines of XI and I.

4. Take 19 d. 45 m. and set them from 12 to 10, and from 12 to 2, and draw E 10 and E 2 for the Hour-lines of X and II; and the like of all the rest, as you find them in the Table, drawing the Hour-lines E IX and E III, E VIII and E IV, E VII and E V, for the true Hour-lines.

The Stile of this Dial may be either a Rod of Iron, or a Plate of Brasse or Copper made to an Angle equal to the Complement of the Latitude, *viz.* 38 d. 30 m. equal to the Angle 12 E F. This Stile must stand upon the Hour-line of XII, and issue from the Centre, and must point downwards towards the South-Pole, as you see in the Figure; and so shall it shew the true Hour of the Day. And thus is your South Dial finish'd. Now

C H A P. VII.

For the North D I A L.

FIG. III.

1. **U**PON the Dial Plain draw an obscure downright Line G H, representing the Meridian, or 12 of the Clock at Midnight. About the middle thereof, as at K, draw a right Line perpendicular thereunto, as the Line V I K V I.

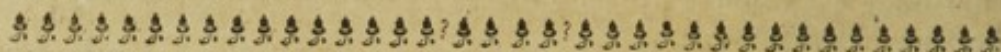
2. With 60 d. of your Chord describe upon the Centre K the Circle L M N O, and taking 38 d. 30 m. out of the Line of Chords, set them from L to P, and draw the Line K P for the Stile of your Dial.

Now because this Dial looketh towards the North part of the Meridian, to which in those middle Latitudes without the Tropicks the Sun never cometh, therefore must the Hours about Midnight be omitted, as 9, 10, 11 and 12 at Night, and 1, 2 and 3 in the Morning: So that this Dial is capable only of the Hours of 4, 5, 6, 7 and 8 in the Morning, and of 4, 5, 6, 7 and 8 in the Evening.

3. Lay the former Table made for the South Dial before you, and there you shall find that the Hour-Distances of VIII and IV of the Clock are distant from the Meridian 47 d. 9 m. Take 47 d. 9 m. from

from your Chord, and set them from M to 8, and from M to 4, and also from L to 8, and from L to 4. Also seeing that the Hour-Distances of VII and V are distant from the Meridian 66 d. 42 m. take them also out of your Line of Chords, and set them from M to 7, and from M to 5, and also from L to 7, and from L to 5.

Lastly, The Stile of the Dial must make an Angle of 38 d. 30 m. equal to the Complement of the Latitude, and must stand upon the obscure Hour-line of 12 at Night, and must point upwards towards the North-Pole, as the South Dials did downwards towards the South-Pole. And so have you finish'd your Dial.



CHAP. VIII.

How to make an East or West DIAL.

THESE Dial Plains lying in the very Plain of the Meridian Circle, in which Circle the Poles of the World are placed, neither Pole can have any Elevation upon them, and therefore the Hour-lines can make no Angles at the Pole; and therefore the Hour-lines do not meet in a Centre, but are all parallel one to another. So that for this Dial there will need no Arithmetical Calculation, and therefore we will proceed to

The Geometrical Construction of these Dials.

FIG. IV. Let A B C D be a Dial Plain, upon which you would draw an East or West direct Dial.

1. Upon the point C, at the lowermost corner, if it be an East Dial, or upon the point D at the other lowermost corner, if it be a West Dial, with 60 d. of your Line of Chords describe an obscure Arch of a Circle E F: then from the same Line of Chords take 38 d. 30 m. the Complement of the Latitude of the Place, (which is also the Elevation of the Equinoctial Circle above the Horizon) and set that Distance upon the Arch from E to F, and draw the Line C F quite through the Plain, which Line shall represent the Equinoctial Circle.

2. That you may the better proportion your Stile to your Plain, and that all the Hours may come on, and be at a convenient Distance one from another, assume two points in the Equinoctial Line, one towards the end C, for the Hour of 11 in the East Dial, (or of 1 in the West Dial) as the point G, and another towards the other end thereof for the Hour of 6, as the point H; and through these two points,

points, G and H, draw two Lines at right Angles to the Equinoctial Line, for the Hour-lines of XI and VI a Clock.

3. Upon the point G with 60 deg. of the Line of Chords describe an obscure Arch of a Circle, (below the Equinoctial Line) as I K, setting thereon 15. d. of your Line of Chords, from I to K, and draw the obscure Line G K, extending it till it cut the Hour-line of VI in the point L; so shall the Distance L H be the Height of the perpendicular Stile proportioned to this Plain.

4. Open your Compasses to 60 d. of your Line of Chords, and setting one Foot in the point L, with the other describe an obscure Arch of a Circle M N between the Hour-line of VI and the Line G L.

5. Divide the Arch M N into five equal Parts (which 15 deg. of your Line of Chords will do) at the points ☉☉☉☉☉, and lay a Ruler from L to each of these points ☉☉☉☉☉, and the Ruler shall cut the Equinoctial Line C H in the points ****, through which points draw right Lines parallel to the Hour-line of VI, as the Lines VII * VII, VIII * VIII, IX * IX, X * X, and they shall be the true Hour-lines of an East Plain, from Six in the Morning to Eleven before Noon.

6. For the Hour lines before VI, namely of IV and V in the Morning, you may put them on by transferring the same Distances upon the Equinoctial Line before VI, as there is between VI, and the Hour-lines of VII and VIII after VI, and through those points draw Lines parallel to the Hour-line of VI, and they shall be the Hour-lines of IV and V in the Morning.

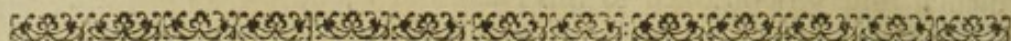
7. For the Stile of these East or West Dials, it may be either a straight Pin or Wire pointed of the just length of the Line H O, or H L, fixed in the point H, or some other part of the Line of VI, perpendicularly to the Plain, which will shew the true Hour only by the Shadow of the very Top thereof. --- Or (which is better) it may be a Plate of Brass or Iron, of the same Breadth as is the Distance between the Hour-lines of VI and IX upon the Equinoctial; which Plate must be set perpendicularly upon the Hour-line of VI, and so shall it shew the Hour by the Shadow of the upper edge thereof: and so is your Dial finished.

8. If you would insert the Halfs and Quarters of Hours into these Dials, you may easily effect it, by dividing each Space between ☉ and ☉ on the Arch M N into four equal parts, and so transferring them to the Equinoctial Circle, as you did the whole Hours. All which may be plainly seen in the Figure.

In the making of this Dial you have made two Dials, namely, a West Dial as well as an East, for it is the same in all respects as to the Hour-distances and height of the Stile. --- Only whereas the Arch E F in the East Dial (through which the Equinoctial passeth) was described on the right hand of the Plain, upon the Centre C, in the West Dial it must be described on the left hand, upon the Centre D: and the Hour-lines of IV, V, VI, VII, VIII, IX, X and XI

in the Forenoon on the East Dial, must be VIII, VII, VI, V, IV, III, II and I in the Afternoon on the West Dial : and this is all the Variation.

And here you may take notice that these five Dials last described, namely, the Horizontal, South, North, East and West, may be made upon a Stone cut in a Cubick Form.



CHAP. IX.

How to make an Upright Declining DIAL in any Latitude.

IT was sufficient for the making of any of the five foremention'd sorts of Dials, to know only the Latitude of the Place where the Dial is to stand ; but in these the Quantity of the Declination, and the Coast to which the Plain declineth, is also necessary : and besides, these two being given, four other things must be found before the Dial can be drawn, *viz.*

1. The Height of the Pole (or Stile) above the Plain.
2. The Distance of the Substile from the Meridian.
3. The Plain's Difference of Longitude.
4. The Angle that each Hour-line maketh with the Substile.

All which shall be here taught how to be found, both by the Tables of Sines and Tangents, and also by the Lines on the Index of the Table.

Let it therefore be required in the Latitude of *London* (which is 51 deg. 30 min.) to make a South Dial declining Eastward 30 deg.

The Arithmetical Calculation of this Dial.

By the Tables of Sines.

1. *To find the Height of the Pole or Stile above the Plain.*

The ANALOGY is,

As the Sine of 90 deg. ----- 10 00000

is to the Sine Complement of the Latit. 38 d. 30 m. 9 79414

So is the Sine Complement of the Plain's Declin. 60 d. 9 93753

to the Sine of 32 deg. 37 min. ---- 9 73167

Which 32 d. 37 m. is the height of the Pole, or Stile, above the Plain.

By

By the Line of Sines.

Extend the Compasses from the Sine of 90 deg. to the Sine of 38 deg. 30 min. the same Extent will reach from the Sine of 60 deg. to the Sine of 52 deg. 37 min. as before.

And that is the height of the Pole (or Stile) above the Plain.

II. *To find the Distance of the Substile from the Meridian.*

By the Table of Sines and Tangents.

The ANALOGY.

As the Sine of 90 deg.	----	----	----	----	10	00000
is to the Sine of the Plain's Declination 30 deg.	---				9	69897
So is the Tangent of the Complement of the Latitude of the Place 38 d. 30 m.	----	-----	----		9	90060
to the Tangent of 21 d. 41 m.	--	-	-	-	9	59957

Which 21 d. 41 m. is the Distance of the Substile from the Meridian.

By the Lines of Sines and Tangents.

Extend the Compasses from the Sine of 90 d. to the Sine of 30 d. the same Extent will reach from the Tangent of 38 d. 30 m. to the Tangent of 21 d. 41 m. the Substile's Distance from the Meridian.

III. *To find the Plain's Difference of Longitude.*

By the Table of Sines.

The ANALOGY.

As the Sine Complement of the Latitude 38 d. 30 m.	-	9	79414
is to the Sine of 90 d.	- - - - -	10	00000
So is the Sine of the Substile's Distance from the Meridian 21 d. 20 m.	- - - - -	9	56758
		19	56758
To the Sine of 36 d. 25 m.	- - - - -	9	77344

Which 36 d. 25 m. is the Plain's Difference of Longitude.

By the Line of Sines.

Extend the Compasses from the Sine of 38 d. 30 m. upwards to the Sine of 90 d. the same Extent will reach from the Sine of 21 d. 41 m.

41 m. to the Sine of 36 d. 25 m. the Plain's Difference of Longitude, as before.

*A Table of the Hour-Distances
of a South Dial, declining
either to the East or West
30 deg. 00 min.*

		D. M.			
Latitude of the Place --		51	30		
Distance of Subst.&Meri.		21	41		
Height of the Stile - -		32	37		
Plain's differ. of Longit.		36	25		
Hours for the East	West	Hour-Distances at the Equinoct.		True Hour-Distances on the Plain.	
		D.	M.	D.	M.
III	IX	88	35	87	22
IV	VIII	73	35	61	20
V	VII	68	35	53	57
VI	VI	53	35	36	8
VII	V	38	35	23	16
VIII	IV	23	35	13	14
IX	III	8	35	4	36
		Substile.			
X	II	6	25	3	28
XI	I	21	25	11	56
XII	XII	36	25	21	41
I	XI	51	25	34	3
II	X	66	25	51	00
III	IX	81	25	74	21

tion of 15 deg. will give you the Hour, as in the Table. Which Table being made, the next thing will be

From the Plain's Difference of Longitude thus found, allowing 15 degrees of the Equinoctial for one hour, and one degree for four minutes of Time, it will follow that the Substile of the Dial (which is the Meridian of the Plain) must fall between the Hour-lines of 9 and 10 of the Clock in the Morning, because the Plain declineth Eastward; for the Plain's Difference of Longitude falling between 30 and 45 deg. (namely, between the second and third hour's Equinoctial Distance) there will be two complete hours and 6 d. 25 min. more. Wherefore make a Table of the Hours fit for the Plain, as is here represented to the Eye, in which, against the Hour of XII, set the Plain's Difference of Longitude 36 deg. 25 min. from which subtract 15 deg. and there will remain 21 deg. 25 min. which set against the Hour of XI, and from 21 deg. 25 min. subtract 15 deg. and there will remain 6 deg. 25 min. which set against the Hour of X, and because it is less than 15 deg. write the word *Substile*, and subtract 6 deg. 25 min. from 15 d. then will there remain 8 d. 35 m. which set above the word *Substile*, against the Hour of IX: To which by the continual Addition

IV. To find the Angle that each Hour maketh with the Substile.

By the Tables of Sines and Tangents.

As the Sine of 90 d. - - - - - 10 00000
 is to the Sine of the height of the Pole above }
 the Plain 32 d. 37 m. - - - - - } 9 73160
 So is the Tangent of the Equinoctial Distance of the }
 next Hour to the Substile, viz. X. 6 d. 25 m. } 9 05101
 to the Tangent of 3 d. 28 m. - - - - - 8 78261
 Which 3 d. 28 min. is the Distance of Ten or Two a-Clock Hour-
 lines from the Substile. So again,

As the Sine of 90 d. -- -- -- -- 10 00000
 to the Sine of the Stile's height 32 d. 37 m. - - 9 73160
 So the Tangent of the next Equinoctial Dist. 21 d. 25 m. 9 59354
 to the Tangent of 11 d. 56 m. - - - - - 9 32514
 Which 11 d. 56 m. is the Distance of the Hour-lines of Eleven
 and One of the Clock from the Substile. And so of all the rest,
 as in the Table.

By the Lines of Sines and Tangents.

This Table may be made more easily by the Lines of Sines and Tangents by one opening of the Compasses, in this manner:

Extend the Compasses from the Sine of 90 d. to the Sine of 32 d. 37 m. (the height of the Stile, or Pole, above the Plain). The same Extent will reach from the Tangent of 6 d. 25 m. (which is the Equinoctial Distance of Ten and Two of the Clock) to the Tangent of 3 d. 28 m. the Tangent of the true Distance of the Hour-lines of Ten and Two of the Clock upon the Plain. --- And the same Extent will reach also from 21 d. 25 m. to 11 d. 56 m. the Distance of the Hours of Eleven and One. --- And from the Tangent of 36 d. 25 m. to the Tangent of 21 d. 41 m. for the Distance of Twelve a-Clock from the Substile. And so of the rest, as in this Table.

The Geometrical Construction of this DIAL.

FIG. V.

1. Upon the Plain you intend to describe your Dial on, draw a downright or perpendicular Line O P, for the Meridian and Hour-line of XII.

2. Towards the upper part whereof, as at O, assign a point, as O, for the Centre of your Dial.

* *

P

3. With

3. With 60 d. of your Line of Chords, upon O, describe an obscure Semicircle R S T.

4. Laying your Table before you, and there finding the Distance of the Substile from the Meridian to be 21 d. 41 m. take 21 d. 41 m. out of your Line of Chords, and set them from S to V, if the Plain decline Eastward, as here it doth; or from S to W, if the Plain had declined Westward; and draw the Line O V for the Substilar-line of your Dial.

5. Finding by your Table the height of the Pole or Stile above the Plain to be 32 d. 37 m. take that Number of Degrees out of your Line of Chords, and set them from V to X, and draw the Line O X, for the Stile of the Dial.

6. Seeing by your Table that the Hour-line of X of the Clock in the East-declining Plain, or of II of the Clock in the West-declining Plain, are distant from the Substile 3 d. 28 m. take 3 d. 28 m. from your Chord, and set them from V to 10, and draw the Line O 10 X for the Hour-line of Ten of the Clock.

7. Take 11 d. 56 m. out of your Chord, and set them from V to 11, and draw the Line O 11 for the Hour-line of Eleven. Again,

d.	m.						
21	41	out of your Line of Chords, and set them from V to	12	And draw the Lines	O 12 XII	for the Hour-lines of	Twelve
34	03		1		O 1 I		One
51	00		2		O 2 II		Two
74	21		3		O 3 III		Three
4	36		9		O 9 IX		Nine
13	14		8		O 8 VIII		Eight
23	16		7		O 7 VII		Seven
36	08		6		O 6 VI		Six
53	57		5		O 5 V		Five
61	20		4		O 4 IV		Four
87	22		3		O 3 III		Three

And so is your Dial finished.

The Stile must stand directly upon the Substile, and must make an Angle therewith equal to the Angle X O V, namely 32 d. 37 m. equal to the height of the Pole above the Plain.

The West-declining Dial is the same as the East-decliner; only the Substile must stand on the contrary side of XII to what now it doth, and the Names of the Hours must be changed, (all but Twelve) for XI must be I, and X must be II, &c. as is before hinted.

And in making of the South Dials you have also made the North Dials; for the South Dial being turned upside-down, so that the Stiles thereof may point upwards to the North Pole, and the Hours about Twelve at Night omitted, the North Dials are also finished. And now I shall proceed to shew you



C H A P. X.

How to draw a Dial upon an upright Plain, declining many Degrees towards either the East or West, whereby the Pole will have but small Elevation, (and consequently the Hours run close together) so that the Center of the Dial must (of necessity) be omitted.

FOR an Example of this kind, let us suppose a Plain beholding the South to decline therefrom Westward 85 d. wherefore observing the former Rules and Canons, the other Requisites will be found to be as in this little Table following, *viz.*

		d.	m.
The	Latitude of the Place - - - - -	51	30
	Declination Westward - - - - -	85	00
	Distance of the Substile and Meridian --	38	23
	Height of the (Pole or) Stile - - - -	03	06
	Plain's Difference of Longitude - - -	86	15

These Requisites being obtained as afore taught, either by the Canons of Sines and Tangents, or by the Lines of Sines and Tangents upon the Index, the Equinoctial Hour-Distances (by the continual Addition of 15 d. for an Hour) will be found as in the second Column of this Table, and the true Hour-Distances upon the Plain to be such as is expressed in the third Column, in which (by reason of the Greatness of the Plain's Difference of Longitude) the Hour-Distances near the Substile fall so near together, that (except they be extended far from the Center) they will have no competent Distance (or Space) betwixt each other. Wherefore the old usual Way hath been to draw the Dial upon a large Floor, (or the like) and to cut off the Hour-lines, (so many as are necessary) Stile and Substile also, till they will competently fill the Plain upon which the Dial is to be described.

To prevent which Trouble and Inconvenience also, I will shew you how such Dials that have great Declination (after the common Requisites are obtained) may be drawn, and that in a little room, which may be augmented or diminished as occasion shall require. And thus quitting Calculation, I shall proceed to

The

		D. M.	
South declining West -		85	00
Dist. Substile and Merid. -		38	23
Stile's height - - - - -		03	06
Pl. differ. of Longitude -		86	05

Hours.	Equinoctial Distances.		True Distances.	
	D.	M.	D.	M.
XII	86	05	33	23
XI	71	05	9	06
X	56	35	4	36
IX	41	05	2	42
VIII	26	05	1	31
VII	11	05	0	30

The Substile's place.				
VI	3	55	0	13
V	18	55	1	04
IV	33	55	2	05
III	48	55	3	33
II	63	55	6	20
I	78	55	15	28

*The Geometrical Projection of this
(or the like) DIAL.*

FIG. VI.

1. Draw a right Line A B perpendicular to one side of your Plain, and towards the left hand, because the Plain declineth Westwards; and with 60 d. of your Line of Chords describe an obscure Arch of a Circle C D E, and upon it (from C to D) set off 38 d. 23 m. the Substile Distance from the Meridian, and draw the Line A D for the Substile, quite through the Plain.

2. Out of your Line of Chords take 3 d. 6 m. the height of the Stile, and set them upon the former Arch from D to E, and draw the Line A E for the Stile.

3. Now because the Stile is but of small Elevation, (*viz.* but 3 d. 6 m.) draw another Line (as G H) parallel to the Line of the Stile A E, at such convenient Distance as you shall think fit; which shall be your augmented Stile.

4. Assume any two points in the Substilar-line A D, at some convenient Distance to each other, as R S, and through these two points draw two infinite right Lines, both of them at right Angles to the Substilar-line A D, as the Lines z z, and x x.

5. From the point R with your Compasses take the nearest Distance to the new augmented Stile G H, and set that Distance upon the Substilar-line from R to K.—Also from the point S take the nearest Distance to the new augmented Stile G H, and set that Distance also upon the new Substile from S to L.

6. Upon these two points K and L with 60 deg. of the Line of Chords describe two Semicircles, and in either of them set off 86 deg. 5 min. the Plain's Difference of Longitude; as from R to M, and also from S to N; both of them on the same side of the Substilar-line on which the first perpendicular line A B was drawn.

7. Divide either of the Semicircles last drawn into 12 equal parts, beginning at the point M, at the points ☉☉☉, &c., which 15 deg. of the Line of Chords will effect.

8. Lay a Ruler to the point L, and the respective points ☉☉☉, &c. and the Ruler will cut the Line X X in the points ***, &c. — Also lay a Ruler to K, and the several points ☉☉☉, &c. and the Ruler will cut the Line Z Z in the several points ***, &c.

Lastly,

Lastly, Lines drawn from the first point * in the Line z z, to the first point * in the other Line x x, (which the Substilar-line will direct you how to do) these Lines so drawn shall be the true Hour-lines proper for the Plain, and will appear as in the Figure; and be at a competent Distance one from another, without having any relation at all to the Centre.

Now in the making of this Dial you have made four Dials, *viz.*

a { South declining West
South declining East
North declining West
North declining East } 85 degrees;

only by changing of the Names of the Hours, and placing the Stile on the contrary side of the Line A B, for the South declining East: And by turning of the Dial upside downwards, for the two North Decliners, so that the Stiles may point upwards to the North Pole, and the Hours about Midnight omitted, as in the former Section.

CHAP. XI.

Concerning direct Reclining and Inclining Dials.

I. Of East or West Reclining and Inclining Dials.

FOR the drawing of these Dials, the best Way will be to refer them to a new Latitude, where they may become upright declining Plains; and that may be known thus: For,

1. The new Latitude will always be the same with the Complement of the Latitude in which the Plain reclineth. And,
2. The new Declination in that new Latitude will be always the same with the Complement of the Plain's Reclination.

So that in the Latitude of *London* 51 d. 30 m. if an East or West Plain should recline from the Zenith 35 d. and you would know in what Latitude that Plain shall be an upright declining Plain:

1. The new Latitude is 38 d. 30 m. which is the Complement of the known Latitude.
2. The new Declination will be 55 d. which is the Complement of (35 d.) the Plain's Reclination.

So that if by the Rules of the two foregoing Chapters you do make an upright Dial for the Latitude of 38 d. 30 m. declining 55 d. that Dial shall be a true Dial for an East or West Plain that reclineth 35 d. in the Latitude of 51 d. 30 m. Only this is to be taken notice of, *viz.*

That in all upright declining Plains the Hour-line of 12 a-clock is a perpendicular or plumb Line; so the Hour-line of 12 in all East and West

West reclining and inclining Plains must be an Horizontal or level Line, as the Line of 6 a-clock is in the North or South Plains.

And note also, that the Stiles of all East and West reclining Plains must point upwards towards the North Pole, (in these North Latitudes) and the Stiles of all East and West inclining Dials must point downwards towards the South Pole.

II. *Of direct South Reclining and North Inclining Plains.*

For the drawing of Hour-lines upon these kind of Plains, it is requisite to refer them to a new Latitude, in which they may be Horizontal Plains; which may be thus done: For,

1. If the Reclination of the Plain be less than the Complement of the known Latitude, subtract the Reclination out of the Complement of the known Latitude, and the Remainder shall be the new Latitude.

So, a South Plain in the Latitude of 51 d. 30 m. reclining 20 d. shall be an Horizontal Dial in the Latitude of 18 d. 30 m. for 20 d. being subtracted from 38 d. 30 m. there will remain 18 d. 30 m. for the new Latitude. So that an Horizontal Dial made (by the Rules before-going) for the Latitude of 18 d. 30 m. will serve for a South Plain reclining 20 d. in the Latitude of 51 d. 30 m.

2. If the Reclination of the South Plain be greater than the Complement of the known Latitude, subtract the Complement of the Latitude from the Plain's Reclination, and the Remainder shall be the new Latitude.

So, a South Plain in the Latitude of 51 d. 30 m. which reclines 68 d. shall be an Horizontal Dial in the Latitude of 29 d. 30 m. for if you subtract 39 d. 30 m. the Complement of the known Latitude, from 68 d. the Plain's Reclination, there will remain 29 d. 30 m. And so an Horizontal Dial made for the Latitude of 29 d. 30 m. will serve for a South Plain reclining 68 d. in the Latitude of 51 d. 30 m.

3. If the Reclination of the South Plain be equal to the Complement of the known Latitude, then doth such a Plain lie directly in the prime Vertical Circle, and parallel to the Axis of the World; and so the new Latitude is 00 d. 00 m.

Wherefore the Pole hath no Elevation above such a Plain, and a Dial for such a Plain must be made in all respects as an East or West Dial is made; only the Hour-line of Six in the East or West Dial must in this be the Hour-line of Twelve, and the Equinoctial Line in this Dial must be the same with the Horizontal Line, and the height (or rather breadth) of the Stile must be equal to the Distance that is between the Hour-lines of Twelve and Nine or Three.

The North Inclining Dials are the same with the South Recliners opposite to them; only the naming of the Hours must be changed: And for the Stiles, if the North Pole be elevated upon the reclining Plain, the South Pole must be elevated upon the inclining Plain opposite thereunto, and the contrary.

III. *Of*

III. Of direct North Reclining and South Inclining Plains.

These Plains also must be referred to a new Latitude, where they must become Horizontal Plains; which may thus be performed:

1. Add the Complement of the known Latitude and the Reclination of the Plain together, the Sum of them shall be the new Latitude.

Thus, in the Latitude of 51 d. 30 m. a North Plain reclining 20 d. will be an Horizontal Plain in the Latitude of 58 d. 30 m. for 38 d. 30 m. the Complement of the Latitude, added to 20 d. the Plain's Reclination, make 58 d. 30 m. And so an Horizontal Dial made for the Latitude of 58 d. 30 m. will serve for a North Dial reclining 20 d. in the Latitude of 51 d. 30 m. But,

2. If the Sum of the Complement of the known Latitude and the Plain's Reclination do exceed 90 d. subtract the Sum of them from 180 d. and the Remainder shall be the new Latitude.

So, a North Plain in the Latitude of 51 d. 30 m. reclining 68 d. will be an Horizontal Plain in the Latitude of 73 d. 30 m. for if you add 38 d. 30 m. (the Comp. of the Latitude) to 68 d. (the Reclination of the Plain) the Sum of them will be 106 deg. 30 m. which (being above 90 d.) take from 180 d. and the Remainder will be 73 d. 30 m. And an Horizontal Dial for that Latitude will be a Dial for a North reclining Plain 68 d. in the Latitude of 51 d. 30 m.

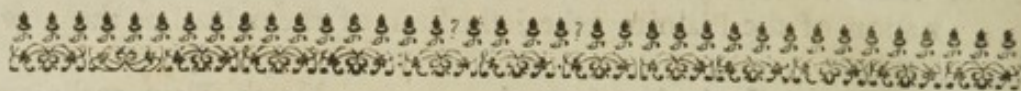
3. If the Reclination of the North Plain be equal to the Latitude 51 d. 30 m. (in our Example) then the Reclination of the Plain and the Complement of the Latitude added together will make 90 d. for the new Latitude.

So shall such a Plain lie parallel to the Equinoctial in the Sphere. And to make a Dial for such a Plain, you have no more to do than to divide a Circle into 24 equal parts, and drawing lines from the Center to each of those equal parts, they shall be the true Hour-lines for such a reclining Plain. And for the Stile, it is to be no other than a straight Wire set upright in the Center of the Circle, and so is your Dial finish'd.

And thus have I shew'd you how to describe Hour-lines upon all sorts of upright Plains, both direct and declining, (which of all others are the most usual) in any Latitude, and that by the most exact and absolute way, namely by Calculation, which for Exactness exceedeth all others: As also upon all direct *East, West, North* and *South reclining* and *inclining* Plains, whereby Dials may be drawn upon many Polyhedronick Bodies, cut out in Stone or Timber.

And now it may be expected that I should say something of *Declining, Reclining, or Inclining Plains*: But having treated of these at large in a particular Treatise of DIALLING, (perform'd three several ways, namely, *Arithmetically, Geometrically, and Instrumentally*) lately by me published, I shall say no more of *Dialling* in
this

this place; but for farther Satisfaction therein, refer you to the fore-mentioned Treatise. But before I conclude this Book, I shall shew you some other ways whereby the Hour may be obtained, not only by the Sun in the Day-time, but by the Fixed Stars also in the Night-season.



CHAP. XII.

How to find the Hour of the Day by help of a Walking-Staff (or other straight Thing) divided into 10 or 100 equal Parts.

YOUR Staff, or other straight Thing, being divided first into 10 equal Parts, and then each of those into 10 other equal Parts, so will the Staff be divided into 100 equal Parts; which being so divided and figured, erect Perpendicular upon some plain, level Ground, and note the Place where the Shadow terminates. Then with your Staff measure the Length of the Shadow thereof in Staves Lengths, and hundred Parts of one Length, according as it is numbered.

This done, in the following Table seek the Day of the Month, (or the nearest thereunto) and cast your Eye along that Line against which the Day of the Month standeth, 'till you find the Length of the Shadow of your Staff as you measured it upon the Ground: Which found, (or the nearest to it) at the Top or Head of the Table you shall find the Hour of the Day, either before or after Noon.

And thus have I shew'd you how to tell the Hour by the Length of the Shadow of a Staff, or other straight Thing, which is divided into 10 or 100 equal Parts, and how to find the Hour of the Day by the Length of the Shadow of a Staff, or other straight Thing, which is divided into 10 or 100 equal Parts, and how to find the Hour of the Day by the Length of the Shadow of a Staff, or other straight Thing, which is divided into 10 or 100 equal Parts.

And now it may be expected that I should give some more of these Tables, or Tables of the Length of the Shadow of a Staff, or other straight Thing, which is divided into 10 or 100 equal Parts, and how to find the Hour of the Day by the Length of the Shadow of a Staff, or other straight Thing, which is divided into 10 or 100 equal Parts.

A Table

A Table by which you may find the true Hour of the Day by a Staff (or the like) divided into 10 or 100 equal Parts.

Hours	Before noon	After noon	XII			XI I			X II			IX III			VIII IV			VII V			VI VI			V VII		
			Staves	Length	100 Parts	Staves	Length	100 Parts	Staves	Length	100 Parts	Staves	Length	100 Parts	Staves	Length	100 Parts	Staves	Length	100 Parts	Staves	Length	100 Parts	Staves	Length	100 Parts
June	11 11	June	0	55		0	60		0	75		0	98		1	34		1	92		3	0		5	72	
			0	56		0	61		0	75		0	99		1	35		1	93		3	1		5	80	
			0	56		0	61		0	76		0	99		1	36		1	95		3	4		5	90	
			0	57		0	62		0	77		1	1		1	38		1	98		3	12		6	18	
May	21 1	July	0	59		0	64		0	79		1	3		1	41		2	2		3	21		6	52	
			0	61		0	66		0	81		1	6		1	44		2	8		3	35		7	11	
			0	63		0	68		0	83		1	8		1	48		2	14		3	51		7	86	
			0	66		0	71		0	86		1	12		1	53		2	24		3	73		9	6	
April	12 1	August	0	69		0	74		0	90		1	16		1	59		2	34		4	0		10	78	
			0	73		0	78		0	94		1	21		1	66		2	47		4	36		13	84	
			0	77		0	82		0	98		1	27		1	74		2	62		4	81		19	63	
			0	82		0	87		1	4		1	33		1	84		2	81		5	43		35	80	
March	11 11	September	0	87		0	92		1	9		1	40		1	95		3	3		6	23		86	40	
			0	93		0	98		1	16		1	49		2	8		3	31		7	43				
			0	99		1	5		1	23		1	58		2	22		3	65		9	22				
			1	6		1	12		1	31		1	69		2	40		4	7		12	18				
February	21 1	October	1	13		1	20		1	40		1	81		2	60		4	60		18	17				
			1	21		1	28		1	50		1	94		2	84		5	31		36	37				
			1	30		1	37		1	61		2	9		3	13		6	27							
			1	40		1	48		1	73		2	27		3	47		7	63							
January	12 1	November	1	51		1	59		1	87		2	47		3	89		9	73							
			1	63		1	72		2	2		2	71		4	41		13	30							
			1	76		1	86		2	19		2	98		5	8		20	94							
			1	89		2	0		2	38		3	29		5	92										
Decemb.	11 11	December	2	5		2	17		2	61		3	66		7	8										
			2	21		2	35		2	84		4	8		8	62										
			2	39		2	55		3	11		4	59		10	98										
			2	58		2	76		3	39		5	18		14	51										
January	21 1	November	2	79		2	99		3	71		5	89		20	81										
			3	0		3	21		4	5		6	68		34	37										
			3	21		3	46		4	40		7	60		82	84										
			3	41		3	68		4	76		8	63													
Decemb.	12 1	December	3	60		3	91		5	11		9	72													
			3	76		4	9		5	42		10	79													
			3	91		4	25		5	66		11	73													
			3	97		4	33		5	82		12	38													
Decemb.	11 11	December	4	1		4	37		5	90		12	64													

The Use of the Table.

Example 1. Suppose that upon the 6th of *May* I erect my Staff perpendicular, and measuring the length of the Shadow thereof, I find the Shadow to contain two times the length of my Staff, and 24 Parts more. Wherefore I look in my Table first for the 6th Day of *May*, which I find in the first Column of my Table, and casting my Eye along that Line towards my right hand I find 2 24, over which at the Head of the Table there stands VII V; which shews that it is VII of the Clock in the Morning (if you made your Observation in the Forenoon), or V in the Evening (if your Observation was in the Afternoon).

In like manner, if this Observation had been made upon the 16th of *July*, and the length of the Shadow the same, *viz.* 2 24 Parts, the Hour would then have been the same: For by the Table you may plainly see, that one and the same Line serves both for the 6th of *May* and the 16th of *July*; and also the same Line that serves for the 21st of *February*, serves also for the 1st of *October*, which Days are of equal length.

Example 2. Again, Upon the 16th of *April* (or the 6th of *August*) I erect my Staff, and find the length of the Shadow thereof to contain once its length, and 30 Parts more: I look in the Line that stands against the 16th of *April*, or 6th of *August*, for the length of my Shadow, viz. 1 30, but I cannot find it, but the nearest thereunto is 1 33, over which there stands IX and III; which shews the nearest Hour to be IX in the Morning, or III in the Afternoon.

Now because the length of your Shadow was less than the Number that you found in the Table, you may conclude that if it were in the Forenoon, that it was a small matter past IX, because the Sun was higher than you find in the Table, and so consequently the Shadow shorter: But had it been in the Afternoon, it had wanted a small matter of III in the Afternoon, for the Reason aforesaid.

Example 3. Again, Upon the 26th of *May*, or the 26th of *June*, I find the length of the Shadow of my Staff to be once its length, and 20 Parts more. If I seek for this length against my Day, I cannot find it, but I find 11 in that Line to stand under IX and III, which is too little; and I find in the same Line 138 to stand under VIII and IV, which is too much: Wherefore I take 20, my odd Parts from 38, the greater Number of Parts, and there remains 18 Parts. Then seeing that the length of the Shadow in one Hour's time increaseth 37 Parts of a Staff, I say, by the Rule of Proportion,

If

If 37 Parts of Shadow give 60 Min. or one Hour, what shall 20 Parts of Shadow give?

parts min. parts min.
As 37 is to 60, so is 20 to 32

$$\begin{array}{r} 20 \\ \hline 37 \overline{) 1200} \quad (32 \\ \underline{111} \\ 90 \\ \underline{74} \\ 16 \end{array}$$

So that you may conclude the Hour to be either 32 min. past VIII in the Morning, or wanting 32 min. of III in the Afternoon.

					in the Morn.	in the Aftern.
And thus upon	January	16	if the length of the Shadow be	(3 21 2 2 2 9 3 65 4 37 0 63)	the hour will be either	{ XI X IX VII VI I }
	February	26				
	March	11				
	April	1				
	December	11				
	May	11				
						or { I II III IV V VI }
						the hour will be XII at Noon.

And thus much for the Use of this Table.

CHAP. XIII.

How to find the Hour of the Night by the Fixed Stars.

FOR this purpose the two following *Tables* are subservient. The First whereof containeth the *Right Ascension* and *Semidiurnal Arch* of 80 principal *Fixed Stars*, so orderly placed, by their difference of *Ascension*, that at all times *one* or *other* is either *Rising*, *Setting*, or upon (or near) the *Meridian*.

The Second shews the *Right Ascension* of the *Sun* for every Day of the Year. And the *Use* of these *Tables* is twofold. For,

First, They direct you to find at what hour and min. any of the said *Stars* in the first *Table* will be upon the South part of the *Meridian*: Or, if you see any of them upon the South part of the *Meridian*, they will direct you to the hour of the Night.

Secondly, They shew also at what hour and min. any Day in the Year any of the said *Stars* do *rise* or *set*: So that seeing any of them *rising* in the *East*, or *setting* in the *West*, you may from thence compute the exact hour or time of the Night. As by *Examples* following shall be made to appear.

A Ta

A Table shewing the right Ascension and Semidiurnal Arch of 80 of the most eminent Fixed Stars in Hours and Minutes.

Names of the Stars.	Right Ascension.		Semi-diurnal Arch.	Names of the Stars.	Right Ascension.		Semi-diurnal Arch.
	H.	M.			H.	M.	
Schedir in Cassiopea	0	22	Sets not	Hydra's Head	9	12	6 38
Southermost in Whale's Tail	0	27	4 4	Lion's Heart	9	50	7 14
Star in the Hexion of Cassiopea	0	37	Sets not	* in the hin. part of Lion's Neck	9	58	8 32
Girdle of Andromeda	0	51	10 6	Lion's Tail	11	32	7 32
Cassiopea's Knee	1	5	Sets not	Virgin's Girdle	12	39	6 28
In the North knot of ♄	1	14	4 45	Vindemiatrix	12	40	7 5
Former Horn of the Ram	1	36	7 39	Virgin's Spike	13	8	5 11
Belly of the Whale	1	36	4 56	Arcturus	14	1	8 2
Hindermost Horn of the Ram	1	37	7 49	Bootes left Shoulder	14	19	Sets not
Andromeda's South Foot	1	43	Sets not	South } Balance	14	33	4 40
Bright * in the Ram's Head	1	49	8 7	North }	15	0	5 17
Middlemost * in Ram's Tail	1	56	7 53	Bright * in the Crown	15	25	8 57
Whale's Jaw	2	45	5 45	Bright * in the Serpent's Neck	15	29	6 40
Medusa's Head, <i>Algol</i>	2	47	Sets not	Scorpion's Heart, <i>Antares</i>	16	9	3 23
Perseus right Side	2	51	Sets not	Hercules right Shoulder	16	16	8 10
Brightest of the 7 *'s <i>Pleiades</i>	3	28	8 16	Left } Knee of Ophiuchus	16	19	5 8
North Eye of the Bull	4	9	7 44	Right }	16	46	4 36
South Eye, <i>Aldebaran</i>	4	17	7 27	Hercules Head	16	59	7 22
South Horn of the Bull	4	32	7 43	Ophiuchus Head	17	20	7 10
The Goat	4	52	Sets not	Bright * in the Dragon's Head	17	50	Sets not
Orion's Foot, <i>Regel</i>	4	59	5 14	Bright * in the Harp	18	22	Sets not
North Horn of the Bull	5	6	9 0	Vulture's Tail	18	51	7 14
Foremost Shoulder of Orion	5	8	6 32	Swan's Bill	19	18	8 51
First in Orion's Girdle	5	16	5 57	Bright * of the Vulture	19	35	6 43
Orion's Head	5	17	8 1	Uppermost Wing of the Swan	19	35	Sets not
South Horn of the Bull	5	18	8 1	Uppermost } Horn of the Goat	20	0	4 46
Second in Orion's Girdle	5	20	5 52	Lowermost }	20	3	4 33
Lowermost in Orion's Girdle	5	24	5 49	Swan's Breast	20	11	Sets not
Auriga's right Shoulder	5	36	Sets not	Waterbearer's left Hand	20	29	5 3
Following Shoulder of Orion	5	38	6 39	Swan's Tail	20	31	Sets not
Right Hand of Orion	5	49	7 21	Lowermost Wing of the Swan	20	33	9 48
The bright Foot of Gemini	6	19	7 32	Waterbearer's left Shoulder	21	13	5 23
The great Dog, <i>Sirius</i>	6	31	4 30	Cepheus Girdle	21	25	Sets not
* in the Belly of the great Dog	6	55	3 21	Pegasus Mouth	21	28	6 44
* near the great Dog's Ear	7	7	4 52	Waterbearer's right Shoulder	21	47	5 50
The little Dog, <i>Procyon</i>	7	22	6 32	<i>Fomabaut</i>	22	39	2 28
Lowermost Head of the Twins	7	26	9 4	<i>Scheat</i>	22	48	8 42
Bright * in the Deck of the Ship	7	54	3 42	<i>Marchab</i>	22	49	7 13
North } <i>Afellus</i>	8	23	8 14	Andromeda's Head	23	52	8 51
South }	8	25	7 50	Bright * in Cassiopea's Chair	23	53	Sets not

A Table

*A Table shewing the Sun's Right Ascension
in Hours and Minutes for every Day in the
Year at Noon.*

Days	Janu. h. m.	Febr. h. m.	March h. m.	April h. m.	May h. m.	June h. m.	July h. m.	Aug. h. m.	Sept. h. m.	Octob. h. m.	Nov. h. m.	Decr. h. m.
1	19 35	21 4	23 29	1 22 3	14 5	20 7	24 9	20 11	19 13	8 15	8 17	10 17
2	19 39	21 4	23 3	1 25 3	18 5	24 7	28 9	30 11	23 13	12 15	13 17	21 17
3	19 44	21 5	23 36	1 27 3	22 5	28 7	32 9	33 11	27 13	15 15	17 17	25 17
4	19 48	21 5	23 40	1 32 3	26 5	32 7	36 9	37 11	31 13	18 15	21 17	29 17
5	19 52	21 5	23 44	1 36 3	30 5	36 7	40 9	41 11	34 13	23 15	25 17	34 17
6	19 56	22 2	23 47	1 40 3	34 5	40 7	44 9	45 11	38 13	27 15	29 17	39 17
7	20 0	22 6	23 51	1 44 3	38 5	44 7	48 9	48 11	41 13	30 15	33 17	43 17
8	20 4	22 10	23 55	1 47 3	42 5	48 7	52 9	52 11	45 13	34 15	37 17	48 17
9	20 9	22 14	23 58	1 51 3	46 5	52 7	56 9	56 11	48 13	38 15	41 17	52 17
10	20 13	22 18	0 2	1 59 3	50 5	57 7	0 10	0 11	51 13	42 15	45 17	56 17
11	20 18	22 21	0 5	1 59 3	54 5	18 8	4 10	3 11	55 13	46 15	50 18	1 18
12	20 22	22 25	0 9	2 3 3	58 5	18 8	10 10	7 11	59 13	50 15	54 18	6 18
13	20 26	22 29	0 13	2 6 4	2 10	18 8	12 10	10 11	3 13	53 15	58 18	10 18
14	20 30	22 33	0 17	2 10 4	6 10	18 8	16 10	14 11	7 13	57 16	2 18	15 18
15	20 34	22 36	0 20	2 13 4	9 10	18 8	20 10	18 11	10 13	1 16	7 18	19 18
16	20 38	22 39	0 23	2 17 4	13 10	22 8	24 10	21 11	14 13	5 16	11 18	24 18
17	20 42	22 44	0 27	2 21 4	17 10	26 8	28 10	25 11	17 13	9 16	15 18	28 18
18	20 46	22 46	0 31	2 25 4	21 10	31 8	32 10	29 11	20 13	14 16	19 18	33 18
19	20 51	22 51	0 35	2 28 4	25 10	35 8	36 10	32 11	24 13	17 16	24 18	37 18
20	20 55	22 55	0 39	2 34 4	29 10	39 8	40 10	35 11	28 13	20 16	29 18	41 18
21	20 59	22 59	0 42	2 38 4	34 10	43 8	44 10	39 11	32 13	24 16	33 18	45 18
22	21 2	23 3	0 45	2 41 4	38 10	47 8	48 10	43 11	36 13	28 16	37 18	49 18
23	21 7	23 6	0 48	2 44 4	42 10	51 8	52 10	47 11	39 13	32 16	41 18	54 18
24	21 10	23 10	0 52	2 47 4	46 10	55 8	56 10	50 11	42 13	36 16	45 18	59 18
25	21 15	23 14	0 56	2 52 4	50 10	59 8	59 10	54 11	46 13	40 16	50 18	3 19
26	21 19	23 18	1 0	2 56 4	54 10	3 9	3 10	58 11	50 13	44 16	55 18	2 19
27	21 23	23 22	1 3	3 0 4	58 10	7 9	7 11	1 12	53 13	48 16	59 18	16 19
28	21 27	23 26	1 7	3 4 5	2 10	12 9	10 11	4 12	57 13	52 17	3 19	17 19
29	21 31		1 11	3 7 5	7 10	16 9	14 11	8 13	1 14	56 17	8 19	20 19
30	21 34		1 15	3 11 5	11 10	20 9	18 11	12 13	5 15	0 17	12 19	24 19
31	21 38		1 19	3 15 5	16 10	24 9	22 11	15 13	15 15	4 19	30 19	

The Use of the two former Tables.

- I. To find (any Day in the Year) at what Hour and Minute any of the Stars mentioned in the first Table will be upon the South part of the Meridian.

To effect this, subtract the Right Ascension of the Sun for the Day given, from the Right Ascension of the Star whose Southing is required, and the Remainder is the time that that Star will be upon the Meridian that Night. --- But if the Sun's Right Ascension be greater than the Right Ascension of the Star, you must (always) in that case add 24 Hours to the Star's Right Ascension, (so that Subtraction may be made) and the Remainder will shew you at what Hour the next Morning the said Star will be upon the South part of the Meridian.

EXAMPLE.

Let it be required upon the 27th of *March* to know at what time the *Pleiades*, or 7 Stars, will be upon the Meridian.

	H.	M.
The Right Ascension of the <i>Pleiades</i> is	3	28
The Sun's Right Ascension for the 27th of <i>March</i> is	1	3
Subtraction being made, there remains	2	25

Wherefore upon the 27th of *March* the 7 Stars will be upon the South part of the Meridian at 25 min. after Two of the Clock in the Afternoon.

But if upon the 15th of *October* (the Sun's Right Ascension then being 14 hours 1 min.) it were required to know at what hour the *Pleiades* or 7 Stars would be upon the Meridian: Then,

	H.	M.
The Right Ascension of the <i>Pleiades</i> being	3	28
Add 24 Hours thereto, and it makes	27	28
The Sun's Right Ascension for the 15th of <i>October</i> is	14	1
Subtraction being made, there remains	13	27

From which 12 Hours being taken, there remains 1 Hour and 27 Min. So that the *Pleiades* will be upon the Meridian at 27 Min. after One in the Morning on the 16th of *October*, which is the Day following. Again,

If upon the same 15th of October you should have seen the Great Dog upon the Meridian, and would from thence find the Hour of the Night.

	H.	M.
The Right Ascension of the Great Dog is	--	--
To which add 24 Hours, the Sum is	30	31
The Right Ascension for October 15. is	14	1
The Remainder is	16	30

From which 12 Hours being taken, there remain 4 Hours 30 Min. for the true Time of the Night; that is, half an Hour after Four in the Morning the next Day.

II. To find (any Day in the Year) at what Time any of the Stars mentioned in the first Table do rise or set.

Having (by the former Section) found at what Hour the Star will be upon the Meridian, if you add the Semidiurnal Ark of the Star to the Time of his being upon the Meridian, you have the Hour and Minute of that Star's Setting. And if from the Time of the Star's coming to the South you do subtract the Semidiurnal Ark of the Star, you have the Hour and Minute of that Star's Rising.

E X A M P L E.

Thus (by the former Section) you found upon the 27th of March,

	H.	M.
The Pleiades were upon the Meridian at	2	25 afternoon
The Semidiurnal Ark of the Pleiades is	8	16

The Sum is 10 41 at night.

At which time the Pleiades or 7 Stars do set upon the 27th of March.

	H.	M.
And by subtracting the Semidiurnal Ark	8	16
from 2 H. 25 M. (the Time of Southing) adding	14	25
12 H. because Subtraction cannot else be made,		
There remains	6	09

So that the Pleiades (upon the 27th of March) do rise at Nine Minutes after Six in the Morning. Again,

Upon

Upon the 15th of October.

	H.	M.
The Time of the <i>Pleiades</i> coming to the South was	13	27
To which add the Semidiurnal Ark	8	16
The Sum is	21	43
From which substract	12	00
There remains	9	43

So that the *Pleiades* do set at 43 min. past 9 of the Clock the next Morning.

Likewise,

	H.	M.
The Time of the <i>Pleiades</i> coming to the South being	13	27
From which substract the Semidiurnal Ark	8	16
There remains	5	11

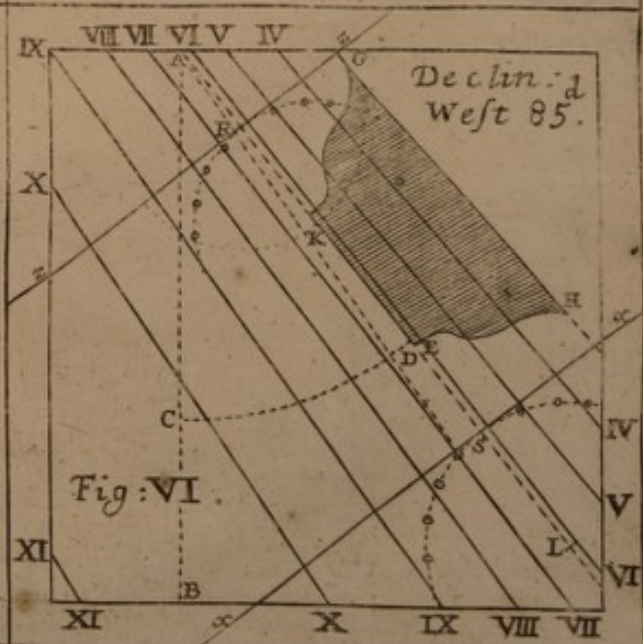
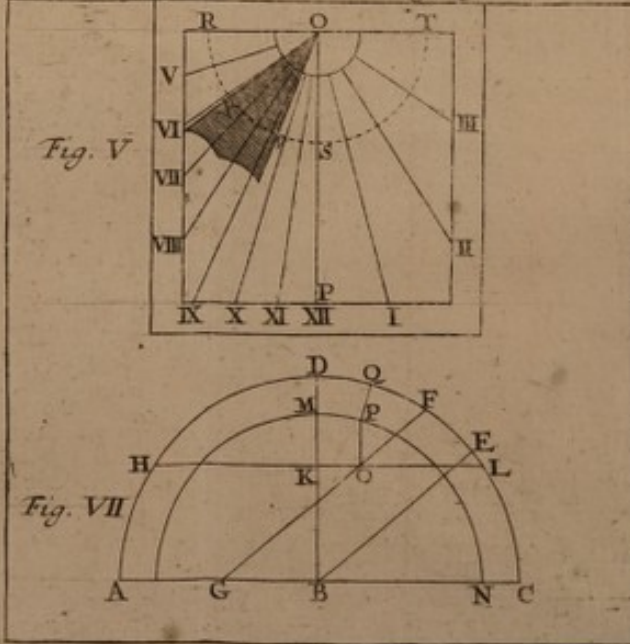
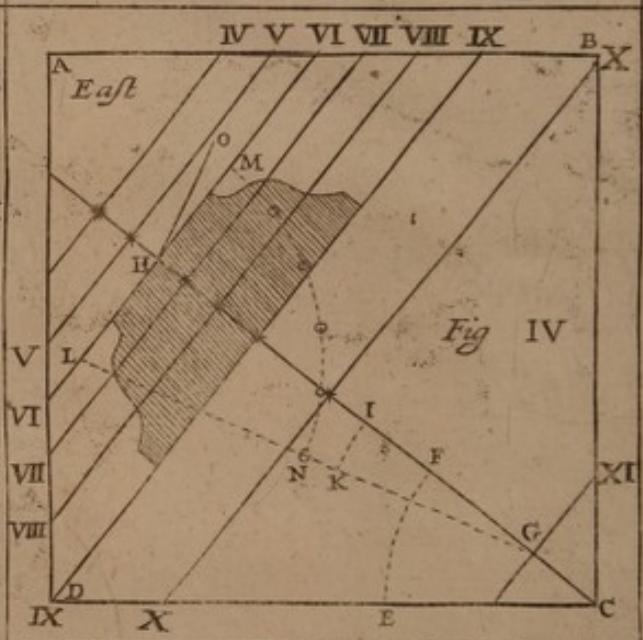
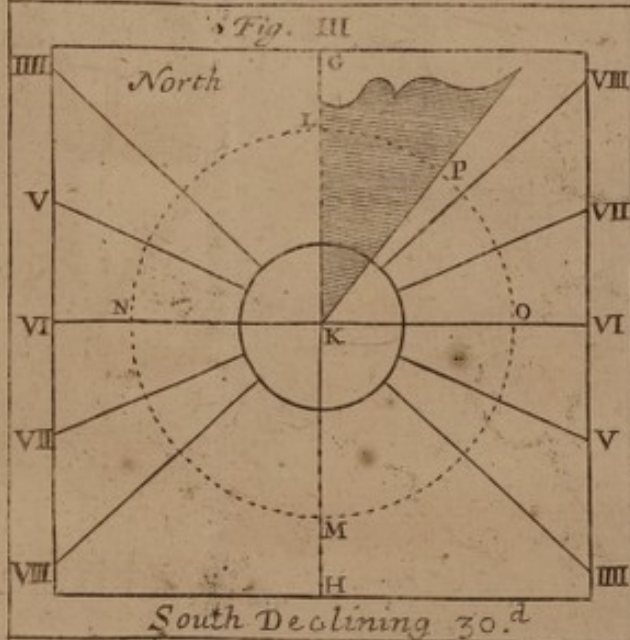
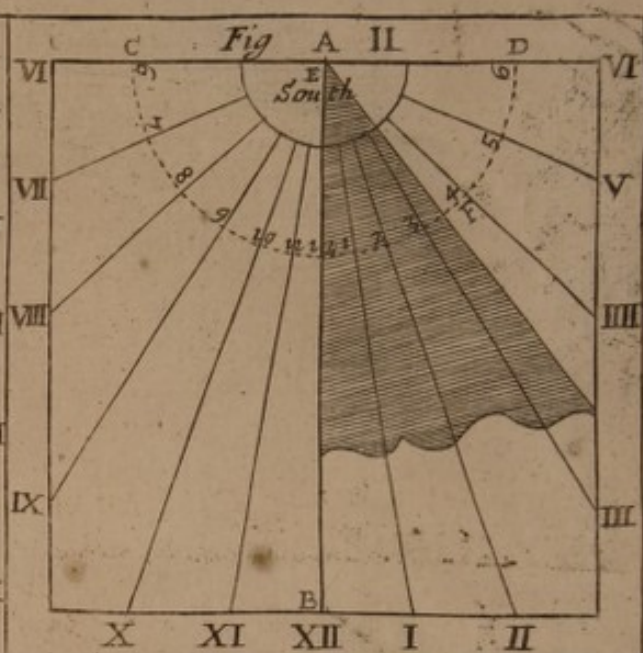
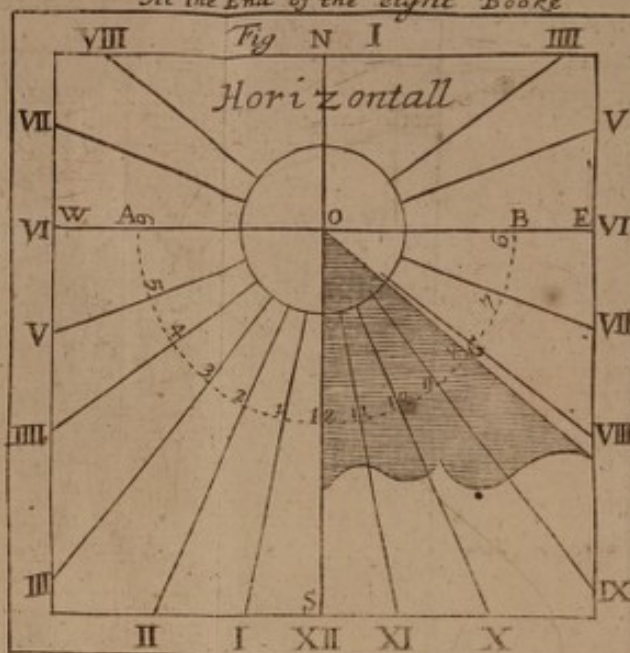
So that upon the 15th of October the *Pleiades* do rise at 11 min. after 5 at night.

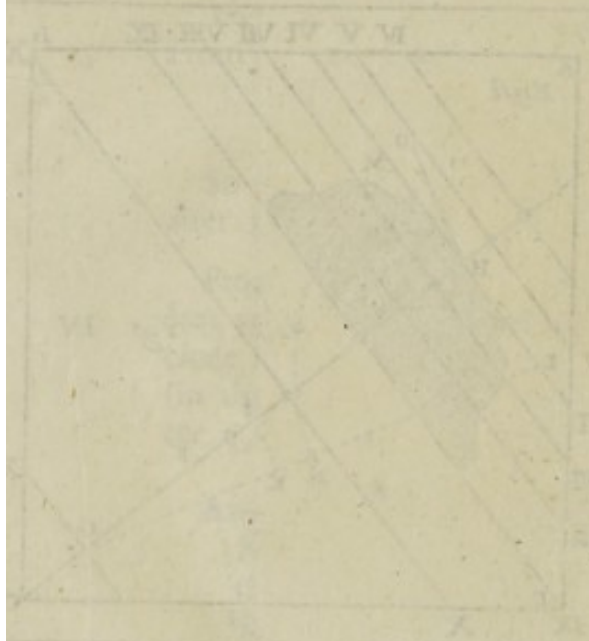
From hence you may conclude, that if (upon the 15th of October) you should see the 7 Stars rising in the East, you may then conclude it to be 11 min. past 5 at night; and if you should see them (in the East) one hour high, you may then conclude it 11 min. after 6, &c.

And thus may you readily and very exactly find the Hour of the Night by the Stars. And with these two Tables, and some of their Uses, (for they are serviceable to other good Purposes) I shall conclude this *Eighth Book*.

The End of the Eighth Book.









THE
LEGAL PART
OF
SURVEYING.

The Ninth BOOK.

THE ARGUMENT.



THE other *Eight Books* consisting principally in *Mathematical Demonstrations*, it may seem something strange to the Reader, to find any thing after: for when Art, by Demonstration, hath done its best, what can be imagined to remain for farther Dilucidation? This at first Sight and common View seems a plausible Inference: but when upon second Thoughts you make a nearer Inspection, you will find that there is something wanting to make that *Idea* complete.

* 'Tis true, the *Mathematicks* demonstratively conclude upon the *Theses* laid in their own Art ;

* Therefore (by the Assistance of a Person learned in the Law) this Ninth Book is added.

Art; And such are the first *Eight Books*, which indeed have very absolute *Conclusions* Mathematically demonstrated: But yet there is a *Unum Necessarium*, one other necessary Ingredient, without which, the whole cannot be compleat: and this is the highest *Refined Reason*, which we in a familiar Style term the *LAW*. And if *Lex*, as is commonly reputed, be derived à *legendo*, from chusing, then we may define it thus: *Lex est ea Rationis pars quam Intellectus format in actum, spectans tam ab antè quàm ad post ad necessitatem rei, consuetudinem loci, & aptitudinem personarum*. Now according to this Definition, it is in a manner impossible that the Intellect should rightly act without the help of these Adjuncts; therefore to shew that we at least endeavour to aim at Perfection in this Work, we have added this *Ninth Book*. 'Tis true, some imperfect *Specimen* there was before, which in it self was, though but an *Essay*, yet gave a Glimpse of future Intentions, which in this we now hope to make appear, and shew you how necessary the Knowledge of the *Law* is to every Art. For when *Land* is measured, (which many Rusticks are able to do) yet the *Lord* is little the better, neither knowing his *Tenures*, nor having due *Entries*, whereby either himself or his Steward are able to hold *Courts*, or decide *Differences* among the *Tenants*; nay sometimes not to set forth the *Exents* or *Bounds*, whether they belong to this or that Lord.

THE



T H E
L E G A L P A R T
O F
S U R V E Y I N G.



E will not trouble you with Definitions of the Word *Mannor*, though we could shew you several Etimologies thereof, as either Learning or Fancy has dictated: but we lead you into the Matter at first.

What a Mannor is.

A *Mannor* then consists of Lands, Wood, Meadow, Pasture and Arable, Messuages, Tenements, Services, and Hereditaments, Whereof part are Demesnes, being such as anciently, & *ultra memoriam*, the Lord has ever used, occupied and manured with the Mannor-house: The rest are either Free-holds, Farms, or customary or copyhold Tenements. And these have usually divers Services, besides Rents belonging thereto.

The Original of a Mannor.

NOW the Beginning of these Mannors originally arose from the KING, who when he gave Lands to his Followers in such quantity as exceeded the Proportion of a Man's manuring, and being not distinguished into Parts or Qualities, he to whom such Land was given to him and his Heirs for ever, enfeofed divers others in smaller Parts thereof, as some in 20, others in 40, and some in 100 Acres, and some more, some less: and in consideration thereof, each Feoffee was to do some Service to the Feoffor, others to pay him Rents, and the like, with Reservation of some Parcel of the Lands to himself to manure for the Support of his Family.

And

And this Erection of *Mannors* we may attribute to the Time of the *Normans*, because we find no such among the *Saxons*, though the thing in Substance was the same: for what we call *Mannor* they called *Berry*, both signifying a Mansion-house or Dwelling-place. And we find several Remains of the *Saxon* Name in divers Counties of this Realm, especially in *Hertfordshire*. The Tenements are usually called in Latin *Prædia*, in English *Granges* or *Farms*, which Word is derived from the *Saxon* *Feormian*, signifying to feed or yield Victual: for heretofore the Reservations were more in Victuals than ready Money.

Things appertaining and appendant to a Mannor.

I. **T**HERE is also belonging to a Mannor a *Court Baron*, and to some of more Note, a *Court-Leet*: to which, and so consequently to the Mannor, are usually appertaining *Fines*, *Issues*, *Amerciaments*, *Heriots*, *Waifs*, *Estrays*, *Escheats*, *Reliefs*, and other Perquisites and Profits of Court,

II. There are also, or have been heretofore appendant to a Mannor, *Wards*, *Marriages*, *Advowsons*, *Patronages*, *Presentations* of *Parsonages*, *Vicarages*, *Chappels*, *Prebends*, &c.

III. Also *Common of Pasture*, *Moors*, *Marshes*, *Free Warrens*, *Customs*, *Liberties*, *Franchises* and *Privileges*.

IV. Likewise *Rents*, *Suits of Court*, *Tiths*, and *Services* issuing or reprimed out of other Mannors.

But all these make not a *Mannor*, nor doth the want thereof destroy it. And indeed of such Nature is a *Mannor*, that although a Man have sufficient Lands to establish *Messuages* and create *Services*, and should divide the same into *Demefnes* and *Tenement-lands*, infeofing Tenants in Fee in some part, and granting to others by Copy of Court roll, and do all other things belonging to a *Mannor*; yet will not all this make a *Mannor*, because it is requisite to a *Mannor*, that all these things be of long continuance.

A Mannor cannot be erected at this Day.

NO Man at this Day can erect a *Mannor*, for there must be *Very Lord* and *Very Tenant* in Fee-simple, and that of ancient Continuance: for a Man may have *Demefnes* to manure, and Tenants to do him *Services*, and that for a long time, and yet no *Mannor*. As if a Man that had Land did give part of this Land in former time to some other to do him *Services*, here are *Demefnes* in the Donor, and *Services* and a Tenure in the Donees; yet because there be not *Very Tenants* in Fee-simple it maketh no *Mannor*.

A Mannor descending in divers Co-heirs.

BUt if a *Mannor* descend to divers Partners and Co-heirs, either in Joynttenancy or in Common, and they sue out a Writ of Partition, and divide the same, and every one hath Demefnes and Services, in such case each hath a several *Mannor*, and may keep several *Courts-Baron*. 26.H. 8. 4.

A Mannor may be destroyed.

THough a *Mannor* cannot be raised at this Day, but in the case above-mentioned, yet may it be dismembred or destroyed both in Name and Nature, by escheating the Free holds and Copy-holds: for if there be not two at the least of either of these, then are there no Suitors, and without Suitors can be no Court, and consequently no *Mannor*: yet it may be termed a *Seignior*y, which can keep no *Court-Baron* at all. 35 H. Fitzh. 3. c.

How two Mannors may be united.

A Man having two *Mannors* lying together, whereof one is decayed, and hath lost the Power of keeping a *Court-Baron*; the Lord is willing to have the Tenants of both these *Mannors* to do their Suits and Services to the Court of the other *Mannor* that remains: this intended Union cannot extinguish their several Distinctions, for they remain two in Nature, though the Lord desire to make them one in Name; and the remaining *Mannor* hath no Warrant to call the Tenants of the decayed one, but every Act done in one to punish an Offender in the other is traversable. Yet if the Tenants will voluntarily submit to such an Innovation, and the same be continued without Contradiction, Time may perfect such an Union. But if one *Mannor* do hold of another, and it escheat to the Lord, the escheated *Mannor* may be united, and of two distinct *Mannors* may become one in use, if the Lord please.

Of the Propriety which a Lord may claim in his Mannor.

WE now proceed to set forth the Propriety a Lord claims in his *Mannor*, and we may term it an *Evidential Right* or *Propriety*, which is made out by his Deeds, Charters and Evidences; or a *Possessory Right*, arising from Duration of Possession; and this may be either perpetual, which we call either *Allodium* or *Feodium*; or determinable.

Allodium.

Allodium or Feodium is an absolute Property and perpetual Right in Possession, without Dependence on any superiour Lord; and

and this is proper solely to the KING, *Jure Corona*. And from hence in the Time of King Edward the Confessor, all the Crown-Lands were called Ancient-demesne. *Kitchin* 98. *Bro. tit. Demesne*. And in *Dooms-day Book* still in the *Exchequer*, they are recorded under the Title of *Terra Regis*.

But this is not the Fee we think of, which we shall divide into *Fee-simple* and *Fee-tail*.

Fee-Simple.

FEE-Simple is of all other Estates the most large and absolute that can by our Laws be made or vested in any Person, and is that which is granted to a Man and his Heirs for ever, without any farther or other Limitation of Use or Uses. But if a Man purchase in *Fee-Simple* to him and his Assigns for ever, omitting the Word *Heirs*, he hath an Estate for Term of Life: Also if Lands be granted to any Man with a Woman in Frank-Marriage, then the Word *Assigns* implieth an Estate of Inheritance, without mentioning the Word *Heirs*: and so likewise to a Man and to his Blood. And here we must consider who are said and understood to be a Man's Heirs by the Course of the Common Law: as for Example.

Heirs, who.

SUPPOSE *A. B.* dies seized of an Estate of Inheritance without Issue of his Body: neither his Brother nor Sister of the half Blood, nor their Issue shall be the Heir, nor his Bastard, nor his Father, Mother, Grandfather or Grandmother; for Inheritance may lineally or collaterally descend, but not lineally ascend: but the Brother or Sister of the Father *A. B.* (being a collateral Descent) shall be his Heir: And then they dying seized without Issue, the Father of *A. B.* shall have the Land as Heir unto his Uncle or Aunt, but not as Heir to him.

Daughters joynt Inheritors.

SO by the Law of *England* the eldest Son is to inherit, and he dying without Issue, the second Son, and so the rest; and if there be only Daughters, they shall joyntly inherit as Coparceners: but if no Issue, neither Son nor Daughter, then shall the eldest Brother be Heir; and for want of such elder Brother, all the Sisters; and in default of them, the Uncle by the Father's side, if the Land came by the Father, or be of the Purchase of him so deceased. But if there be no Heir of the Father's side, the purchased Lands goes to those of the Mother's side: But if none such be, then the Lands escheat to the chief Lord of the Fee.

Fee-Tail general.

FEE-Tail, *Feodum talliatum*, is two-fold; either general, or special. *Fee-tail general* is, when Lands or Tenements are granted to any Man and the Heirs of his Body begotten, without Limitation to what Woman. Wherefore if such Tenant in Fee-tail general marries divers Wives, and hath Issue by them severally, they shall all be capable to inherit those Lands. But if mention be made from what Woman the Heirs shall come, as if a Gift be made to *A. B.* and to the Heirs of his Body lawfully begotten on the Body of *C* his Wife, this is an Estate in *Fee-tail special*, for by means of this Grant none shall inherit that are begotten of another Woman.

Fee-Tail special.

Also if Lands be granted to *H. I.* and *K.* his Wife, and to the Heirs of their two Bodies lawfully begotten; here the Man and his Wife are Joynt-purchasers: and this is also a *special Tail* both in him and her.

So if a Man grant Lands or Tenements to another Man with his Daughrer in Frank-marriage, this also is a *special Tail*,

So if Land be granted to a Man and the Heirs Males of his Body, this is an *Estate Tail*: and here the Females shall not inherit.

Of determinable Rights.

Determinable Rights are fourfold; *viz.* 1. Estates after possibility of Issue extinct. 2. by Curtesy. 3. in Dower. 4. for term of Life or for Years, as by Lease, Mortgage, &c.

Tenancy after Possibility.

1. **A**fter Possibility of Issue extinct is this: If Lands or Tenements be granted to a Man and his Wife, and to the Heirs of their two Bodies lawfully begotten, and either of them die without such Issue between them, then is he or she surviving Tenant in Tail of those Lands, but without Hope, and past Possibility of having such Heir as was limited to inherit those Lands; and therefore such Survivor is called *Tenant in Tail after Possibility of Issue extinct*: and after the Death of such Survivor, the Estate Tail shall be utterly void, and the Estate of Inheritance of, in and to those Lands shall revert to the first Donor and his Heirs.

By Curtesy.

2. **B**y Curtesy: As if a Man marry a Wife being an Inheretrix, and hath Issue by her, and she dye; he shall enjoy such Lands as his Wife died seized of either in Fee-simple or Fee tail during his Natural life; and he is called *Tenant per le curtesy d'Angleterre*

terre, Tenant by the Curtesy of *England*, because no other Nation admitteth such an Estate: But in this Case the Law requires that such Issue be born alive and heard to cry, although it dye immediately after: it is requisite also that the Husband be in actual Possession of those Lands and seized of them *jure uxoris* at the time of her Death. But such Tenant by Curtesy may not commit Wast, for he is punishable for it by an Action of Wast.

In Dower.

3. **I**N *Dower*: as for Example; By the Law of *England*, if a Man marry a Wife, and at any time during the Coverture he be lawfully seized either by Purchase or Descent of any Lands or Tenements either in Fee-simple or Fee-tail, and being so seized die, his Wife shall be endowed of a full third part of all those Lands and Tenements during her Life, and is called a *Tenant in Dower*, this is by the *Common-Law*.

Dower in Custome.

THERE is a *Dower by Custome*; for in some Places the Woman shall have a Moyety, and in some more, and in other Places less of her Husbands after Death: but this is according to the several Customs of the several Places.

But if the Wife be not above the Age of nine Years at her Husbands Death, by the Common Law she shall not be endowed.

There are besides these other kinds of Dowers, *viz.* one *ex assensu Patris*, by the Fathers assent; another termed *Dos ad ostium Ecclesie*; and a third *de la plus belle part*: As may be seen at large in our Books.

And though the Common Law be thus careful, yet for divers Causes a Woman may be defeated of her Dower: as, if she or her Husband commit Treason, Murther or Felony, and be thereof attainted, (though afterwards pardoned:) so if she forsake her Husband and live unchastly, and be not reconciled again without Compulsion of Law: or if she detain and with-hold the Deeds and Evidences from the Heir of those Lands wherein she claimeth Dower, and the like.

There are also several things whereof a Woman cannot be endowed, as of Commons, Annuities, Estovers *sans number*, Homages, Services, and the like.

Tenant for Life.

4. **F**OR *Term of Life*. Now a Tenant for Term of Life, is one who holdeth Lands or Tenements either for Term of his own Life, and then he is termed barely *Tenant pro termino vite*, Tenant for Life; or else for term of another Man's Life, and then is called *Tenant pur terme d' autre vie*, that is Tenant for term of another Man's Life. And if either of these commit or suffer Wast, the

Lessor

Lessor or Reversioner may have his Action of Wast against him, and thereby recover treble Damages:

By Copy.

5. **B***T Copy of Court-Roll.* These in divers Mannors hold Lands and Tenements to them and to their Heirs, some in the Nature of Fee-simple, others in Fee-tail, or for term of Life or Lives at the Will of the Lord, according to the Custom of the Mannor: In some they hold by Copy for term of Years. And all these have no other Evidence to shew for their Lands, save only the Copies of the Rolls of their Lord's Court. And if any of these alien or sell his Lands by Deed, he absolutely forfeits the same into the Hands of the Lord. If therefore he intend to alien, he must come into the Lord's Court, and surrender the same into the Lord's Hands to the use of Purchasors. But in many Mannors the Surrender may be made out of Court to any Copyhold-tenant in the presence of two of the Homage to the use aforesaid, who are to present unto the Steward at the next Court, where the Purchasor shall be admitted. And if any of these cut Timber growing on his Lands, without license of the Lord, (but only for the Repair of his Tenement) it is not only a Wast, but an absolute Forfeiture. And in most Mannors if any such Tenant shall let out his Lands for a longer time than a Year, without the Lord's license, it is likewise a Forfeiture. But in these, and many other Cases we are to be guided by the Custom of the Mannor of which such Tenants hold. Thus having gone through Estates of Inheritance and Freeholds, we next come to Chattels.

Of Chattels.

C*Hattels* are of two sorts, real, and personal.

Chattels real.

C*Hattels real* are threefold: 1. Term of Years; 2. Tenure at Will; 3. Wardship of Lands.

Tenant for Years.

1. **T***erm of Years.* A Tenant for Term of Years is one to whom an Estate is granted of or in Lands for any number of Years agreed upon between the Lord and Tenant, which Term is always expressed in the Lease so granted, as we see every Day. On which Lease there is usually reserved some Rent payable either half yearly or quarterly: For the Recovery and obtaining of which Rent being arrear, the Lord may either distrain, or bring his Action at Common Law. And upon these Leases there needs no Livery of Seisin, as in Leases for Term of Life or Lives there must be. Nor may such Tenant commit Wast. And if he grant unto any other a larger Estate of what he holds than he himself hath therein, he shall forfeit his Lease.

At Will.

2. **T**enant at Will is one to whom Lands and Tenements are granted to hold at the Will of the Lessor : and this Tenant may be ejected or put out at any time, yea although he hath tilled and sown his own Lands. Yet in this Case the Law allows him liberty of Ingress, Egress, and Regress, as well to take, cut and carry away his Corn when it is ripe, as to take and carry away his Goods and Household stuff within convenient time, without committing Trespass or otherwise. But the Lessor hath the same Remedy against this Tenant as against Tenant for term of Years, for Recovery of his Rent that may or shall be in arrear or unpaid. But this Tenant is not chargeable with Reparations,

3. *Wardship of Lands.* But this is absolutely taken away by a Statute made in the twelfth Year of KING CHARLES the Second, Chap. 24. intituled *An Act, &c.*

Of the several Tenures in a Mannor.

THE next to be legally observed in a Survey, are the several Tenures that are, or may be found within the Mannor : as *Knights Service*, including Homage, Fealty and Escuage, and formerly drew unto it Ward, Marriage and Relief : but these three last are taken away by the before-mentioned Statute, 12 Car. 2. cap. 24. *Castlegard* also is within this Tenure, and also *Grand Sergeanty*.

Petit Sergeanty.

Then follows *Petit Sergeanty*, which in effect is no other than Socage, because the Tenant is not bound to the Performance of any Personal Service, but to pay something yearly. Then *Socage*, where a Man holds Lands or Tenements by Fealty and certain Rent for all manner of Services : and it was called *Servicium Socæ*, because in ancient time these Tenants were obliged certain Days in the Year to plough and sow their Lords Demesnes : and the French Word so signifying, *Vomer*, a Coulter or Plough-share, seems to imply so much. But now that Service is by mutual Consent between the Lord and Tenant in many Places changed into an annual Rent, yet the name of Socage still remains.

Burgage.

THE next Tenure is *Burgage*, where an ancient Borough holds of the KING by a certain yearly Rent. And these have divers Customs and Usages peculiar to themselves, and distinct from other Places, and sometimes very different from the Common Law ; but their Probability and Coherence with Reason together with a long Prescription make them allowable, and therefore particular respect must be had to them,

Of Copyhold-Tenure.

THere is also *Copyhold-Tenure*, which (saith *Kitchin* 80.) is a base Tenure, and was originally called *Villanage*. *Fitz.* 12. But this may now be properly termed *Meer-copy-hold*, and escheats forthwith to the Lord by Felony. *Kitchin* 81. And some is of more Eminence, and held by Verge (*Per Virgam*) in ancient Demesne, according to the Custom of the Mannor, being in effect a kind of Free-hold, (though reputed Copy) and yields to the KING *Annum, diem & vastum* upon Felony.

Fine at the Will of the Lord, Fine certain.

Some of these Copy-holds make Fine at the Will of the Lord; others are held by Fine certain. And this is a kind of Customary Inheritance.

Tenants by Court-Roll.

But there is a kind of Customary Land belonging to the ancient Duchy of Cornwall, and some few other Places, where the Tenants have no Transcripts of the Entries of their Admittances: and these Tenants may not improperly be called *Tenants by Court-Roll*. But where they have such Transcripts, they are called *Tenants by Copy of Court-Roll*. In the first of these the Land was among the Saxons called *Folk-land*, and the latter *Bock-land*. *Kitch.* 86. 89.

Of Tenure in Fee-Farm.

THere is also a Tenure in *Fee-farm*; and that is a Fee, and imports a Perpetuity to the Investee and his Heirs for an annual Rent of the third part, or the fourth part of the Value.

Of Rents, and their several Natures:

WE will not insist any farther on this Point, but proceed to what follows necessarily, *viz.* Rents and their several Natures. Now these Rents are either proper, or improper.

Rents Proper.

Rents Proper are three: *viz.* Rent Service, Rent Charge, and Rent Stock.

Rent Service:

Rent Service is where a Man holds his Lands of his Lord by Fealty and certain Rent; or by Fealty, Service and certain Rent. *Lit. lib. 2. c. 12.* or that which a Man, making a Lease to another for term of Years, reserveth yearly to be pay'd for them.

Rent Charge.

Rent Charge is where a Man makes over his Estate to another by Deed indented, either in *Fee, Fee-tail*, or for *Life*, yet reserves to himself by the same Indenture a Sum of Money yearly to be pay'd to him, with Clause of Distress for Non-payment. See *Littleton ubi supra*.

Rent Secke.

Rent Secke, or dry Rent, *Redditus siccus*, is that which a Man, making over his Estate by Deed indented, reserveth yearly to be pay'd to him, without Clause of Distress mentioned in the Indenture.

Rents improper.

Rents improper are, where of an uncertain and casual Commodity a certain Rent or Receipt is by Contract created and raised: as for *Licences, Swan-marks, Profits of Fairs, Markets, Courts, Customs, Tollage, Pontage, Cranage, &c.*

Of Perquisites or Parallels to Profits belonging to a Mannor.

Other Revenues belonging to a Mannor, and necessarily to be taken notice of in a Survey, are either Perquisites, or Parallels to Profits.

Increase.

Perquisites come either by Increase, or Casualty. Increase comprehends all Profits derived from the Production of the Earth.

Casualty.

By Casualties are intended all Duties and Services that be Appurtenant or Appendant to a Mannor.

Appurtenances.

Under Appurtenances may be ranged, all *Royalties, Prerogatives, Jurisdictions, Franchises, Priviledges, Liberties, Services, Customs, &c.* and all Advantages derivable from them, as *Perquisites of Courts*, and therein *Pleas, Fines, Amerciaments, Heriots, Waifs, Estrays, Deodands, Goods of Felons and Fugitives*, (by special Grant) *Forfeitures, Escheats, Treasure trove, Warrens, Commons of Pasture, Turbary, Piscary, &c.*

Appendants

Appendants.

Appendant are *Hospitals, Patronages of Churches* and Benefices, whose value is to be accounted from the Privilege of electing and presenting an able Clerk to supply the Church, not from a Simoniackal Advantage raised from any Contract with another for Presentation, &c.

Parallels to Profits.

Parallels to Profits are *Pursuits of wild Game*, which is held equivalent to profitable Accrements, such are *Hunting, Hawking, Fishing* and *Fowling*.

Hunting.

FOR *Hunting*, record what Beasts of the Forest there be, and how frequent, and what of the Chace.

Hawking.

FOR *Hawking* enumerate the Fowls of Warren, as *Pheasant, Partridge, &c.* and to this may *Fowling* be reduced.

Fishing.

Fishing is either in fresh Waters, as *Rivers, Brooks, Pools, Ponds, Lakes, Meers, or Ditches*; or else in *Seas* or other salt Waters. It is necessary therefore that all those Fishings be taken notice of.

Of Reprises, Deductions, Payments, Charges, and Duties, issuing out of the Mannor.

AS we have formerly understood that several Rents, Profits, and Commodities may yearly arise or grow out of any Mannor to the Lord thereof; so is it as fitting to consider what Reprises, Deductions, Payments, Charges and Duties may be yearly issuing or going out of any Mannor: for otherwise in the Conclusion of our Survey, or in making perfect Constats or particulars, (such Duties not being reprised) the true Value of the Mannor may oftentimes seem greater than in Truth it is.

These *Reprises* and *Deductions* are never certain or generally alike in all Mannors. They are Impositions and Duties whereunto the plot or Fee is in peculiar liable; and are any manner of Rents, either in Money, Capons, Hens, Pepper, Cummin seed, or the like, issuing and pay'd out of one Mannor to another.

Also *Suits of Court*, or annual *Fines* for the same, and the like, may be issuing and payable to a Sheriff's *Tern* or *Hundred*: also *Pensions* or *Portions* to *Ecclesiastical Livings*. Likewise a *Rent* may be issuing for a *Way* leave or some particular passage; also for *Water-Courses*, or placing of *Pipes* for Conveyance of Water. Likewise yearly *Fees* to Officers, as *Stewards*, *Receivers*, *Bailiffs*, *Collectors*, &c. and also *Stipends*, *Salaries*, *Annuities* to *Chaplains*, *Lawyers*, or the like. All which are to be deducted, and the Estimation of *Reprises* to be opposed to the total Valuation; by which means the *Remanet* is rectified, and the true Value retrieved.

Observations and Courses to be held and taken for the orderly marshalling of Surveys.

HAVING thus far informed you of *The Legal Part of Survey*, by having shewn what a *Mannor* is, and the several Parts thereof, and likewise of all *Estates* in general, and what *Tenures*, *Services* and *Rents* are thereunto incident, appertaining and belonging: we will now proceed to the *Observations and Courses* to be held and taken for the orderly marshalling of Surveys, for accommodating *Field-Entries* in rough Books, for *Ingrossments* and their Exemplifications, with framing of *Terrars*, *Rentals*, *Custom* and *Court-Rolls*, *Particulars*, &c.

For the effecting of this, the Surveyor is to consider for whom he is to undertake his Survey, whether for the King, or a Lord of a Mannor.

If it be to the King, then Commission is to be obtained out of such of his Majesties Courts as relate to the Lands of the Surveyed, as out of the *Exchequer*, *Dutchy*, &c. Unto which Commission Articles are to be annexed, which Articles ought to (see that they) be as strong and efficacious as may be, for that he knows not what obstinate persons he may meet with in his perambulation.

But if the Survey be undertaken for a private Person, Lord of a Mannor, then (the Surveyor of himself not having power to administer an Oath) the Steward of the Mannor is to be joyned with the Surveyor. Or otherwise, The Surveyor is to have a Commission granted from the Lord of the Mannor, under his Hand and Seal, to perform the Office both of Steward and Surveyor of his Mannors, Lands, and Tenements, for a certain time, during his pleasure. And then may the Surveyor of himself execute the Offices and Duties both of Steward and Surveyor.

The

The Form of a Deputation or Commission granted from a Lord of a Mannor to a Surveyor, may be in this or the like Form.

OMnibus ad quos hoc presens scriptum pervenerit A. B. de C. Comit' E. Armig' salutem. Sciatis me prefat' W. L. tam pro sincero amore & benevolentia qua jamdudum affectus sum erga A. R. de cujus provida circumspectione, pia sedulitate, ac singulari in hac parte prudentia merito plurimum confido, quam pro diversis aliis causis & considerationibus, ex mera & spontanea voluntate me dedisse & per presentes concessisse eidem A. R. Officium Seneschall' sive Seneschalciam omnium & singulorum Domin', Maner', & Hereditament' meorum quorumcunque in Comit' F. & custod' sive Officium tenendi omnes & omnimodas Cur' Baron' Letar' vis' Franc' pleg' Dominor' & Maner' predict' & eorum cujuslibet, ac gubernationem & supervisionem eorundem, ac Ipsum W. L. Generalem ac Capital' Seneschal' ac supervisorem meum omnium Curiarum, Dominorum, Maneriorum & Hereditamentorum meorum predict' facio, constituo & ordino per presentes, Habenda tenenda gaudenda exercenda & occupanda Officia predict' cum pertinentiis, a dat' presentium durante beneplacito meo. Mando insuper universis & singulis Balivis, preposit' firmariis, tenentibus & occupatoribus meis premissor' & eorum cuilibet, quod prefat' A. R. de tempore in tempus, assistentes sint, obediens, & auxiliantes in omnibus prout decet durant' termin' predict'. In cujus rei testimonium huic presenti Scripto meo Sigillum meum apposui. Dat'.

Or to the same purpose in English.

TO all Persons to whom this present Writing shall come, I A. B. of ----- in the County of C. Knight and Baronet; send Greeting. It is my Will and Pleasure, That W. L. &c.

This is an usual Form, but commonly Lords of Mannors do direct their own Letters of Warrant to their Tenants, unless the Surveyor be a known Surveyor by Patent, for the holding a Court-Baron; which being performed, and the Charge of the said Court ended, the Surveyor may proceed in this manner:

First, Taking notice of the Names of every Tenant, both Freeholder and Copy-holder, Lessee and Tenant at Will in a Paper, and a Jury for the Survey being impannell'd (after they be sworn) the Surveyor may give them a Charge in Words according to his own Discretion relating to all the Particularities we have herein before mentioned, and such others as suit with the Exigence of the said Mannor.

Then he is to receive from the Bailiff all such Rentalls as he hath as well ancient as later, which you are diligently to compare together, noting the Difference: and if the latter be less, then what

De-

Decays of Rent there are, and how occasioned; if greater, then what encrease of Rent; and how raised: which must be carefully expressed when the Roll comes to be engrossed.

Next let the Rental be reduced to an Alphabetical Form wherein write the present Tenants Name and the Name of his Predecessor, which will be a great Help for the speedy Dispatch of the Entries, and the more easie and ready finding any Tenants Name or Rent; in this manner.

	lb.	s.	d.
<i>Anderton Thomas</i> , late <i>Chapmans</i> , Rent per Annum —	01	10	00
<i>Barnadiston George</i> , late <i>King</i> , Rent per An. —	02	00	00
<i>Cadman William</i> , late <i>Fisher</i> , Rent per An. —	00	10	00
<i>Dodson George</i> , late <i>Smart</i> , Rent per An. —	00	13	04

It is also to be considered, that most *Mannors* consisting of divers Townships or particular parts, and the Tenancy of those Townships of divers Estates, as aforesaid, therefore it is fitting that not only every of those Townships but the several Estates therein, be entred and taken severally and particularly by themselves, that is all of one and the same Township and Estate under one and the same Title, for avoiding Confusion. And these Entries ought to be made in loose Sheets of Paper at large, keeping them always sorted according to the several Townships and Estates, till they be all finisht; and then to be filed together orderly in a Book. When this is prepared and the Instrumental Mensuration finished, and the several Contents thereof cast up, then make an Alphabetical Table of all the Tenants Names; with the Name of the Lord also for Demesnes, and of the Parson for the Glebe; and so accordingly perfect your Entries from your Field Books and rough Books of Entries. And when this is done for the true and certain Quantities according to Measure, then proceed to the Valuation.

Now the best, speediest, and most certain means to accomplish this may be this: First, Let it be considered that all Grounds generally as to quality consist of these three kinds; 1. Meadow; 2. Arable; 3. Pasture. And supposing every of these kinds likewise to consist of 3 sorts as to Value and Goodness, as, the 1st and best sort, the second and mean, the third and worst: Therefore at the time of the Instrumental Mensuration let it be considered, and noted in your Field-Book which of those three sorts any Field or Close consisteth of. And having informed your self of the general Value, what the best sort of Meadow, Arable, and Pasture is worth by the Acre, and the like of the other sorts throughout the whole *Mannor*; then according to those Rates enter every particular parcel by it self; yet before these Entries are to be engrossed, it is to be enquired and considered what other profits and Commodities, besides these Lands and Tenements, are demised and granted by the Lord to any Tenant within the *Mannor* for yearly Rent or otherwise, which likewise are to be entred with the Rents and Yearly Values thereof, as Mines of Tin, Lead, Copper, Coal, &c. Quarries of Stone, Fishing, Fowling, Hawking, Hunting,

Hunting, Justments, Herbage and Pannage, free Warrens, customary Works or Services, Profits of Fairs and Markets, and Mosses of Peat and Turf; all, or any of which, and the like, may be within a *Mannor*, and disposed and let out for annual Rents, and are in no wise to be omitted. All which Premises, and the several quantities, Rents and Values thereof, are to be summed up, and their several Totals to be expressed.

Then must be set forth the several Reprises issuing out of the same *Mannor*, being such as we have before mentioned. All which being likewise summed up, the Total thereof is, as we said, to be deducted from the former Value, and the clear Remainder is to be set down.

The next thing to be considered is, if any of those Profits or Commodities last before named, or the like, are within the *Mannor*, and not by Lease or otherwise for any certain yearly Rent: and if any such be, they are to be mentioned as Casualties, and the yearly Value thereof estimated, what they may or are likely to prove worth by the Year. Also the Names and Quantities of the common Fields, common Meadows, stinted Pastures, and all other unstinted Commons, how they are accustomed, held and occupied; whether peculiar to the Lords and Tenants of that Mannor, or whether any other Lord or Lords and their Tenants have rake, escape, catage, or other Interest therein, and the Butts, Bounds and Limits thereof severally. Also what Woods and Under-woods are within the Mannor, and their several Values. Then would there be entred an Abstract in nature of a Custom-roll, shewing briefly all the Customs anciently of or belonging to the Mannor: and also a Suit-roll of all the free Suitors, &c. and lastly, a true and perfect Description of all the Out-bounds and Limits of the whole Mannor.

For other the Lord's possessions comprised or fit to be comprised within the Survey, and reputed no part or Member of the Mannor, they require to be recorded apart in the *Infra* under the distinct Title of *Non-Parcels*, viz. Churches, Chappels, Alms-houses, &c. Also Patronages, Villains, Commons, Annuities, and other particulars held in gross. And now when all is done, Register all Omissions under the separate Title of *Memorandums*.

Of the Order of keeping a Court of Survey. And of the Charge to be given to the Jury, by the Steward of the Court: or by the Surveyor (if authorised thereunto.)

HAVING followed these Directions in your Entries and Books, it is now time to summon together your Tenants in order to the keeping of your Court of Survey, which is to be performed in this or the like manner.

The several Tenants of the Mannor being met together at the place appointed where the Court is to be kept, and the Style (or Title) of the Court entred: Then cause the Bayliff of the Court to make Proclamation by crying once *O Tes*; and afterwards will him to say after you, Thus:

ALL manner of Persons, who were summoned to appear here this Day, to serve the Lord of the Mannor for his Court now holden, draw near and give your Attendance, and every one answer to his Name as he shall be called, upon the Pain and Peril that may fall thereon.

Then call (by the help of your Rental) all the Tenants severally by their Names, marking such as are absent to be amerced. This done, Cause the Bayliff of the Court to make another *O Tes*, willing the Tenants to draw near, keep Silence, and out of those Tenants which are present, select most of the sufficientest and ablest for your Jury, whose Names having from your Rental written in a paper by themselves, call them by their Names accordingly. Which done, cause him that is the Foreman to lay his right Hand on the Book, and swear him in this or the like manner.

YOU shall diligently enquire and make true Presentment of all such Matters as on the Lord of this Mannors behalf shall be given you in Charge. You shall neither for Fear, Favour, or Affection, or other partial Respect whatsoever, forbear to present what you ought to find; or find what you ought not to present. You shall herein keep the Lords Counsel, your own and your Fellows, and in all things according to a sincere and upright Conscience you shall present the Truth, the whole Truth, and nothing but the Truth, as by Evidence and your own Knowledge you shall be induced, to the best of your Power, so help you God, &c. causing him to kiss the Book.

When the Foreman is thus sworn, cause three or four more of the Jury to lay their Right Hands on the Book, and give them their Oath as followeth:

THE same Oath which your Foreman before you hath made and taken, you and every of you, for your Parts, shall truly keep and perform to the utmost of your Power, so help you God, &c. and let them severally kiss the Book.

And in this manner swear all the rest.

Which done, Cause the Bayliff of the Court to make a third *O Tes*, and say thus;

ALL you that be here sworn, draw near, and hearken to your Charge, the rest keep Silence.

The

The Charge to be given to the Jury, may be divided into these following Heads, *viz.*

1. You are to enquire whether *A. B.* be Lord of this Mannor of *C.* and if not, who hath the Right and Interest in or of the same to your Knowledg.

2. You must shew unto the Surveyor in his Perambulation all the Circuit, Butts, Bounds and Limits of the same, and upon what and whose Mannors, Lordships, Lands and Parishes it borders; and whether any confining Lord or his Tenants do any where in-croach upon it, and by whom, where and how much is so in-croached.

3. Whether there be any other Mannor or Mannors lying within the Limits or Circuit, or extending in part into this Mannor: what are their Names? and who are Owners of them? and how are they distinguished from this? and doth this lye within any other Mannor?

4. What Freeholders there are within, or belong unto, and hold their Land of this Mannor? what are their Names? what Land do they hold, and by what Tenure? what Rent do they pay? and what Services do they owe?

5. Whether any Freeholder within or belonging to the Mannor hath committed Felony or Treason, and hath been thereof convicted, the Lord not yet having the Benefit of the Forfeiture: or whether hath any such Tenant died without Heir general or special? If so, who hath the present Use and possession of the Land, and by what right? what is the Land? where lies it? and how much in Quantity, and of what Value?

6. Whether doth any Bastard hold any Land belonging to the Mannor as Heir to any? what is his Name? what Land is it? where does it lye? and what is it yearly worth? Here we are to observe that a Bastard, though he be known to be the Son of that Father that leaves him the Land, cannot inherit *jure hereditatis* but by Conveyance. Neither if he purchase Land in his own Name, can any inherit it after him of his supposed Blood, unless he be married and have Children lawfully begotten, because it is *contra formam Ecclesie*, as appears by the *Stat. of Merton, cap. 9.* For a Bastard is no Man's or every Man's Son or Daughter; according to the old Verses,

Cui Pater est Populus, Pater est sibi nullus & omnis:

Cui Pater est Populus, non habet iste Patrem.

7. What Demefne-lands has the Lord within or belonging to the Mannor? what and how much Woods, Under-woods, Meadow, Pasture, Arable, Moors, Marishes, Heaths, Wafts or Sheep-walks? and what is every kind worth yearly by the Acre? how many Sheep may the Lord keep upon his Walk Winter and Summer? what is a Sheep-

Sheep-gate worth by the Year? and what is every Acre of Wood worth by the Year?

8. What Demefne lands hath the Lord lying in the common Fields of the Mannor? how much in every Field and every Furlong? what is an Acre of ordinary Field arable Land worth by the Year? The like is to be said of Demefne-meadow lying in any common Meadow within the Mannor.

9. What are the Names of all your common Fields? and how many Furlongs are in every Field? what common Meadows and their Names? and what Beasts or Sheep may every Tenant keep upon the same when the Corn and Hay is off? and what is a Beast-gate and Sheep-gate worth by the Year? at what time are your common Fields and Meadows laid open? how are they or ought they to be used? whether is it lawful for the Tenants to inclose any part of their common Fields and Meadows without the License of the Lord and Consent of the Tenants?

10. What Commons are there within the Lordship which do properly belong to the Lord and Tenants of the Mannor? and how are the Tenants stinted? whether by the Yard-land, Plough land, Ox-gang, Acres, or Rent? how many may every Tenant keep after either Proportion or Rate? Here we are to take Notice of the Statute called *Extenta Manerii* made 3 E. 1. in which this kind of Pasture is called *Pastura forinfeca*, forein Herbage or Pasture, because no part of it is proper to any peculiar Tenant, no nor to the Lord himself, as are the common Fields and common Meadows. This kind of Common or *Pastura Forinfeca* is of three sorts. The one is where a Mannor or Township, holding their Land in severalty, have by consent limited a certain parcel of Ground to lie common among them, and from the beginning have stinted every Man according to a proportion between them agreed; and that is commonly by the Acre. 2. A second manner of such kind of common Pasture is where certain wast Grounds, one, two or more lie within the Township or Mannor, and the Herd of the whole Town is guided and kept by one appointed by the Tenants, and at their general Charge, to follow and look to their Cattle: in which kind of Pasture there is also a Limitation both of the Number and Kinds of Cattel. And this is usual in the North Parts. 3. A third kind of this Pasture or common Feeding is in the Lord's own Woods that lie common to the Tenants, as also common Moors or Heaths that were never arable. In the two former there is a certian Stint and Allotment both to the Lord and his Tenants: but in this latter the Lord ought not to be limited, because supposed his own, and the Tenants have no certain parcel thereof laid to their Holdings, but only bit of Mouth with their Cattel. But the Tenants ought to be stinted in all sorts of Common. Now Commons may be distinguished into, 1. Common in Gross; 2. Common Appendant; 3. Common Appurtenant; and, 4. Common by way of Neighbourhood. 1. *Common in Gross* is where a Man by Deed granteth unto another

another Common of Pasture, 2. *Common appendant* is where a Man is seized of Land to which he hath Common for such Beasts as serve for composting his Land, wherein Geese, Goats and Hogs are exempted : and this kind of Common is by Prescription as an Appendix or Addition only to arable Land, and not to any other. 3. *Common Appurtenant* is in the same Quality, but with greater Liberty, because it is for all kinds of Cattel, Hogs, Goats, &c. as well as other Cattel. And this Common may be made at this Day, and may be served from the Land to which it is appurtenant, and so cannot Common appendant be. 4. *Common by way of Neighbourhood* is where the Tenants of two Lords or more adjoining do inter-common either upon other with all commonable Cattel. But one may not put his Cattel upon others Commons otherwise ; for if they do, an Action of Trespas lies.

11. Whether hath any Man incroached upon any part of the Lord's Wast by Inclosure, or adding any part thereof unto his own Land? who hath so done? where? how much, and how long hath it continued?

12. Whether hath the Lord any Park or Demefne-wood, which by stocking, may turn to the Lord's better Benefit by Pasture, Arable or Meadow? and what is an Acre worth one with another, the stocking? how many Acres does the Wood contain? and what will an Acre of the Wood be worth? and what will the Land so stocked be worth an Acre?

13. What customary Tenants are there within or belonging to the Mannor? what are their Names? and what Messuages, Tenements, or Lands do they hold by Name? and what Rent do they pay? and what arises to the Lord by the Death of any such Customary Tenant, or by the Death of any Free-holder, by Fine, Heriot or Relief by the Custom of the Mannor?

14. How doth the customary Land of the Mannor by Custom descend after the Death of an Ancestor? and whether will the Custom of the Mannor allow an Entail by Copy? and whether doth it bear Widows Estate? and whether may a Man be Tenant by the Courtsey.

15. Whether are there any Customary Tenements that are Heriotable dismembred and divided into parcels to the weakning of the Tenement? and who be they that have these Heriotable parcels? and what quantity hath every one of them?

16. Whether are not the Fines for Admittance of a new Customary Tenant being Heir, or coming in by Purchase or upon Surrender, at the Will of the Lord? or are the Fines always certain?

17. How and by what means may a Customary Tenant forfeit his Copyhold-Tenement? and whether hath any such Tenant offended in any such manner? and who by Name? that is, have they felled any Timber-trees, ploughed up Ley-grounds or Meadows never tilled before, suffered their Houses to decay, pulled down any Houses, or committed any other wilful Wast?

18. What are the Customs of the *Mannor* in general, both in the Lord's behalf to perform or suffer to the Benefit of his Tenants, and of the Tenants to perform to the Service of the Lord?

19. Whether is there within the *Mannor* any *Villain* or *Neife*, that is, any *Bond-man* or *Bond-woman*? if there be, what are their Names? what Land do they hold? and what is the same annually worth? and what Goods do they possess? Observe this Tenure is quite out of use.

20. Whether hath any Tenant or other Person within the *Mannor* stocked up any Hedge-row, ploughed up any Balk or Land-share, removed any Mere-stone, Land-mark, or other Bounds between the Lord's Demesne and the Tenant's Freehold or Customary Lands of Inheritance, or between his Freehold and Customary Land, or elsewhere? where is any such Offence committed? by whom? and where ought the same to stand?

21. What Customary Cottages are there within the Lordship, Tofts, Crofts, or Curtelages? what are the Tenants Names? what Rent do they pay? and what Services do they owe?

22. Whether are there within the *Mannor* any new Tenements or Cottages, Barns, Walls, Sheds, Hovels, Hedges, Ditches, or such like, erected or set up, or any Water-Courses or Ponds digged up on any part of the Lord's Wast, without the Lord's license? where is it? and by whom was it done, and by whose license, and upon what Consideration?

23. What Tenants are there within the *Mannor* that hold any Lands or Tenements by Indenture of Lease? what are their Lands? what hold they, for what Rent, under what Conditions or Covenants, and for what Term of Years or Lives?

24. Whether hath or doth the Lord imploy any Land to *Justment*, as in taking in Cattel to Pasture and Herbage? who hath the disposing of the same? what quantity of Land is so disposed? and how many Cattel will it pasture? and what is a Cow, Ox, Horse, or Sheep gate worth within the *Mannor*?

25. Whether hath the Lord of the *Mannor* any Customary Water-mill, Wind-mill, Horse-mill, Griest-mill, Mault-mill, Walk-mill, or Fulling-mill? whether is there within the *Mannor* any other Mill, Iron-mill, Furnace, or Hammer, Paper-mill? Sawing-mill, Sheer-mill, or any other kind of Mill? what is it worth by the Year? and in whose Occupation is it? Here observe, that to the Customary Corn-mill doth belong the Duty from the Tenants, *viz.* that they are bound to grind their Corn at the Lord's Mill: and that kind of Custom is called *Socome*. And this may be divided into two sorts; *Bond-socome*, where the Tenant is bound by Custom, as where his Corn grows upon the *Mannor*; and *Love-socome*, where he grindeth of free Will; as Corn bought in the Market, the Tenant is at liberty to grind it where he pleaseth, yet out of kindness to his Lord brings it to his Mill.

26. Whether

26. Whether hath the Lord of the *Mannor* any particular Fishing within any River, Brook, Meer, Pond or other Water? where and how far doth it extend? and what is it yearly worth? and who be Farmers thereof? and what common Fishings are therein? and how are they used? concerning this Article see 25 *H. 8. cap. 7.* and 31 *H. 8. cap. 2.*

27. Whether hath the Lord any Fowling within his *Mannor* by reason of any Moors, Marishes, Watets, Brooks, Reeds or such like; or any Woods wherein do breed any Stork, Shovelars, &c. or any Pibble, Beach, or Sea-bank wherein any Fowl breed? who takes the Profit of them? and what may they be worth by the Year unto the Lord?

28. Whether hath not the Lord of the *Mannor ultra memoriam hominis*, had and received all Waifs, Estrays, Felons Goods, Treasure trove, and such like profits within the *Mannor*? and whether hath he been answered of them from time to time truly or not? and who is the Officer that oversees the same, and whether be they totally and fully answered?

29. Whether are there within the *Mannor* any Tin-Mines, Lead-Mines, Copper-Mines, Coal-Mines, Quarries of Stone, viz. Marble, Free-stone, Mill-stones, Lime stones, Grind-stones, Marle or Chalk-pits, slimy or moorish Earth fit for soiling of Land, or any Potters Clay or Clay for Brick or Tile, or any Fullers Earth, or any Sand Gravel-pits, or such kinds of Commodities? and what are every of them worth by the Year to the Lord? or how are they improvable?

30. Whether there are within the *Mannor* any Turfs, Peats, Heath, Broom, Furzes, &c. which are or may be sold yearly within the *Mannor* to the Lord's profit? and what may they yield by the Year if improved to the utmost Value? Here note that these things before mentioned are not of equal Use and Advantage in every Country: for *Essex* affords little of them; but *Northumberland*, *Cumberland*, and *Westmorland*, as also *Lincolnshire*, *Cambridgeshire*, *Lancashire*, *Torkshire*, and many other places yield good store of them. and they are there used as good Fuel.

31. Whether is there within the *Mannor* any Slate-stones for Tiling, red or black Lead or Oker for Marking-stones? Note that *Cornwall* abounds in Slate, and *Derbyshire* hath plenty of the Marking-stones, and some Mill-stones.

32. What Deer hath the Lord in his Park? who is Keeper? and what is his annual Fee? hath he any Warren of Coneys or Hares? who is the Keeper of either of them? and what Fee hath he by the Year? what are the said Park and Warren worth by the Year to be let by the Year, if the Deer, Coneys or Hares were destroyed? Note that a Park for Deer is more for the Pleasure than for the Profit of the Lord or Commonwealth: Warrens of Coneys are not unnecessary, as requiring no rich Grounds to feed in, but mean Pasture and craggy Grounds are fittest for them.

33. What

33. What Pensions, Portions, Payments or Fees are or ought to be yearly paid out of the *Mannor*? to whom ought they to be paid, and for what? and whether have they been duly paid, or discontinued, and how long? These Things ought to be duly examined, as well as to what goes out of the *Mannor*, as what is received in.

34. Whether is there within this *Mannor* any Weekly Market, or any Fair at any time of the Year? on what Day or Days? who hath the Toll and Profits thereof? and what may they be worth, either in his own Hands, or to let to Farm? Here note, that Markets and Fairs are not appendant to a Mannor, but commonly held by Patent from the KING.

35. Whether hath the Lord any Leet or Law-Day within the *Mannor*? what is the Extent thereof? and whether is there any Court kept within the *Mannor* from three Weeks to three Weeks? and of what hath the said Court power to judge and determine.

36. Do you know of any that have any Deeds, Evidences, Court-Rolls, Rentals, Suit-Rolls, Custom-Rolls, Books of Survey or Account, or any other Escripts or Muniments touching or concerning this *Mannor*? if you do, you are to produce them, or cause them to be produced.

37. Who hath the Advouson, Nomination, Presentation and Gift of the Parsonage, Vicarage, or Free-chapel belonging to this *Mannor*? whether the same is an Impropriation? and who is Incumbent of the said Parsonage or Vicarage? or who hath the Impropriation in use? and what is it worth by the Year? This, though it ought to be inquired, yet I suppose is not to be reckoned as parcel of a *Mannor*, because a Matter of Spiritual or Ecclesiastical Function cannot be parcel of a secular Living: But a *Mannor* as touching the Tithes may belong to an Ecclesiastical Charge. Nor do I conceive an Impropriation, though it belong to the Lord, to be parcel of the *Mannor*; because from the first Institution it was separated to a Spiritual Office: and though the profits were afterwards disposed to a Secular person, yet do they thereby become parcel of the *Mannor*.

38. Whether is there any Land concealed or Rent detained within this *Mannor*, and by whom, for what, how much, how long? or whether is any Land granted in Mortmain?

39. Who is the Lord's Bailiff? what is his Name? hath he a yearly Fee? and doth he hold by Patent for Life, or at the Will of the Lord? who is Steward of the Lord's Courts? what is his Fee? and how doth he hold? who is Woodward? and what other Officers are there within or belonging to this *Mannor*? and what are their Fees or Salaries? Here note, that sundry *Mannors* have divers Officers, some appointed by the Lord, and some by the Tenants: But these are so known, that they need not be particularized.

40. Within what Diocese and Deanery, or within what Division and Hundred lies this *Mannor*? what Beacons are you appointed to watch and ward at? and where are you generally called to Muster
and

and shew your Armour? Here observe that the Ecclesiastical Jurisdiction takes place in all Counties, for the Ordinary is precluded in his Visitation. Every Subject is to answer for himself according to his Family and the Extent of Family or Lordship, The Ordinary may inquire concerning Recusancy, and the Ministerial and Civil Officers into Bounds and Limits. How necessary Beacons have been in the times of common Invasion, is obvious to every Eye that has lookt into our Histories: and for Musters, though there were anciently a certain place, yet by late Statutes since his *M A J E S T Y*'s happy *Restoration*, the *Militia* is otherwise settled, and all persons may be called to Muster and shew their Arms, where the Lords-Lieutenants, or the Deputy Lieutenants shall summon them to appear within the County, and in case of Invasion they may be sent farther.

41. What Market-towns are nearest unto this *Mannor*? and what Commodities are there specially vented? This is very necessary to be known by the Lords, especially such as live far distant from their *Mannors*, because many times they may fit themselves with Tenants fit and capable to supply those Necessaries, which haply otherwise might be wanting.

These are the principal Articles that every *Surveyor* ought to inquire into; but he may in his Discretion order his Business so as not to be tied to this particular Form of Words, yet he must take the Substance of these Articles, or such or so many of them as he conceives (guided by some Preinstruction or fore Knowledge of the State of the *Mannor*) are fittest to be delivered to the Jury: and withal he is to explain to them the Meaning of every Article more at large, as in several before we have shewed to him. And when he has finished his Charge, it is not inconvenient to give the Articles in writing to the Jury, that they may the better and more easily answer their Knowledges; for perchance the Jury cannot so methodically set down their own Meanings; therefore the Surveyor may correct the Form, still retaining the Meaning and Intent of the Jury. Then let him read to them, that they may allow or disapprove the same: and if they doubt any thing, he may give them a Day or more (as he sees occasion) to consult and deliberate, and then adjourn the Court for that time,

Immediately after the Charge ended, the Surveyor is to make Proclamation in the Name of the Lord of the *Mannor*, that every Tenant do forthwith produce his Deeds, Copies, Leases and other Evidences, to the end they may be entred into a Book of Parchment for Continuance.

The manner of these Entries is as followeth:

Intrationes omnium & singularum Chartarum, Copiarum, Indenturarum, omniumque aliarum Evidenc^{ie} Tenentium ibidem fact. 22 die Octobris Anno Regni nostri Caroli II Dei Gratia, Angliæ, Scotiæ, Franciæ & Hiberniæ Regis, Fidei Defensoris, &c. vicesimo quinto Annoque Domini 1673. ut sequuntur: viz.

Charta liberorum Tenentium: and under this Head set down all Freehold-estates. Thus:

Charta Liberorum Tenentium. Thorne Township Free-holders.

Socage	{	Abraham Knowles, holdeth freely to him and his	Fealty, &c
		Heirs for ever, by Deed indented, bearing Date the	
		27th of May in the 13th Year of the Reign of	
		King Charles the First, &c. made and granted by,	s. d.
		and from Solomon Smith of &c. All that	xiiij. iv.
	{	Messuage or Tenement (expressing the very Words	
	{	of the Grant) On which Grant there is a Deed of	
	{	Feoffment of the same Date, with Livery of Seisin	
	{	thereon past accordingly; by the yearly Rent and	
	{	Services of—	

The Particulars granted by this Deed.

	A.	R.	P.
The Mansion-house, Out-housing and Site, consisting of	1	00	00
an Orchard, 2 Gardens, 2 Yards, containing together	00	03	18
A Close or Meadow called <i>Home Close</i> , containing	06	02	11
Another Close called <i>Well Close</i> , containing	09	01	10
Of Meadow lying in 3 parcels in <i>Long Mead</i> , containing	16	03	07
A Close of Arable Land, called <i>Bownse</i> , containing	10	01	19
Arable in <i>South-field</i> , in 6 parcels, containing	04	02	00
A Close called <i>Fearn-Close</i> , containing 12 Beast-gates, at			
12 s. le Gate, —————			12 Gates
In the great Moore, at 6 s. 8 d. per Gate, —————			20 Gates.
On the Downs, depasturing for 90 Sheep, at 3 d. le Gate —			90 Gates.
Common (<i>sans stint</i>) on the Moors.			

Thomas Richardson, holdeth by Copy of Court Roll bearing Date the 18th of October, in the sixth Year of the Reign of our Sovereign Lord King Charles the second, of the Surrender of M. G. Two Messuages or Tenements (express the Words of the Copy) late in the Occupation of S. K. and before that in the Occupation of O. N. to him and Heirs, at the Will of the Lord, according to the Custom of the Mannor, for which he payed Fine x lb. iii s. viii d. and payeth Rent per Annum. —————

After this write the Particulars, as before in the Free-hold.

If the Estates be for Lives, then the Entries must be according to the Words of the Copy; and at the Foot of the Entry of every Copy he ought to set down the Ages of the Tenants in possession, and likewise of them in Reversion, and other necessary particulars: in the Order following;

Audley

Audley Township, Copy-holders for Lives.

Thomas Cooper, holdeth by Indenture bearing Date the 10th of August, in the twenty first Year of King James, made and granted by and from R. S. All that Messuage or Tenement, &c. (expressing the Words of the Grant) for the Term of the natural Lives of the said Thomas Cooper aged fifty three Tears, of Isabella his Wife now aged forty one Tears, and of James their Son, now aged sixteen Tears successively each after other, and payeth Rent per Annum ————

15.
XV.

After this write your Particulars as before, and after them such brief Notes or Memorandums as you shall see fitting, according to former Directions.

When this is done, then proceed to Leases, wherein the Surveyor must observe these following particulars.

Dies, Mensis, Annus. Partes inter quas facta est Dimissio. vel Indentura. Consideratio concessionis. Particularia que per Indenturam conceduntur. Habendum, cum termino annorum aut vitarum pro quo aut quibus conceduntur, Redditus & tempora solutionis. Clausula distractionis, aut forisfactura. Conventiones & provisiones, breviter, sed distincte. Quomodo obligatur ad warrantizandum Concessor, &c.

And this is sufficient for the manner of entring all sorts of Deeds.

The Order and Manner how the Juries Verdict is to be received.

COMing near to the concluding of your other Businesses, as are before directed to be done, you must hasten the Jury to perfect their Verdict, which effected, call them before you, and examine and compare the Articles with their several Answers thereunto, and reduce the same into an orderly Form, observing well the Substance of what they have found and presented, and reading the same to them, and having their Approbation and Allowance thereof, cause the Clerk to ingross the same in Parchment accordingly, together with your own private Notes and Observations, and reading them over to them again, being so Ingrossed, and they having set their Hands and Seals thereunto, demand of them if they be mutually agreed in this their Verdict, which when they have acknowledged, receive the same from the Foreman, (in the behalf of the rest) and dismiss your Court.

After all this is done, the Surveyor is now at Leisure to perfect his Perambulation and Survey of the Mannor, and to Ingross the same.

The

The Manner how to Ingross a Survey.

A True and perfect Survey of the *Mannor* of *B.* in the County of *C.* being parcel of the possessions of *M. S.* who holdeth the same of our Sovereign Lord the King, as of his *Mannor* of *L.* in Fee, and common Socage (or otherwise if the Tenure be other) and by the yearly Rent of 6 s. 8 d. had, made and there taken, as well by Inquisition, and the Oaths of a sufficient Jury in that behalf, as by the View and particular Mensuration of all and every the Messuages, Lands and Tenements of, within, and belonging to the same. *Anno Dom. 1671. Annoque Regni Regis Caroli II. 24.*

After this (or the like) Title is to be expressed, 1. An Alphabetical Table of all the Tenants Names. 2. A general Rental of the whole *Mannor*. 3. The Names of the Out-boundaries of the whole *Mannor*. Mention the *Mannor*-house, and the Dimensions thereunto belonging, and in whose Occupation the same is, whether in the Lord's own, or let by Lease or otherwise, to an Under-Tenant or Tenants, with the Rent thereof to the King. 4. What Parks, and what Number of Deer in them, and of what Kind. 5. What Fields, Closes and Demesnes are in the Lord's own Hand. 6. What is let out by Lease, for Lives, Years, &c. as hath been already shewed. And under the Paragraph of Demesne, enumerate all Mills, Mines, Games, as aforesaid. 7. The Rectory, Parsonage, and Vicarage (if any be) and Glebe. 8. The Free-holders Land. 9. The Copy-holders. 10. The Tenants for Life.

Here note, That all the Lands in any *Mannor*, are one of these seven Tenancies, viz. 1. Demesnes. 2. Glebe lands. 3. Freeholds. 4. Customary. 5. For Lives. 6. For Years. 7. At Will. And in this Order you ought to Engrosse them.

Having thus far proceeded in the Engrossment of your Book of Survey, and expressed at large the Quantity, Quality, Tenure and Value of all Particulars contained within the *Mannor*; you may briefly sum up the whole as is expressed (for Example sake) in this following *Analysis*.

The

		A.	R.	P.
The Lord	Quantity	1630	00	00
	Value	lb.	s.	d.
		720	00	00
Demesnes in the use of	Number of Tenant	5		
	A. R. P.			
Lands.	Quantity	210	02	16
	lb. s. d.			
The Tenants	Rent	97	06	08
	Value	176	05	10
	Ad demit.	78	19	02
Casualties made certain	Number of Tenants	4		
	A. R. P.			
	Rent	32	10	06
	Value	58	16	04
	Ad demit.	26	05	10
Glebe Lands	Quantity	116	Acres	
Free holders of Inheritance	Number of Tenants	10		
	A. R. P.			
	Quantity	732	03	16
	Rent	25	lb. a Fat Buck	
The Mannor Consists of	Number of Tenants	12		
	A. R. P.			
Customary Lands,	Quantity	1000	00	00
	lb. s. d.			
	Rent	242	00	00
	Value	470	00	00
	Ad demit	228	00	00
For Lives	Number of Tenants	8		
	A. R. P.			
	Quantity	432	03	00
	lb. s. d.			
	Rent	126	06	08
	Value	204	12	10
	Ad. demit	78	06	02
For Years	Number of Tenants	24		
	A. R. P.			
Tenement Lands,	Quantity	730	02	17
	lb. s. d.			
	Rent	216	09	03
	Value	410	16	01
	Ad demit.	193	06	10
At Will	Number of Tenants	6		
	A. R. P.			
	Quantity	326	02	24
	lb. s. d.			
	Rent	51	18	06
	Value	135	09	03
	Ad demit.	83	10	09

Of the Appellations, or Names of Lands in several Places.

HAVING thus run through the several Particulars of Survey according to the Law, we will give you the several Distinctions of Lands by their Appellations in particular Places. Those generally known are distinguished into *Perches, Roods, Acres, Yard-lands, Plough-lands, Hides, &c.* But besides these there are other Denominations given to Land, which we may suppose to have been anciently taken from Coins, as *Fardingdeals, Ubolates, Denariates, Solidates, and Librates.*

The *Fardingdeal, Quadrantata terra*, signifies a Rood, or a $\frac{1}{4}$ of an Acre. See *Crompton's Jur. and Reg. orig.* 1. We read in *Fitzb.* 87. of *viginti Libratas terra*; as also *Reg. orig.* 49. & 248. importing, as it seems, so much Land as yields twenty Shillings Rent annually. So you may read farther *Reg.* 249. *centum Solidatas terrarum, tenementorum & reddituum.* But Roods and Acres differ many times according to the Custom or Usage of several places. Yet notwithstanding the several Varieties, the Surveyor must make his Computation by the Standard; although perhaps it may be that the Lord's Demesnes in ancient Surveys have been measured by the twenty-foot Pole, called *Mensura major*, and the Customary Land by sixteen Foot and a half, called *minor Mensura*. So the French *Arpent* or Acre, containing 100 square poles, is laid out in measuring Woods by the twenty two foot pole, which is called the *King's Arpent*; yet their other Lands are computed by the pole of 20, 19, or 18 Foot.

The *Ox-gang*, called by *Skene Bovata terra*, is reputed to contain thirteen Acres; yet we find it sometimes more, sometimes less, as Custom leads: and *Bovata* is properly used of Lands in *Gainour*, that is usually ploughed.

The *Yard-land, Virgata terra*, as Mr. Lambard holds, is sometimes twenty, other times twenty four, and sometimes thirty Acres; and it is not reputed in Demesne, but in *Gainour*.

A *Plough-land* or *Carue of Land, Carucata terra*, is said to contain four Yard-lands at thirty Acres to the Yard-land; that is, *quantum aratrum arare potest in novali tempore.*

A *Hide of Land, Hida terra*, is said to be such a portion of Land as may be tilled with one Team in a Year and a Day, according to their several Tilths and Seasons; and so *Crompton* affirms it to be 100 Acres by Statute, and so confounds *Hida* with *Carucata*. Others say that every Hide of Land contains four Plough-lands at 120 Acres, and so four Hides make a Knight's Fee.

A *Knight's Fee, Feodum Militare*, is so much as is sufficient yearly for the Maintenance of a Knight and his Retinue with convenient Allowance and Revenue, which in the time of *Henry the Third* was fifteen pound. But *Sir Thomas Smith* in his Book *de Rep. Anglor.* rateth

rateth it at 40 *l.* per Annum. But *Camden* records it to be 680 or 800 Acres. After some Computations it contains 5 Hides of Land, each Hide 4 Yard-lands at 24 Acres.

In the Duchy of *Lancaster* a Knight's Fee contains 4 Hides of Land, each Hide 4 Plough-lands, each Plough-land 4 Yard-lands at 30 Acres, amounting in the whole to 1920 Acres.

Two Knights Fees makes a *Cantred*, 2 *Cantreds* and a half make a *Barony*, and one *Barony* and a half makes an *Earldom*, that is to say, 38400 Acres.

But although these proportions of Land do not always hold with their Titles of Honour, yet their Denominations continue their Original Institution; and however they may be dismembred *quoad quantitatem*, yet the Right and Dignity is indivisible; insomuch as if a Capital Messuage be *Caput Comitatus vel Baronie*, it may not by any means be parcelled. And the Relief depends upon the Dignity after the first Allotment; viz. 100 *s.* for a Knight's Fee, 100 Marks for a *Barony*, and 100 *l.* for an *Earldom*. See *Magna Charta*.

In the last place, the Surveyor is to observe that the Tenants of Mannors holding freely by Charter in ancient Demefne cannot be impleaded nor impannelled upon Enquests out of the same Mannor, and they are Toll-free for all things concerning their Sustenance and Husbandry, and exempt from Contribution towards the Expences of Knights of the Shire that serve in Parliament. *F. N. B.* 14, and 128. Of these there are several sorts: as,

Infeoffing with *Toll* implies Freedom from Custom, &c.

With *Caruage*, from Taxation by Carues.

With *Bruck-bote*. from repairing and re-edifying Bridges; as with *Burgh-bote*, being the same for Castles.

Footgeld, implies a Privilege to keep Dogs within the Forest, not being expedited or lawed without Controul.

Waives, Weifs or *Waived Goods* import such Goods and Chattels as being stolen are left or forsaken by the Thief in his Flight.

Infangthesfe enables the Lord of the Mannor to judge of Felons inhabiting within his Fee: as *Utsangthesfe* to judge, or at least to execute Judgment of Felons apprehended within Fee.

For Accrements to the Lord of the Mannor by Felons, not only their Goods both real and personal, are forfeited, but also their Lands non entailed elcheat *post annum diem & vastum*, except in Gavel-kind and some peculiars.

Baronies infeoffed with them had formerly power to dispose of Villains, their Children, Goods and Chattels.

Abissherfing, aliàs *Missherfing*, implies both Forfeitures and Amerciaments of all Transgressions within the Fee, and also the Immunity from the like penalty.

Bloddwite is all Amerciaments of Courts for shedding of Blood.

Estovers granted out of Woods or Forrests include *House-bote*, and *Plough-bote*.

The Conclusion.

IN this short and small *Traēt* there hath been an Endeavour to lead you, as by a Clew, through the *Legal Part* of what you had before from the *Mathematical Artift*. We have not troubled you with *Charts* or *Tables* to be as *Fac Simile's*. Whoever undertakes the Work of a *Surveyor* without some Knowledge of the *Law*, can with all his Art reduce it to no Certainty: And any Art without Certainty is like running in a Circle, where there is neither Beginning nor End. You have in this little *Traēt* the Nature, Quality, Appurtenants, Appendants and Extents of a Mannor: If you receive that Satisfaction which was intended and desired, then you have little cause to complain that your time is ill spent in the Perusal. However, 'tis hoped you shall receive a greater Advantage by the Inspection, than the Author expects Applause for his pains, because he knows that *facile est addere*.

A N

A N
A P P E N D I X
To the W H O L E ;
CONTAINING
P R A C T I C A L
O B S E R V A T I O N S
Relating to the
Whole B U S I N E S S of
Land-Surveying.

By S. CUNN.



London, Printed in the Year 1722.

A N
APPENDIX
To the WHOLE;

CONTAINING
PRACTICAL
OBSERVATIONS
Relating to the
Whole BUSINESS of
Land-Surveying.

B. S. CUNN.



London, Printed in the Year 1722.

THE APPENDIX.

The Tenth BOOK.

CHAP. I.

Of Instruments used in Surveying Land.



INSTRUMENTS used in Surveying are, either, to measure, or lay down the Lengths of Lines, or their Positions.

The most proper Instruments for measuring Lengths, in Towns, Streets, or any other Buildings, are 5 Foot and 10 Foot Rods, and a Chain of 50 Foot long; for Fields and Woods a Chain of 66 Foot or 4 Poles, consisting of 100 Links, each containing 7 Inches and $\frac{2}{3}$; and a Rod whose length is equal to $\frac{1}{4}$ th part of the Chain, that is 10 Links, or 6 Foot 7 Inches and $\frac{1}{2}$: For Roads the Wheel.

The Instruments used for taking the Positions of Lines are of two kinds.

With some we take the Position of a Line, by the Angle which that Line makes with the Meridian, using a Box and Needle; as with the *Theodolite*, the *Circumferentor*, the *Plain Table*, the *Perambulator*, the *Perafter*, &c. And this is usually called the *Bearing of the Line*.

With

With others we take the Position by the Angle that the Line makes with any other given in Position; as with the Limb of the *Theodolite*, the Limb of the *Semicircle*, the *Frame* of the *Plain Table*, the *Bevel*, the *Chain*, or *Rods*.

All other Instruments either differ from these only in their Names, or else are contained in them.

But with some of these Instruments, very conveniently we take the Position in both manners, at one Observation; as with the *Theodolite*, the *Semicircle*, or the *Plain Table*.

With some of these Instruments we take the Angle itself, as with the *Bevel*, or with the *Plain Table* covered with a Sheet of Paper; and with others, we express the relative quantity of that Angle by Numbers. So when we use the *Chain*, we express the Angle by Sextants, Links and tenth parts of a Link; when we use *Rods*, we express it, by Sextants, and centesimal parts of a Rod; and when we use other Instruments, we express the Angles by Degrees and Minutes.

We also observe, that of *Theodolites* and *Semicircles* there are various kinds; in some the Box is fixt to the Plate, in others to the Index. And the working with each of these varies according to the manner of their Numbering.

As for *Roads*, the Wheel with its Indices shewing the Distance, and its Box and Needle with Sights shewing its Bearing or Position in respect of the Meridian, is an Instrument speedy and sufficiently exact; provided we reject the Breadth of the Road, and only regard the Bearing and Length.

Lastly, Instruments for plotting, are a Scale decimally divided the whole Length, close to both the Edges; and at every tenth Division numbered 0, 1, 2, 3, 4, &c. denoting Chains; the numbering so ordered that we may count either from the Right to the Left, or from the Left to the Right; and a *Protractor* always to be divided numbered and fitted to your Instrument.

For all *Circumferentors* (either so distinctly, or used as such, viz, when contained in the *Theodolite*, *Semicircle*, or *Plain Table*) Let the Numbers in the *Protractor* encrease contrary to those in the Box; But when the Box and Needle takes the Bearing, as the *Peractor* or *Perambulator* doth, the Numbers of the *Protractor* must encrease as those in the Box. And for the Limbs of all *Theodolites*, *Semicircles* and *Plain Tables*, if the Circuit be made $\left\{ \begin{array}{l} \text{according to} \\ \text{contrary} \end{array} \right\}$ to the Numbers on the Limb, the Numbers of the *Protractor* most conveniently encrease the $\left\{ \begin{array}{l} \text{contrary} \\ \text{same} \end{array} \right\}$ way with the Numbers on the Limb of the Instrument.

C H A P. II.

To observe the Position of a Line by any of the preceeding Instruments.

1. *By the Circumferentor.*

THE Box of the *Circumferentor* is divided into 360 Degrees, and numbred in 4 Quarters, from the North and South both to the East and West, by the Figures 10, 20, 30, 40, 50, 60, 70, 80, 90, but these Divisions are also numbred from the North towards the East or West, all round, till they end at the North again; by the Figures 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, and so on to 360. Of these two ways of numbering, the latter is properly the *Circumferentor*, and the former the *Traversing Quadrants* or *Quarters*.

Now if it be required to observe the Bearing of the Line A B (Fig. 1.), the Instrument standing at A. The Flower-de-luce being towards you, direct the Sights to B; and the South End of the Needle will point at 207 Degrees in the *Circumferentor*, and at S. W. 27. in the *Traversing Quadrants*.

And if you were going round the Field, and so next to observe the Bearing of the Line B C, at B; turn the Index about, the Flower-de-luce being towards you, till through the Sights you see the Hair cut C; then will the South end of the Needle point at 111, in the *Circumferentor*, (which is the Bearing, always counted from the North, and in these Examples indeed Eastward); and at S. E. 69 in the *Traversing Quadrants*; which is the Bearing always counted from the North or South towards the East or West. Here we may note, that the Bearing taken with the *Circumferentor* may be any Number of Degrees not exceeding 360, but, that with the *Traversing Quadrants* never exceeds ninety Degrees.

When you suspect the Needle doth not play well; direct your Index to your Mark, and note the Degrees pointed at by the Needle in a waste Piece of Paper; then with a clean Knife, or a Key, or any other polished Bit of Steel, which hath touch'd a Loadstone, move the Needle, by applying it to the Box, and examine when it hath settled again, what Degrees it then points at, your Index being still directed to the preceeding Mark; and if the Degrees are the same, they may be entred in the Field-Book; but if not, the Cap and Pin must be cleansed with some brown Paper and a little Putrey, and thereby freed of such Dust or Dampness as hath gotten to it; if after all the Needle doth not play freely, screw in a new Pin, or use another Needle, or do both; these Necessaries every Surveyor ought to have in his Pocket while he is in the Field.

If you suspect any Error in the Bearing of any Line already taken, arising, from the Needles being acted on by some hidden Magnetick Power, or from your own Mistake in observing the Degrees pointed at; the Doubt may be cleared and the Error corrected at the next Station; thus,

Having come to B (Fig. 1.), the Flower-de-luce being from you, look back to A, and then will the South end of the Needle point at 207 degrees in the *Circumferentor*, and at S. W. 27 degrees in the traversing Quadrants; just as it did at A.

Lastly, if you have no Reason to suspect the Needle, and it is most convenient to plot by it, the speediest way is to place the Instrument only at every other Angle; and there to take the Bearings of the two Lines constructing that Angle.

So, if you would observe the Bearings of the Lines of Fig. 1; first, place the Instrument at B, and with the Flower-de-luce from you, direct the Sights back to A, so the South end of the Needle will point at 207 degrees in the *Circumferentor*, and at S. W. 27 degrees in the Traversing Quadrants which is the bearing of A B; then with the Flower-de-luce next you, direct the Sights to C, so the South end of the Needle will point at 111 degrees in the *Circumferentor*, and at S. E. 69 degrees in the Traversing Quadrants, which is the bearing of B C.

Now, place the Instrument at D, the Flower-de-luce being from you, direct the Sights back to C, so the South end of the Needle will point at 44 degrees 30 minutes in the *Circumferentor*, and at N. E. 44 degrees 30 minutes in the Traversing Quadrants, which is the bearing of C D; and directing the Sights to E, the Flower-de-luce being towards you, the South end of the Needle will point at 102 degrees 15 minutes in the *Circumferentor*, and at S. E. 47 degrees 45 minutes in the Traversing Quadrants.

In like manner work at F, &c. always keeping the Flower-de-luce from you, when you look backwards, and towards you when you look forwards; so will the South end of the Needle point at the Degrees of the bearing in both Cases.

*To protract any Line whose Bearing is taken by the
Circumferentor.*

FIRST, draw Lines parallel to one another quite through the designed Draught, at Distances not exceeding the breadth of the Diametrical part of your *Protractor*, as in Fig. 1. and mark them with N. and S. for North and South; then lay the Center of the *Protractor* on the given Point A, representing the Station A in the Field, and, by Help of the Divisions continued beyond the Ends of the Diameter of the *Protractor*, lay the Diameter parallel to those North and South Lines, the beginning of the numbering Northwards, when the degrees are fewer than 180, but Southwards when more; the *Protractor* being thus placed close to the Limb against 207, the degrees of the Bearing, make a Mark
and

and to it draw the Line A B ; and so will A B have a Bearing like to that, which you observ'd the Line A B to have in the Field. In like manner you may lay down the bearing of any other Line, as B C ; if you observe to lay the beginning of the numbering Northwards, when the degrees are less than 180 degrees, and Southwards when more.

And if you would lay down the bearing of any Line A B from any assigned Point A, with the Traversing Quadrants ; after you have drawn North and South Lines as before, the North being upwards, write East on the right Hand side of the Map, and West on the Left. Now lay the Center of the *Protractor* and *Diameter* as before taught ; save that instead of observing the Number of the degrees, you turn the Limb of the *Protractor* Eastward, when the bearing is N. E. or S. E. and Westward, when it is N. W. or S. W.

The *Protractor* being thus placed, against S. W. 27, make a Mark and to it draw the Line A B, and so will A B have a Bearing like to that which A B was observ'd to have in the Field. In like manner you may lay down the bearing of any other Line.

2. With a Theodolite, both by the Limb, and by the Box and Needle.

BEfore you engage in a Survey, you ought to consider the numbering of your Instrument ; thus, when the Eye is conceived plac'd in the Center, consider whether the Numbers encrease from the Left to the Right, or from the Right to the Left ; or according to the Farmer's familiar Phrase, whether the Numbers encrease with or against the Sun's Motion.

And then observe, that with a *Theodolite* whose Box is fix'd to the $\left\{ \begin{array}{l} \text{Plate} \\ \text{Index} \end{array} \right\}$ the Circuit is most conveniently made $\left\{ \begin{array}{l} \text{with} \\ \text{against} \end{array} \right\}$ the increasing of the Numbers ; and the first Sights shall always be directed to the $\left\{ \begin{array}{l} \text{next} \\ \text{last} \end{array} \right\}$ Station, and the Index to the $\left\{ \begin{array}{l} \text{last} \\ \text{next} \end{array} \right\}$ And then if you keep the beginning of the degrees towards you when you direct the first Sights, and the Flower-de-luce towards you when you direct the Index ; the degrees cut by the end of the Index which is next you are the degrees of the Angle ; and the degrees pointed at in the Box by the South end of the Needle, give the bearing of the next Length. And this bearing will be in all respects the same with that taken with the *Circumferentor* ; provided that the Box be divided and numbred like that of the *Circumferentor*.

This double Observation is of great use to the Surveyor ; for hereby he may either plot by the Angle or by the Bearing, or both, as he shall find most convenient ; and also he may prove his Observation before he moves his Instrument. For, of the Numbers expressing

pressing the bearing of the Lines forming any Angle, if the lesser be subtracted from the greater, and the Remainder be $\left\{ \begin{array}{l} \text{increased} \\ \text{diminished} \end{array} \right\}$ by 180 Degrees when $\left\{ \begin{array}{l} \text{less} \\ \text{greater} \end{array} \right\}$ than 180, the Result will give either the Angle it self or its Supplement to 360 degrees.

When we use a *Theodolite* with a Box fixt to the $\left\{ \begin{array}{l} \text{Plate} \\ \text{Index} \end{array} \right\}$ and the Numbers in the Box encrease the $\left\{ \begin{array}{l} \text{same} \\ \text{contrary} \end{array} \right\}$ way with the Numbers on the Plate, as they generally do, or as I would chuse to have them; then a *Protractor* being numbred contrary to the Numbers in the Box, will be fitted to lay down the Plan, either by the Angles taken by the Limb, or by the bearing taken by the Needle, or by both together in order to prove the Truth of each other. And then also may the Truth of the Angle or bearing be proved, before the Instrument is moved from the Station by either of the two following Rules.

If to the present bearing be added 180 degrees, and from the Sum you subtract the last bearing; then the Remainder will be the present Angle.

And if to the present Angle you add the last bearing, and from the Sum subtract 180; then will the Remainder be the present bearing.

But if the Degrees to be subtracted are more than those from which they are to be subtracted; the latter must be encreased by 360, and then subtract.

And if the Remainder be more than 360, then abate 360, and the Result gives the Degrees required.

So, with a *Theodolite* that hath the Box fixt to the Index, and the Numbers on the Plate, while the Eye is conceived placed in the Center, encrease from the Left to the Right, but those in the Box the contrary way, and so most proper to work against the Sun; if you would take the bearings of the Lines of Fig. 1. and if you would begin from any assigned Angle, suppose A; then, your Instrument being planted at A, direct the Index to the next Station at B, and the South end of the Needle will point at 207 degrees in the *Circumferentor*. And for the following Angles and Bearings when the Instrument is

planted at	$\left\{ \begin{array}{c} B \\ C \\ D \\ E \\ F \\ G \end{array} \right\}$	direct the fixt Sights to	$\left\{ \begin{array}{c} A \\ B \\ C \\ D \\ E \\ F \end{array} \right\}$	and there screw the Instru- ment fast, and then direct the Index
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Index to $\left. \begin{matrix} C \\ D \\ E \\ F \\ G \\ A \end{matrix} \right\}$ and the end of the Index next your Eye will cut on the Limb the Angles $\left. \begin{matrix} 84. & 00 \\ 113. & 30 \\ 237. & 45 \\ 49. & 35 \\ 102. & 40 \\ 234. & 00 \end{matrix} \right\}$

and the South end of the Needle will, as in the *Circumferentor*, point at

$\left. \begin{matrix} 111. & 00 \\ 44. & 30 \\ 102. & 15 \\ 331. & 50 \\ 254. & 30 \\ 308. & 30 \end{matrix} \right\}$

And with a *Theodolite*, that hath the Box fixt to the Index, and the Numbers of the Plate contrary to those of the Box, while the Eye is conceived plac'd in the Center, encrease from the Right to the Left, and so most proper to work according to the Sun's Motion; if you would take the Angles and the Bearings of the Lines, of Fig. 1. and begin from any assigned Angle, suppose A; then your Instrument being planted at A, direct the Index to the next Station G, and the South end of the Needle will point at $231^{\circ} 30'$ in the *Circumferentor*. And for all the following Angles and Bearings, when the

Instrument is planted at $\left. \begin{matrix} G \\ F \\ E \\ D \\ C \\ B \end{matrix} \right\}$ direct the Sights to $\left. \begin{matrix} A \\ G \\ F \\ E \\ D \\ C \end{matrix} \right\}$

and there screw the Instrument fast, and then direct the Index to

$\left. \begin{matrix} F \\ E \\ D \\ C \\ B \\ A \end{matrix} \right\}$

and the end of the Index next the Eye will cut on the Limb the Angle

$\left. \begin{matrix} 234. & 00 \\ 102. & 40 \\ 49. & 35 \\ 237. & 45 \\ 113. & 30 \\ 84. & 00 \end{matrix} \right\}$

and the South end of the Needle as in the *Circumferentor* will point at the bearing

$\left. \begin{matrix} 285. & 30 \\ 208. & 10 \\ 77. & 45 \\ 135. & 30 \\ 69. & 00 \\ 333. & 00 \end{matrix} \right\}$

But with a *Theodolite* that hath the Box fixt to the Plate, and the Numbers on the Plate as well as those in the Box (the Eye being placed in the Center) encrease from the right to the left, and therefore most proper to work contrary to the Sun's Motion; if you would take the Angles and the Bearings of the Lines of Fig. 1. and begin at an assigned Angle A; then your Instrument being planted at A, direct the fixt Sights to B, and the South end of the Needle will point at $207^{\circ} 00'$, as in the *Circumferentor*, and as in the first Example. And for all the following Angles and Bearings, when

the Instrument is planted at $\left\{ \begin{array}{c} B \\ C \\ D \\ E \\ F \\ G \end{array} \right\}$ direct the fixt Sights to $\left\{ \begin{array}{c} C \\ D \\ E \\ F \\ G \\ A \end{array} \right\}$;

then screw the Instrument fast, and direct the Index to $\left\{ \begin{array}{c} A \\ B \\ C \\ D \\ E \\ F \end{array} \right\}$

so will the end of the Index next the Eyecut on the Limb, the Angle $\left\{ \begin{array}{cc} 84. & 00 \\ 113. & 30 \\ 237. & 45 \\ 49. & 35 \\ 102. & 40 \\ 234. & 00 \end{array} \right\}$;

and the South end of the Needle, as in the *Circumferentor*, will point at the bearings $\left\{ \begin{array}{cc} 111. & 00 \\ 44. & 30 \\ 102. & 15 \\ 331. & 50 \\ 254. & 30 \\ 308. & 30 \end{array} \right\}$;

both as in the first Example.

Also with a *Theodolite*, that hath the Box fixt to the Plate, and the Numbers on the Plate, as well as those in the Box, the Eye placed in the Center; encrease from the Left to the Right, and therefore most proper to work according to the Sun's Motion; if you would take the Angles and the bearings of the Lines of Fig. 1. and begin at an assigned Angle at A, direct the fixt Sights to G, and the South end of the Needle will point at $23^{\circ} 30'$ as in the second Example. And for all the following Angles and Bearings when the Instrument

ment is planted at

$\left\{ \begin{array}{c} G \\ F \\ E \\ D \\ C \\ B \end{array} \right\}$

direct the fixt Sights to

$\left\{ \begin{array}{c} F \\ E \\ D \\ C \\ B \\ A \end{array} \right\}$;

then screw the Index fast, and direct the Index
to

$\left\{ \begin{array}{c} A \\ G \\ F \\ E \\ D \\ C \end{array} \right\}$;

and so will the end of the Index next the Eye cut
on the Limb the Angle

$\left\{ \begin{array}{ll} 234. & 00 \\ 102. & 40 \\ 49. & 35 \\ 237. & 45 \\ 113. & 30 \\ 84. & 00 \end{array} \right\}$,

and the South end of the Needle as in the *Circumfe-*
rentor will point at the bearings

$\left\{ \begin{array}{ll} 285. & 30 \\ 208. & 10 \\ 77. & 45 \\ 135. & 30 \\ 69. & 00 \\ 333. & 00 \end{array} \right\}$

both as in the second Example.

With either of these four Instruments, the Angles and the Bearings of the Lines are taken, at once setting the Index, as easily and expeditiously as the Angle it self only; which evidently appears from the four preceeding Examples. And the Truth of these Observations may be readily proved by either of the Rules already laid down.

For, the Instrument being planted at B, in the first and third Examples; if to $111^{\circ} 00'$ the bearing there taken, you add $180^{\circ} 00'$ and from the Sum $291^{\circ} 00'$, take the last bearing $207^{\circ} 00'$, there will remain $84^{\circ} 00'$, which gives the Angle taken at B, exactly as there observed; and proves the Angle and these two bearings to have been truly observed.

In like manner, the Instrument being planted at C, in the same Examples; if to the bearing there taken, $44^{\circ} 30'$, you add $180^{\circ} 00'$ and from the Sum $224^{\circ} 30'$, you subtract $111^{\circ} 00'$, the bearing taken at the last Station; the Remainder $113^{\circ} 30'$ gives the Angle at C exactly as it was there observed; which proves that the Angle and also the last and present bearings are truly observed.

Also

Also the Instrument being planted at D ; if to the bearing there taken $102^{\circ}. 15'$, you add $180^{\circ}. 00'$, and from the Sum $282^{\circ}. 15'$, take $44^{\circ}. 30'$ the last bearing ; the Remainder $237^{\circ}. 45'$ gives the Angle at D. as there observed.

But the Instrument being planted at E ; if to the bearing there taken, $331^{\circ}. 50'$, you add $180^{\circ}. 00'$, and from the Sum $511^{\circ}. 50'$, you subtract $102^{\circ}. 15'$, the last bearing ; the Remainder $409^{\circ}. 35'$ lessen'd by 360° , because greater than 360 , gives $49^{\circ}. 35'$, the Angle at E. And so of all the rest.

And in like manner may the Angles and Bearings be compared in the second and fourth Examples.

Or the Angles and Bearings may be compared by the second Rule thus. The Instrument being planted at B ; if to $84^{\circ}. 00'$ the present Angle, you add $207^{\circ}. 00'$ the last Bearing, and from the Sum $291^{\circ}. 00'$ you take $180^{\circ}. 00'$, the Remainder $111^{\circ}. 00'$, gives the present Bearing, as observed.

The Angles and Bearings being truly taken, it remains to shew how

To Plott, and therein to discover and correct an Error before it is communicated to the following Part of the Work.

HAVING provided your self with a *Protractor*, whose Numbers increase contrary to those in the Box, draw all over your designed Draught parallel Lines, as in plotting Observations taken with the *Circumferentor*.

Then from some Point convenient to represent your first Station, as in the $\left. \begin{array}{l} \text{first and third} \\ \text{second and fourth} \end{array} \right\}$ Examples, from A, lay down by the bearing $\left\{ \begin{array}{l} 207^{\circ}. 00' \\ 231^{\circ}. 30' \end{array} \right\}$ the first Line $\left\{ \begin{array}{l} AB \\ AG \end{array} \right\}$ as taught in plotting Observations taken with the *Circumferentor*.

Then on the Point $\left\{ \begin{array}{l} B \\ G \end{array} \right\}$ lay the Centre of the *Protractor*, and its Diameter on the Line $\left\{ \begin{array}{l} AB \\ AG \end{array} \right\}$ produced both ways if need require, so that the beginning of the Degrees may be towards the last Station if the Angle be less than 180 Degrees, but the contrary way if greater, then at the Edge of the *Protractor* make a Mark against $\left\{ \begin{array}{l} 84^{\circ}. 00' \\ 234^{\circ}. 00' \end{array} \right\}$ the Degrees of the Angle $\left\{ \begin{array}{l} B \\ G \end{array} \right\}$, and draw the Line $\left\{ \begin{array}{l} BC \\ GF \end{array} \right\}$. Now turn the *Protractor* about on its Center, till its Diameter be parallel to the Meridians, so that the beginning of the Degrees be towards the North, when the bearing is less than 180 , but contrarily when more ;

more; and then if the Line $\{BC\}$ cut the bearing $\{111^{\circ} 00' \}$
 $\{285^{\circ} 30' \}$ on the Edge of the *Protractor*, that Line is truly laid down: Other-
 wise not.

In like manner, may any other Angles be examined, and if found erroneous, the Error may be corrected, before it is communicated to the following Part of the Work.

And we may observe, that, if the Plot be laid down by the bearings of the Lines, those bearings may be examined by measuring the Angles as soon as plotted.

Though this Method sufficiently recommends it self, both in respect of Dispatch as well as ACCURACY; I do not expect it will be practised by any but the Unprejudiced. For He, who hath surveyed much Land, with a *Circumferentor* alone, or with a *Semi-circle* or *Theodolite*, without a Needle or with any other Instrument, that doth not afford a double Observation; He, I say, hath not provided a Check to his Frailty, and will scarce forsake his old Way, because he will not accuse himself.

There are two other ways to use these *Theodolites*, each equally exact with the former, but not so expeditious. One way is to take the bearing with the Traversing Quadrants; the other is to take the Bearing with the Degrees on the Limb. But the Angle is always taken as above.

If you would use the Traversing Quadrants, then the observing, the plotting, and the Proof in plotting, are all as easily, speedily, and exactly done as by the first Method; but the Proof of the Observation in the Field, though equally true with the former, is neither so easily performed, nor so easily reduced to one single Rule. But the Person who is resolved to plot by the Traversing Quadrants, had best take the Observation both by the *Quadrants* and by the *Circumferentor*: and then prove the Observation in the Field by the *Circumferentor*, and the plotting by the *Traversing Quadrants*.

Lastly, If you would take the Direction by the Divisions on the Limb with a *Theodolite*, whose Box is fixt to the Plate, then (after you have taken the Angle, as before taught) turn the Instrument about till the North end of the Needle point at 360 degrees in the Box, and screw it fast; now direct the Index to the next Station, and the end next you will give on the Limb the Direction in Degrees and Minutes as in the former Examples.

But with a *Theodolite*, whose Box is fixt to the Index, if you would take the Direction by the Divisions on the Limb; then (after you have taken the Angle as before taught) direct the fixt Sights to the next Station, and screw the Instrument fast, and turn the Index about till the North end of the Needle point exactly at 360 degrees in the Box; and then will the end of the Index nearest to the South end of the Needle cut on the Limb the Direction in Degrees and Minutes. But the *Protractor* to lay this bearing down must be numbered contrary to the Limb on the Instrument.

The great Advantage usually proposed by this last Method, is, that the Degrees on the Limb are larger and more distinctly cut, and consequently more nearly estimated than those in the Box. But consider that you can no better bring the Needle to point at any one Degree, than you can estimate its Position in any other Degree; and that since we use the Needle, all the Objections made in one Method are incident to the other; and then you may easily conclude that the Advantage is only imaginary.

Besides, here we are obliged to take two Observations, either of which take up as much time as the one Observation used in the former Method; which renders it not so fit for a Practitioner.

Of the Use of these *Theodolites*, I have one thing more to advertise, viz. To measure and cast up the Content of one large single Wood or Common, where there are some scores of Angles to be taken; the safest way is to cast, without plotting, by Help of the Needle. And in this Case I would take the Directions both with the *Circumferentor* and the *Traversing Quadrants*; and in the Field prove the Directions taken with the *Circumferentor* by the Angles taken by the Limb; and then, still in the Field, prove both Lengths and Directions, in calculating a Traverse, by Help of a Traverse Table; and lastly from this Traverse (at Leisure) deduce the true Content.

But the Traverse Tables that are now extant, are but Specimens of those which are fit for Use; Instruments are not sufficiently exact, and Trigonometrical Operations too laborious; and therefore I must defer this way of Computation, till some Person who hath Leisure and Patience to serve the World, in calculating such a Table is resolved to do it; If I can procure it, as indeed I have some hopes thereof, it may be published with its Uses in Practical Surveying and Navigation in a Pocket Volume.

Of any one of the four *Theodolites*, which have the Number of the Box contrary to those *Theodolites* before described, one or more inconveniencies will always arise, use which of the three foremention'd Methods you please.

It is true, the Angle taken by the Limb is perform'd as taught in the preceeding Rules; but since it is not safe to work by the Limb only; if you use the *Circumferentor* as taught in the first Rule, you must either subtract the Direction from 360 Degrees, and enter the Remainder instead of the Direction pointed at by the Needle; or else use two *Protractors*, which will be troublesome, and also apt to cause Mistakes by using the one for the other.

If you use the *Traversing Quadrants* only, then indeed the Use is in all respects the same with the preceeding ones: but these as I have already shewn is not so expeditious as, nor more exact than, the Method first laid down.

If you will take the Direction by the Limb, and still make one *Protractor* plot both Observations, you must direct your Instrument
twice,

twice, whereas by the first Method laid down, it might be done at once.

Lastly, of *Theodolites* these are best which have Telescopes with plain Sights on them; and so contrived that the Surveyor may at any time adjust any small Accident, without coming to a Workman, and that both of them may be elevated or depressed at least ten degrees; one of these Telescopes instead of the fixt Sights, the other instead of the moveable ones; and as long a Needle as will play well, with other the like Conveniencies, sufficiently known to a skilful Instrument-maker.

To observe with a Semicircle that hath a Box and Needle.

A Semicircle is just half the *Theodolite*, and admits of just as many Varieties, it is numbred on the Limb to 180 Degrees, and in an Arch concentrick to this is numbred under 10, 20, 30, &c. with the Numbers 190, 200, 210, &c. to 360. Its Use in all respects (both to the Plate and Box) is the same with the *Theodolite*; save in this, that when the End of the Index falls off the Plate; the Degrees cut on the Limb are to be taken from the farther Part of the Index from the Degrees of the inner Circle; and will be always more than 180 Degrees.

There are some other manners of numbering and dividing (and perhaps without a Box and Needle,) used in these Instruments; but they are not worth Notice.

The Peractor

IS part only of that *Theodolite* whose Box is fixt to the Plate; and the Directions for the *Theodolite* will serve for this; and our Author hath himself laid down

The Use of the PERAMBULATOR;
to which I refer you. And as to the Divisions on the Limb of the **PLAIN TABLE** with its Box and Needle.

Like that of the *Theodolite*, or *Modern Circumferentor*; if the 360 Degrees of the Limb be upwards, and the Box and Needle screwed to the Side of the Table; it performs in all respects the Use of the *Theodolite*, whose Box is fixt to the Plate. For lay the Edge of the Index on the Division numbered 360, to that numbered 180; and turn the whole Instrument about, till through the Sights you see the next Station (the 360 being towards you as taught in the *Theodolite*) and there screw it fast; then turn the Index about upon the Centre, till you see your last Station, and so will the end of the
Index

Index next you cut the Degrees of the Angle, and the South end of the Needle will give the Direction.

But if the Box be screwed to the Index; it in like manner becomes a *Theodolite*, with a Box fixt to the Index.

If the Box and Needle be screwed to the Staff; it is a *Circumferentor*.

If the Box be screwed to the Table, and that side of the Frame be upwards, which is divided into four Nineties; it is the *Perambulator*.

If that side of the Frame is upwards, which hath only the 180 Degrees of the Semicircle numbred on it; then it is a Semicircle, either with the Box to the Plate or not; according as the Box is fixt to the Table or the Index.

And what hath already been said of these Instruments may serve for Directions, to use the plain Table these several Ways, and need not be again repeated here.

And hence it seems that the Plain Table might properly be called *Panorganon*, in respect of Land-Surveying.

Indeed, if instead of the small Holes for Centers to be used with a Protracting-pin by the Fiducial Edge of the Index, there were Conick Holes through the Tables; and also a Hole, being the next adjoining great Segment of the same Cone made in the Index to screw into the Centers by a Conical Pin at the End of it; and the Fiducial Edge of the extream parts was filed away, so that when continued they would pass thro' this Central Pin; and if the Divisions on the Frame be cut as well as on the Limb of the *Theodolite*; and if also the Wood would neither shrink nor swell no more than Brass; and a Telescope mounted on the Sights; and the back side of the Index brought also to a Fiducial Edge; then I should think it a very compleat Instrument.

It remains to shew how to take Angles when we use the plain Table covered with a Sheet of Paper; but this hath been sufficiently handled by our Author, therefore I shall content my self with laying down a Method to correct an Error committed before it is communicated to the following parts of the Work: Though I do not any ways doubt but the Reader may, by what follows, learn the use of this plain Instrument.

Suppose you were to draw the Plan of the Field *ALMNOPQR*; (Fig. 2.) draw on the Table a Line to represent *AL* in the Field, and by your Scale lay down on the plan the distance you found *AL* in the Field to be, when you measured it with a Chain. Then planting your Table at *L*, lay the Index on *AL*, and turn the whole Instrument about till you see *A*, and then screw it fast, then turn the Index about on *L*, till through the Sights you see *M*, and draw *LM*; and by your Scale give it on the Table the same Length you found it to have in the Field, by measuring with your Chain.

Now

Now in order to examine the Length of LM , and also its Position in respect of AL ; plant your Instrument at M , lay the Index at LM , and by turning the Instrument, direct the Sights to L , and there screw it fast; then direct the Index turn'd about on M , towards A in the Field, and if the Edge doth not cut the Point A in the Table, the Line LM is false either in Position or Length, and therefore must be examined and corrected before you proceed.

The Line LM being truly laid down, plant the Instrument at M , and lay the Index on LM , and direct the Sights to L , by turning round the whole Instrument, and then screw the Instrument fast; now turn the Index about on M , till through the Sights you see the Hair cut N , and by the edge of the Index draw a strait Line; and by your Scale, from N lay the Length NM equal to what you measured it in the Field.

But to prove whether the Line NM is truly laid down both in Position and Magnitude; having Planted the Instrument at N , and directed the Index on NM to M , and there screwed the Instrument fast; from N direct the Index to either of the Marks L or A in the Field, and if the Index then doth not accordingly cut L or A on the Table, the Line MN is false; and must be corrected before you proceed.

And in like manner through the whole Survey you may proceed to lay down every Line, and examin it before you leave it, provided that you leave your Marks all standing at every Station, by laying the Index on the last Line, and turning the Instrument about till thro' the Sights you see the Hair cut the last Mark; and then screwing the Instrument fast; if you turn the Index about on the Point representing the Station where the Instrument stands, till you see any one of the Marks passed by, except the last of all; and if the Edge of the Index doth not cut on the Table, the Representative of that point; the last Line is not truly laid down.

But when you are at any Mark, suppose N , if you cannot see any other Mark but M ; set up some Mark a , from whence you may see some of the preceeding Marks, suppose L , as well as M and N ; and from this point a examine the Truth of the position of the Line MN .

Or thus, you may set up a Mark a , any where in the middle of the Field, from whence all or several of the Angles may be seen; then the Instrument being at A , and the Index on AL , screw the Instrument fast; and turn the Instrument about on A , till you see a , and draw Aa .

The Instrument being at L , the Index on LA , and the Index directed to A ; let the Instrument be screwed fast; turn the Index about on L , till through the Sights you see a , draw by the Edge of the Index La ; and so will the point a be determined.

Then the Instrument being at M , the Index on LM , and the Sights directed to L , and then the Instrument screwed fast, turn the Index about on M , till through the Sights you see the Mark a

in the Field : then if the Edge of the Index doth not cut *a* in the Table ; the Line *LM* is false either in Position or Magnitude.

In like manner the Table being at *N*, the Index on *NM*, and the Sights directed to *M*, and then the Instrument screwed fast : turn the Index about on *N*, and direct the Sights to the Mark *a* ; and if the edge of the Index doth not cut *a*, on the Table ; then *MN* is false either in position or magnitude.

Lastly, instead of a Mark set up as *a*, you may use any remarkable Tree, Steeple, &c. not at too great a distance from you, whether it be in the Land you are then Surveying or not.

And when the Mark you have last used is at too great a Distance from you, or lies almost in the same strait Line with that which you are about to lay down ; then use some other Mark in its stead.

To take Angles with a Chain.

IN order to do this, provide three round Sticks, very strait and about four or five Foot long. And if you were to take any Angle as *DBC* (Fig. 3.) first place one Stick upright in *B*, and there hold one end of the Chain, and let your Assistant carry the other end, and another Stick towards *C*, and direct him to move side ways, till the Stick held upright at *E*, be exactly in the right Line *BC*, where let him leave it.

Then let him take the end of the Chain and move towards *D*, and as before direct him to plant the third Stick upright in the Line *BD* at *F*.

Then measure the distance *EF* in Links and decimal Parts of a Link, if less than one Chain, and enter them in the Field-Book ; so if the distance *EF* were 94 Links and 7 Tenths of a Link, they might be entered thus, 0 . 947, denoting 0 Sextants, 947 parts.

In this Work great Care ought to be taken, that the Sticks be as strait as a Workman can shoot them with a long Plane ; and that they are planted either exactly perpendicular, or at least so that the Sticks planted at *B* and *E*, and the Mark *C* may be exactly in the same plane and also the Sticks *B* and *F*, and the Mark *D* in another Plane.

But because it is very difficult to erect a Stick exactly perpendicular ; it will be easier to perform the latter ; thus, plant the Stick as nearly perpendicular as you can ; then move your self backwards towards *G*, the farther the better, till your Eye, the Stick at *B*, and the Mark at *C* are all in one strait Line, there stand and direct your Assistant to plant his Stick, so that the Stick at *B* exactly cover it from the top to the bottom.

But if it so happen that you cannot move backwards at all towards *G* ; then having planted the Stick at *B* as upright as you can, let your second Assistant move forwards towards *C*, and let him there

there direct your first Assistant to plant the Stick at E, so that it exactly cover the Stick at B, while you direct him to place it in a right Line with the Stick B, and the Mark at C. And the like Caution must be used in planting the Stick F. Nevertheless it will often so happen that the Mark at D may be a little shifted, and in this Case, time and trouble may be a little lessened; for having planted the Stick at F, nearly in a true Position, move forwards towards D, and direct your Assistant to incline the Stick at F, so that it exactly cover the Stick at B, then returning to B, direct your Assistant at D to place the Mark in a right Line with the Sticks B and F.

But, secondly, if the Line EF be longer than the Chain (as in Fig. 4.) lay out a Sextant: thus while the Chain was laid from B to E, set down an Arrow at H 50 Links; then let your Assistants hold the Chain's ends at H and B, while you with the middle in your Hand laying both Halves strait, set down an Arrow at I, and so constitute the Equilateral Triangle HBI; and therefore have thereby laid out the Angle HBI, a Sextant. Now the Chain's end still held at B, stretch it through the point I to K, where also set down an Arrow; Lastly, measure KF in Links and decimal parts of Links, which suppose to be 76 Links and 4 Tenths; and then shall be entered in the Field Book 1^s 764. implying one Sextant and 764 parts.

In like manner, if the Angle were more than two Sextants (as in Fig. 5.) then having laid off the Sextant HBI. Let your Assistants hold the ends of the Chain at B and I, while you with the middle of the Chain in your Hand set down an Arrow at L, constituting the Sextant IBL; and then as before the Chain being still held at B, lay it through L, and at the other end M set down an Arrow; lastly, measure MO, which suppose to be 43 Links and 5 Tenths and then enter in the Field Book 2^s 435; that is 2 Sextants and 435 parts.

If I would continue a strait line, I signifie it by entering in the Book 3 s. 000; that is 3 Sextants.

If an Angle be external, and so containing more than three Sextants (as in Fig. 6.) let one Assistant hold one end of the Chain at B, and let the other Assistant stand with the other end of the Chain at E, and there hold a Stick so that E, B and C, are in the same Plane as before taught, and also plant a Stick at F, so that the Sticks B and F and the Mark D be also in the same Plane. Then measure the Angle EBF, as already taught, and to it add the Sextants, and so will the Sum be the Measure of the external Angle CBD. So if the Angle GBD be 0 s. 947, then will the external Angle CBF be 3 s. 947. But if the Angle GBD be 1 s. 764, then the external Angle CBD will be 4 s. 764. And if the Angle GBD be 2 s. 435, then the external Angle CBD will be 5 s. 435.

Now to plot any of these Angles, thus taken (suppose that in Fig. 3.) chuse some Line divided into 1000 equal parts, and with this Line describe an Arch ER, and lay on it from E to F 947 equal parts and draw BD.

And

And if you would plot the Angle taken in Fig. 4. from B with the length of the divided Line describe an Arch E F, and lay thereon the length of the divided Line from E to K, and afterwards 764 parts from K to E, and draw the Line B F D, and you will construct the Angle required.

And if you would plot the Angle of Fig. 5. then as before with the length of the divided line describe the Arch E O, and thereon lay E P, P M, each equal to the Radius; and afterwards lay 435 equal parts from M to O, and draw B O; and you have the Angle as required.

Also if you would protract an Angle greater than three Sextants, (as the external CBD, in Fig. 6.) first continue the line CB, then from the Angle subtract three Sextants, and make the Angle G B D equal to the Remainder.

If you would protract by a *Protractor*, let it be made thus; let the Semicircle (Fig. 7.) be divided into three Sextants in the Points A and B. Then draw the blank lines C A, A B, B D, and divide each into 100 equal parts; and then transfer them to the Arches C A, A B, B D; lastly, from the Center draw the Divisions, which number thus, I. 10, 20, 30, 40, 50, 60, 70, 80, 90, I. 10, 20, 30, 40, 50, 60, 70, 80, 90, II. 10, 20, 30, 40, 50, 60, 70, 80, 90, III. But observe that with this order of numbering, the Work must be carried on against the Sun within the Field, and with the Sun's Motion without the Field. And the use of this is in all respects like that of other *Protractors*; for when the *Protractor* is placed as above, and you are to lay down 2 s. 435 parts, count out on the edge of the *Protractor* beyond II. towards III. 43 Divisions, which answers to 2 s. 430; and for the last place conceive every Division subdivided into ten equal parts, and by the Eye estimate the parts required, which in this Example is 5, and falls in the middle between the 43d, and the 44th Division; lastly, against this estimated point make a Mark, to which from the Center draw a Line, and Angle as is required. Thus much of taking Angles by the Chain only when we work in the inside of an open Field.

But if you would go on the outside of a Field, or survey a very bushy Wood, as in Fig. 8. then instead of working according to the Order of the Letters A B C D, and against the Sun, work from A to F, and so to E with the Sun; and instead of taking the Angles themselves within the Wood B A F, A F E, F E D, E D C less than three Sextants, take their Supplements to six Sextants, by adding three Sextants to the Angles G A F, H F E, I E D, K D C; also instead of the Angle D C B within the Wood greater than three Sextants by the Angle L C D, take its Supplement to 6 Sextants, the Angle D C B without the Wood.

And then in the same Order proceed to plot from A to F, and so on to E; as before taught.

But

But when the Angles are each less than 3 Sextants and so all internal ones, as in Fig. 9. you may work as though you were within the Wood by taking the Angles FAG, HBI, KCL, &c. made by continuing the Lines EA, BA, BC, &c. for these Angles are equal to the internal ones, EAB, ABC, BCD, &c. because vertically opposite to them.

And indeed the like Method may be observed in Fig. 8. provided that when we come to the external Angle BCD, that here we take its Supplement to 6 Sextants; and enter in the Field-book the quantity with the Word *Supplemental* added to it.

N. B. If you have two Chains, you may (as will be better) lay out the Sextants so, that each side of the equilateral Triangle be one whole Chain.

But take especial Care that the Rings at the end of each tenth Link be at their true distance from the Chain's end; and then take the intermediate Links and parts with a Rod of 10 Links, divided into 100 parts.

Angles are taken with Rods of 5 and 10 Foot,

AND also laid down in all respects as with the Chain; but observe that one end of each Rod should be sloped off to an edge, like the Rod Gaugers use for taking the Diagonal Line of a Cask. Also that each Rod be nicely divided into Feet, and that the intermediate distances be estimated by a Foot Rule divided into 100 equal parts.

Angles taken with Rods are usually about Gardens and Buildings, but are no ways fitting for large Plans.

As for the Chain, a *Surveyor* may with it for a shift, perform many Works, but not all; and this, at best, is both laborious and tedious.

The best Instruments for Surveying all manner of Lands both great and small in all Cases, are the *Theodolites* before mentioned.

If the *Surveyor* have only a Chain, and hath drawn his Plane, and would draw thereon a Meridian-line; he may do it thus; exactly at 12 a Clock mark the shadow of some upright Object, as the Corner of a House, or some straight Tree, or your Staff set upright; then plot this Line on your Plane, and it is a Meridian Line.

Or thus, in a Night when the *Pole Star* is to be seen; place yourself so, that your Eye, the *Pole Star* and some upright Object, as the Corner of a House or straight Tree, be in one straight Line; then plot the Line from your Feet to the upright Object, and it will be a Meridian-line.

Indeed the *Pole Star* moves round the real Pole; but at so small a distance from it, that in this Case the Variation may be rejected.

However

However you may observe that the *Pole-Star* is full North about the 20th Day of

March and September at 12	}
April and October at 2	
May and November at 4	
June and December at 6	
July and January at 8	
August and February at 10.	

a Clock either Morning or Evening ; always encreasing nearly two Hours for every Month.

Therefore if the Observation is made about these times, the Variation will be very inconsiderable.

Also observe, that 5, 6 or 7 Hours before or after these times, if the pointers are to the $\left\{ \begin{array}{l} \text{Eastward} \\ \text{Westward} \end{array} \right\}$ of the Pole ; then the Variation by the Star is about 3 degrees and $\frac{1}{2} \left\{ \begin{array}{l} \text{Westward} \\ \text{Eastward} \end{array} \right\}$ and this Variation is the greatest.

CHAP. III.

Of the Chain.

First, provide a Staff just 6 Foot 7 Inches and $\frac{1}{2}$ long, which divide into 10 equal parts ; and so will the whole be the length of 10 Links, and each part the length of one, and 10 times the length of this Staff the length of the whole Chain.

With this Staff examine the length of the Chain, and also of every 10 links ; stretching it on level Ground the while, to such a degree as you design to stretch it, when you measure with it.

Before you measure with it, provide 9 Arrows or small Sticks each about two Foot long, and two strait Staves about 5 Foot long each.

When you are about to measure with it, let him that leads the Chain take the 9 Arrows and one of the Staves ; and he that follows it the other Staff.

Then the Follower standing at the Station, let him direct the Leader to place his 5 Foot Staff at the Chain's end in the same right Line with the Stations ; and then let the Leader take up the Staff, and in its place sticking down one of the Arrows go on.

Now the Follower being come to the Arrow, let him direct the Leader to place his staff as before.

And then let the Leader standing at his staff, look back towards the last station, and he will see the staves and the station in one right Line, if they have directed right. But if they are not in one right line the leader must direct the Follower to place his staff at the Chain's end in the same right line with the station and the Leader's staff.

And

And so, let each direct the other till the two staves and the two stations are in one right line, and then must the Leader put down an Arrow in the place of his staff, and go on: And the Follower take up the Arrow where he last stood, and go after him.

And let him thus proceed till they have measured to the station, or till the Leader is nearer the station than one Chain's length: and then will the Number of the whole Chains measured be expressed by the Number of the Arrows prickt down; which suppose 7.

Now let the Leader go on to the station, and there hold the end of the Chain, and let the follower stretch the Chain as usual; and then see, how many Links are contained between the last arrow and the station; which may be readily counted by help of different bits of Brals; or Curtain Rings, or other Marks fixt at the end of every tenth link: which links suppose to be 47.

Lastly, enter in your Field-book the Chains and Links without any Distinction between them; and they will be 847; which imply either 847 links, or 8 chains 47 links.

But here we are to observe, that the links must always possess two places; as 8 Chains and 4 Links must be written 804; that is 8 chains and 4 links, 804 links, and 8 chains without any links, must be written 800, implying 8 chains, or 800 links.

It is necessary that the *Surveyor* should enquire of his Assistants at the end of every measured length, how many arrows each hath; and if the Sum of the arrows are not nine, it is evident they have dropt or left behind those that are wanting; and consequently the last length measured is doubtful, and must be remeasured before you proceed.

When you are come to the station, if it be convenient to continue the length; let the Follower stand at the last arrow, and let the Leader go on with the Chain, and so place his staff, that it and the two stations are in one right line; then in the place of the staff put down an arrow, and go on; always directing himself to place his staff, and consequently his arrow by the two stations.

When you have continued your length, till you have nearly lost sight in the farthest station, set up another station-staff in the place of the last arrow, and go on to continue by the two nearest stations.

But withal take this Caution; that it is not safe to continue lengths very long, when the stations are near one another.

Lastly, when your length is very great, having measured nine Chains, let the Leader go on and set his staff down at the tenth; now let the Follower put his staff in the place of the Leader's, and give the Leader the nine arrows, and then go on. But observe to enter in your Field-book these ten Chains, and never trust to your Memory. And if your length consists of ten Chains more, work as before, and enter 20 Chains: and so on.

The Problems of laying out lands, as met with in practice, are in Number 3.

CHAP. IV.

Of the Laying out of Lands.

WHEN any Number of Acres, Roods and Perches are to be laid out; it is convenient to reduce them to square links; which may be done thus:

If the Roods are $\left\{ \begin{smallmatrix} 1 \\ 2 \\ 3 \end{smallmatrix} \right\}$ add $\left\{ \begin{smallmatrix} 40 \\ 80 \\ 120 \end{smallmatrix} \right\}$ to the Perches, and to the Sum annex 4 Cyphers. Divide this last by 16, and write the Quotient Figures if they be 5, after the Acres.

But when the Quotient Figures are but $\left\{ \begin{smallmatrix} 4 \\ 3 \end{smallmatrix} \right\}$ write $\left\{ \begin{smallmatrix} \text{one Cypher,} \\ \text{two Cyphers} \end{smallmatrix} \right\}$ after the Acres and then the Quotient Figures: And so will you have the square links required.

A. R. P.

Ex. I. Reduce 7. 2. 24 to square Links.

24
80

16)1040000(65000

80000

Answer 765000

A. R. P.

Ex. II. Reduce 7. 0. 11 to square Links.

16)110000(6875

146

120

80

Answer 706875

A. R. P.

Ex. III. Reduce 7. 0. 01 to square Links.

16)10000(625

40

80

Answer 700625

The Problems of laying out lands, as met with in practice, are in Number 3.

For

For, either the Partition-line is required to be parallel to some other line assigned, or to pass through a point assigned in the Fence, or to pass through some point assigned within the Land.

In the Solution of each of these I chuse an arithmetical Approximation rather than a Geometrical Construction; for Reasons sufficiently known to those who have practised.

PROB. I. *Let it be required to cut off towards AB, Fig. 10. 8 Acres, 3 Rods 18 Perches by a Line drawn parallel to AB.*

First, Draw parallel to AB a line CD by guess, and then cast up the Content of the Figure CDHG, which suppose to be 772575

A. R. P.

square links, which is less than 8 3 18, or 886250 square links, by 113675 square links, which shews that the Partition-line is more towards K.

Now divide the excess 113675, by 965, the length of CD in links, and at the distance of 118 links the Quotient, draw EF parallel to CD, and it will be sufficiently near the Partition-line required.

But if by Curiosity you are led to correct the Variation; you may conceive CD, to be a Line given in Position, and 113675 square links, to be the quantity to be cut off, and EF the Line drawn by guess.

But if the Line CD had cut off the quantity CDHG greater than that required, then the Partition-line had been more towards GH, whose Distance from C.D, would be found as before, by dividing the Difference by the Length CD.

A. R. P.

PROB. II. *To cut off 5 0 35 towards L, Fig. 11. by a Line drawn from the Point V.*

A. R. P.

Reduce the given quantity 5 0 35 to square Links, and they will be 521875.

Then draw LV, forming the Triangle VLW, which being cast up amounts to 3800 square links, which is too little.

To the next Angle draw VM, forming the Triangle VLM, which being cast up will be found to amount to 297632 square links, which added to the Triangle VLW, you have 328432 square links, the Content of the Trapezium VWLM; which is still too little.

To the next Angle draw VP forming another Triangle, whose Content 403850 square links added to 328432 the Content of the preceeding Figure, gives 732282 square links, which is more than the required quantity by 210407 square links; therefore the Partition line passes between P and M. Divide the Excess by 497, half

K k

the length of VO the Perpendicular in links; and lay 423 the Quotient from P to N; and so shall VN be the true line of Partition.

A. R. P.

PROB. III. To cut off 7 3 13 towards B from a Line passing by the Point A. see Fig. 12.

It may be thus performed; consider through which two sides the Partition-line will pass. Reduce the Figure to a *Trapezium*, still retaining those sides. Which divide by a line through the assigned point A, as taught in the first Book.

But, because this Method is tedious, and depends on the Concourse of many lines; and tho' we should use Numbers, we should little mend the matter, and indeed is often impossible to be performed by one single line, it may not be amiss to shew how to do it by two lines.

From A to any two Angles H & B draw the lines AH, AB, forming the Triangle AHB, which being cast up amounts to 338000 square links less than the quantity required.

To the next Angle C draw AC forming the Triangle ABC, which being cast up amounts to 322500 square links, which added to the Triangle AHB gives 660500 square links, which are still less than the quantity required.

To the next Angle F draw AF, forming the Triangle ACF, whose Content 280800 square links added to the preceeding Triangles AHB ABC gives 941300, which exceeds the quantity required by 158175 square links; now divide this Excess 158175 by 292 half the length of the Perpendicular EL, and lay the Quotient 541 from F to D, and draw AD; and so will the lines HA AD be the Partition required.

It may not be improper, perhaps to add in this place, the manner of casting up such Fields as consist of many small Breaks in the Hedges; without reducing them to a multitude of Triangles. *e. g.*

Let Fig. 13. be such a Field. Produce NM, some one of the longest sides; then lay the edge of a strait Ruler from M, one of the Angles at the end of NM, to G the next but one; holding the Ruler thus fast, take with a pair of Compasses the distance from L to the Edge of the Ruler, and with this distance let one point of the Compasses move gently close to the Ruler, while the other point traces out a Line parallel to it, and crosses NM in Q. Now draw GQ, and it will reduce that side of the Figure, which was bounded by the two lines ML LG; to another bounded by GQ, one single line only.

In like manner QG being produced, and a Ruler laid from G to E, carry the distance of F from the Ruler parallel to it, till you cross MG in K. Secondly, lay a Ruler from K to the next point D, and carry the distance of E, the last point, from the Ruler parallel to it, till you cross MG in H. Thirdly, lay a Ruler from H to the next point C, and carry the distance of D the last point from it, parallel, till you cross MG in I. Lastly, Draw IC; and

and the side G C which consisted of the four lines G F F E E D D C, will be reduced to the side I C, consisting of one line only. And in like manner we might proceed if the lines were never so many.

And thus laying a Ruler from C P draw P O; and in like manner A Q. So will the ten sided Figure be reduced to a four sided one, and so then may be cast up by one Multiplication only.

Provide a Plate of thin Brass in form of an Arch of a Circle; near whose ends let there be drilled small holes; thro' which string it with a very fine Hair. Being thus provided; when a Hedge as G C bends in and out in several places, and those Bends contain very small spaces; lay the Hair over it length wise, so that the quantities cut off from the Figure thereby may be equal to those added to it; and with your Protracting-pin near the ends of the Hair make two Marks, through which draw a strait Line; and so will this irregular side be reduced to a regular one. And here we may observe that in very small Bends, by the Eye we judge better than we can by the Compasses.

Lastly, if Hedges consist of large Curvatures (as in Fig. 14. 15.) Chuse out such points, and so many of them that right lines drawn from point to point, may vary the Quantity by such Quantities only as may be rejected. And herein your Hair will be a ready Assistance.

C H A P. V.

The use of the Theodolite exemplified in Surveying several Parcels of Land lying together.

AFTER a general Description of Instruments and their Uses; some practical Examples are necessary to illustrate and explain the particular Varieties which often occur.

The following Example I have handled in the same Method which I my self practise.

The Instrument which I use is a *Theodolite* numbred on the Limb from the left to right; and in the Box (which is fixt to the Index) from the right to the left; the Eye being supposed in the Center.

The *Chain*, the *Off-set Staff*, the *Arrows*, &c. are as described in the third Chapter.

The Field-Book I divide into three Columns. The middlemost contains the several Lengths taken by the Chain. The outermost Columns contain the several *Off-sets* and the Description of the most remarkable Objects, which are to be met with in the Survey.

By

By the Mark $\odot$. I denote a Station, by $\sphericalangle$ I denote an Angle, by B I denote a Bearing, by *Int.* I denote a cutting a Hedge by the Chain, by *ag.* I denote some remarkable Object on the farther side of the Hedge. These Symbols I have used instead of Words, because they constantly fall in the way; but other Objects which are more rarely met with I express by Words.

Being thus provided, in the first Page of the Field-Book near the top I enter the Title of my Survey. Then having fixt my Instrument in some convenient place, as A to begin at, I enter in the middle Column $\odot 1$. denoting the first station.

Here may be observed that I always chuse to work in a Lane, as oft as Opportunity presents.

My Instrument being planted at A , I send a station staff forwards in the Lane as far I can see distinctly; the farther the better (suppose to B^3). and when I work in the Land, I send a station staff to the next eminent Bend in the Hedge or even to the farther end of it, if the Line from the Instrument to the Staff be not too great a distance from the Hedge, so as to cause Off-sets greater than a Chain or a Chain and a half or thereabouts. For Off-sets taken too great, produce some Uncertainties.

First then, I observe the Bearing of the line AB , thus, the Flower-de-luce in the Box being towards me, I direct the Sights to B^3 , and then find the Needle cut 327° , which I enter in the middle Column under $\odot 1$. thus, $B 327^\circ$.

The Observation being made of the Line's position, which I am about to measure, the next thing is to lay the Chain from this station A in a right line towards the next station B^3 ; which being done I let it lie, till I have entred the Occurrences in this Chain's length, *viz.* I measure the Distances of the Chain from the Brow of each Ditch, which I enter in the outside Columns, that of the right Hand of the Chain in the right Hand Column, that on the left in the left Hand Column, and also the Names of the Persons who own these Lands abutting; or if these Lands are some of those which I am about to survey, I enter the Names of them, and in all cases express to which Land the Hedge belongs.

These Precepts I shall not repeat, though I shall ever make use of them, but if I use any other, I shall lay them down the first time I meet with them in this Example, but not afterwards.

First then, I enter $\odot$ in the middle Column, and 20 in the right Hand one, and 20 in the left, denoting that at no distance, or at the Instrument, the Ditch on the right Hand is 20 links from the chain, and that on the left also 20. In the right hand column I write *William Wary's Land, Hedge to Wary*; and in the left, *Lord Titles Land, Hedge to Lord*; because the Land and Hedge on the right is *Wary's*, and that on the left *my Lord's*.

Being

Being come to *a*, I am right against the South Hedge of *Hazle Spring*, and also of *Woodfield*, and there find the distance from the Ditch on the right hand to be 25, and on the left to be 20, and that afterwards the Hedge on the right hand belongs to *Hazle Spring*, and on the left to *Woodfield*. Therefore I enter in the middle Column 65, and in the right hand Column I enter 25, *ag.* Hedge on *Hazle Spring*, Hedge to Spring; and in the left 20, *ag.* Hedge on *Woodfield*, Hedge to Field.

Here may be observed that I always measure these Off-sets or Distances of the Chain from the Hedge (with my ten link Staff which I therefore call my *Off-set Staff*) perpendicular to the Chain, and so far till I come to that Brow of the Ditch, which is farthest from the Stem of the Hedge. And that here by the Brow of the Ditch I mean the determined Distance of five Links from the Stem of the Hedge. And in order to lay this staff perpendicular to the Chain, it would be convenient to have two pieces at one end of it at right Angles, like the Squares used on a Drawing-board; and these pieces for Convenience in Carriage, may be made to fall into the Staff by Springs like a Clasp-knife.

Having entred my Observations in my first Length of my Chain, I observe what place of the Ground is exactly under the Centre of my Instrument, by dropping a Musket bullet; then I remove my Instrument, and in that place fix as upright as I can, a Station-staff, and then proceed with the Chain.

And because in the second and third Lengths of the Chain I meet with no sensible Turns in the Hedge, nor other material Occurrences, I go on to lay it a fourth time, and there against 45 links I find a Bend in each Hedge; where on the right Hand the Brow of the Ditch is 50 links distant from the Chain, and on the left 40; therefore in the middle Column I enter 345 (denoting 3 chains 45 links) and in the right hand Column 50, and in the left 40.

And here may be observed that I take Off-sets only at each end of such parts of a Hedge as run very nearly strait, omitting the intermediate parts; since when the Extrems of a right line are given, that right Line itself is also given. So here, though the Distance of the Hedges from the Chain between *a* and *b* continually vary, yet I only take the Off-sets at *a* and *b*, since these are sufficient. But when the Hedge runs on with a continued but irregular Curvature, I take Off-sets at every Chain or half Chains length or perhaps oftener, as the thing requires. But when the Curvature is regular, I take its Extremities by Off-sets, and express its Nature by a Sketch, in the outside Columns figured.

In going on from *b* towards *B*, when I am come to *c*, the Chain touches the Brow of the left Hand Ditch, against 20; then I ask the hindmost Man how many Arrows he hath, he answers 5; then I enter in the middle Column 520 (denoting 5 chains 20 links) and in the left Hand Column 00, denoting that the Brow of the Ditch is at no distance from the Chain. The Chain still lying against 40 links, I find a Bend in the right Hand Hedge; where the Ditch is distant from the Chain 50 links.

Now it may be observed that I frequently ask the Follower of the Chain, and also the Leader how many Arrows they have, especially when I am about the off-set or other occurrence, partly to know the Number of the Chains, and partly to prevent the loss of an Arrow; for this always raises a Doubt of the Length, and must be removed before we proceed; and lest when a Stick is dropt another may be pickt up in its room, I always give my Arrows some Marks of Distinction.

If the Sum of the Arrows in both my Assistants Hands are less than nine, then the last Length must either be remeasured, since it's doubtful, or else the Surveyor must step it, and thereby discover, which dropt it: And this with a little practice he will easily do by counting his Steps, and using himself to step about the same distance each Step; and by loosing a Button of his Coat when he hath gone as many Steps (as by Experience he knows) carry him the Length of a Chain. And hence he may know exactly the Number of the Chains, though he cannot perhaps find exactly the odd Measure. But the Number of Chains is sufficient, because the Error by dropping Arrows always falls in whole Chains.

In like manner, at the Length of just 800, because the Chain touches the right Hand Ditch, and is distant from the Bend in the left hand 40 Links; I enter in the middle Column 800, in the right hand Column 00, and in the left 40.

Then I continue on to my station-staff at B³, which I find to be at the Length of 825, where because there is no Bend in the Hedge, nor other material occurrence; I enter 825 in the middle Column, and under it I draw a Line, denoting that this Length, and all the occurrences therein are observed and entered in the Field-book.

Since I have endeavoured to be plain and easy in this first Length; so shall I in the following part of this Example, be as concise as I can, unless where I meet with Matter not before spoken of; referring the Reader rather to the Field-book and Explanations, than tiring him with Repetitions.

Being come to B³, I there so plant my Instrument, by help of my Bullet, that its Center is directly over the Hole, which the Station-staff stood in; and I send my Station-staff forwards, as far as I can conveniently see it, as to C.

Now with the beginning of the Degrees towards me, I direct the fixt Sights back to the Staff at A; and then screw the Instrument fast. And then with the Flower-de-luce towards me, I direct the Index to the Staff at C; and there find, that the end of the Index next me, cuts $202^{\circ} 15'$, and the South end of the Needle points at $304^{\circ} 45'$. Therefore I enter in the middle Column of my Field-book, O 2, and under it $\sphericalangle 202^{\circ} 15'$, and next under this B $304^{\circ} 45'$; denoting that at the second Station the Angle made is $202^{\circ} 15'$, and the Bearing of the second Length is $304^{\circ} 45'$.

But

10', I enter in the middle Column 15, and on the left hand 10 Corner, then on *Long Mead*, then *Hedge to Long Mead*.

But because on the right hand we have still *Hazle Spring*, and the Hedge is still to the Spring, and because these have been always on the left hand since I first enter'd them; I go on without any farther Remark till I meet with a different occurrence.

Being come to L, I observe, enter and prove the Bearing and Angle and then proceed to M. At M I observe and proceed in like manner to N. But at N, the seventh Station, instead of going on in the Lane, I proceed to close in *Hazle Spring*, and therefore send a station staff to O in *Spring Close*.

Therefore at the seventh station N in the Lane, having observed, entred and prov'd the Angle MNO, and the Bearing of the Line NO, and directed the Chain from N towards O; I find the Chain cuts the Brow of the Ditch at 10 Links distant from N; therefore in the middle Column I enter 10 *Int.* denoting the Chains intersecting the hedge, and before I write in *Spring Close*, denoting that the Land we are in is called *Spring Close*, and in the right hand Column but the next Line I write *Hazle Spring*, and under this *Hedge to Spring*, denoting that the Land on our right hand is *Hazle Spring*, and that the hedge belongs to the same. Then I proceed to observe, measure and enter those occurrences, as they are found in the Field-Book till I come to O.

At O, I observe, enter and prove, and proceed as usual towards QD; noting that at the length 720 the Chain did cut the hedge in the very corner of the Fence; and therefore enter in the middle Column 720 *Int.* and in the right hand Column 00 *Corner*, and then in the middle Column I write in *William Wary's Land*; and so proceed to Q.

Being come to Q, the ninth Station, I send a station-staff towards A; and then observe, enter and prove my Angle and Bearing; and so proceed with the Chain entering all occurrences, as in the Field-book, till coming to the length 830, I find my self right against the corner of *Hazel Spring*, and 43 distant from it; which being entred as you see in the Field book, I write in the middle Column * *Close Hazel-spring*, denoting that the Extremity of this Off-set co-incides with the first Off-set taken to *Hazel-spring*.

Having thus compleated *Hazel-spring*, I return to N, my station in the Lane according to that general Law I always observe, of working in a Lane, and according to that Law of closing as oft as possible.

Now if I turn back the Leaves of my Field-book, I find the station immediately before my coming into *Spring-Close* was by Number the seventh. Therefore in my Field-book I enter $\odot$ 7.

But here may be observed that when soever I design to return to the same station; before I left it, I cut a Turf from the hole where the staff stood, or leave some other Mark, whereby I may exactly find it again readily; and in the Filed-book to the Mark $\odot$, I pre-

fix the Letter *R*: by which and the other concomitant Notes I readily discover the number of the Station.

Having now planted my Instrument a second time at *N*, and sent a Staff forwards to *R*, I observe the Angle *MNR* made by the Line *NR* I am next about to measure, and the Line *MN*, that which I measured immediately before I came to *N* the first time.

And this I always make a constant Law, *viz.* To observe the Angle with that Line which was measured immediately before I came to the station, where I took the Angle the first time. So here I observe the Angle made with *MN* and not with any other as *ON*, and therefore in proving the Angle *MNR*, I use the Bearing of *MN* taken at *M*.

Now having taken, enter'd and prov'd the Angle *MNR*, and the Bearing of *NR*; I go on with the Chain towards *R*, entering the several occurrences as you find them in the Field-book.

Being come to *R*, the tenth Station, though my Design is to enclose *Spring Close*; yet because the last length continued strait forwards, will take the South hedge of *Long Mead*; in the middle Column I enter $\odot 10$, $\angle 180$: and then direct the Leader of my Chain to lay it right forwards by help of the Stations *R* and *N*. And accordingly I enter the occurrences of that Length, as you see in the Field Book.

This finisht I return to *R*, and sending a Station staff to *S*; I enter again $\odot 10$ and the Angle and Bearing at *R*; and so proceed to *S*.

And then from *S* to *T*; and so from *T* the 12th Station to *P*, enclosing *Spring Close*.

Spring Close being finished, I return to my 4th station at *D*. And then send a Station staff forwards to *E*; and then under $\odot 4$, observe and enter the Bearing of *DE*, and the Angle *CDE*; and then by the Bearing of *CD*, taken at the Station *C* immediately before I came to *D*, prove the Angle *CDE*; and proceed with the Chain entering all occurrences as usual.

Being come to *E*; I send the station to *F*, in order to close in *Woodfield*. Now after I have observed and entred the Angle and Bearing at the thirteenth station *E*, when I come to prove them; I find by adding 180° to $353^\circ 15'$, the Bearing of the Line which brought me to this station; and when from the sum $533^\circ 15'$ I have subtracted 82° the present Bearing, I find the Remainder to be $451^\circ 15'$, a Number greater than 360 . Now as oft as this happens I lessen this Number by 360 degrees, and so will the Remainder be as in this Example $91^\circ 15'$ the present Angle exactly.

Then entring the occurrences, I proceed to *F*, and in like manner from *F* to *G*, from *G* to *H*, from *H* to *I*, and then from *I* the seventeenth station to *K* thereby enclosing *Woodfield*.

This done, I return to *E*, and there because I can continue my Length *DE*, right forwards conveniently I enter $\odot 13$, $\angle 180^\circ 00$, and then go on to *V*.

And then entering Angles, Bearings and other Occurrences; I proceed from V to W, and from W to X the 20th station.

Being come to X, and having entered $\angle 234^{\circ} 20'$ and $B 307^{\circ} 40'$, then after I have added $180^{\circ} 00'$ to the last Bearing $2^{\circ} 00'$, I find the Sum 182.00 , is less than $307^{\circ} 40'$ the present Bearing; in such Cases I always add 360 to the Sum 182 and then from the Result taking the present Bearing $307^{\circ} 40'$, the Remainder will be, as in this Example $234^{\circ} 20'$, the present Angle.

Then I proceed to Y, and from Y to Z.

Being come to Z, the 22d Station, in order to enclose *Long Mead*, I go off to α , from α to β , from β to γ ; where because the several Bends of the River cannot so commodiously be taken without it, from γ I go off to δ ; and then from γ to ϵ , from ϵ to ζ , from ζ to η , and from η the 28th station to θ ; thereby enclosing *Long Mead*. And then return to Z.

Being come to Z, I find it convenient to continue my length strait forwards, and therefore under $\odot 22$, I write $\angle 180$, and so go on to κ , from κ to λ , from λ to π ; and then in order to enclose *Butts Close*, I go off from π , the 31st station to ρ , and ρ to σ .

Then returning to π , I go on to A^2 the 33d station, and then in order to close the *Home Close*, I go off to B^2 , and so then to C^2 , and D^2 .

Returning then to A^2 , I go on to E^2 , from E^2 to F^2 , from F^2 to G^2 , and from G^2 to H^2 , the 41st station.

Being come to H^2 , in order to close in *Mottle Mead*, I go of to I^2 from I^2 to K^2 , from K^2 to L^2 , the 44th Position, and from L^2 to M^2 , and so is *Mottle Mead* finished.

Then in order to enclose *Hazle Wood* I go from L^2 to N^2 , from N^2 to the Angle at F, and so is *Hazle Wood* finished.

Then I return to H^2 the 39th station, and thence go to O^2 , and from O^2 to P^2 the 45th station.

And now in order to close in *Hazle Field*, I go from P^2 to Q^2 , and from Q^2 to T^2 .

Which being done, I go from P^2 to R^2 , and from R^2 to S^2 ; and so the whole is finished, as you find it in the Field Book, and as far as relates to the Field Work.

It remains to shew how this Work may be plotted without any regard to the Memory; nay, though it were survey'd by one Person how it may be plotted by another who never saw the Land; provided that the Person who survey'd it hath strictly observed the Laws here laid down. And I do affirm, that any Method of keeping a Field-book which lays a Burthen on the Memory, or by which a Person remote from the Land, cannot plot it, is imperfect and ought not to be practised.

C H A P.

CHAP. VI.

*To protract the Observations contained in the
preceeding Field-Book*

First, I draw parallel right Lines, as those in the Scheme mark N S, representing Meridians or North and South Lines, at a Distance from one another not exceeding the breadth of the Diametrical part of the *Protractor*.

Then picking out some convenient Place to represent the first station as A; my Field-book being open before me, I lay the Center of the *Protractor* on the Point A, and the Diameter parallel to the Lines N S, and the beginning of the Degrees downwards, because the Bearing is more than 180; then against 327 degrees I make a Mark with my *Protracting Pin*, to which I draw an obscure Line from A, representing the Chain-line from the station A to the station B.

Then to this obscure Line I lay the Edge of my *Plotting Scale*, the beginning of the Divisions coinciding with A, and encreasing towards the next station B, and because the Off-sets in the first length are taken at the Distances 65, 345, 520, 540, 800, 825; therefore against these Numbers on the Scale I make Marks in the obscure Line close to the Edge of the Scale.

This done, I turn my Scale perpendicular to the obscure Line, and apply it successively to these several Points, and there prick off the lengths of the several Off-sets on their respective sides of the obscure Line; so at A, I prick off 20 on the right hand and 20 on the left; at the length 65 which is the next point, I prick off 25 on the right hand and 20 on the left; and at the next point which is at the distance 345, I prick off 50 on the right hand, and 40 on the left; at the fourth point, which is at the distance 520, I prick off 00 to the left hand; at the fifth Point, which is at the distance 540, I prick off 50 to the right hand; at the next point which is at the distance 800, I prick off 00 to the right hand, and 40 to the left; at the last point, because no Off-set was taken, I lay none down.

And now if Lines are drawn from point to point on each side of the obscure line, they will represent the Fences as was required. But when the Off-set is 00, as in the fourth and sixth Distances, those points, to prevent being overlook'd, should be mark'd with a black lead Pencil, or something else which may be easily rub'd out again.

At the second Distance, where we were against the South Fences of *Woodfield* and *Hazel Spring*, with a black lead Pencil draw two short lines, cutting the Lane, to denote that the South Fences come up to the Lane, and will hereafter be of use in closing these Plots.

Having

Having thus finish'd my first length, I produce it, if occasion require from B, both ways, till it is as long each way as the *Radius* of the *Protractor*. Then I place the Center of the *Protractor* on B, and thereon turn it about, because the Degrees of the next Angle are more than 180, till the beginning of the Degrees of the *Protractor* are contrary to the last station A, and the Diameter coincident with AB. Then close to the edge of the *Protractor* right against $202^{\circ} 15'$ I make a Mark with my *Protracting Pin*, and to it from B draw an obscure line representing the Chain line from B to C.

Then I turn the *Protractor* about, the Center still coinciding with B, and because the Bearing is more than 180, the beginning of the Degrees towards S. and the Diameter parallel to the Meridians; and then if you have truly wrought, the line BC before drawn will meet the Limb of the *Protractor* against $304^{\circ} 15'$, the bearing of the line BC.

But if it doth not, the line BC is not in its true Position, and must be corrected before you proceed.

Or thus, the Center of the *Protractor* coinciding with B, I turn it about till the beginning of the Degrees is towards S. because the bearing is greater than 180, and till the Diameter lies parallel to the Meridians; and then close to the edge of the *Protractor*, with my *Protracting Pin*, I make a Mark against $304^{\circ} 15'$, the bearing of the line DC, and to it from B draw a strait line representing the strait line BC. Then turning the *Protractor* about on the Center C, and because the Angle there taken was of $202^{\circ} 15'$, more than 180, I turn the beginning of the Degrees of the *Protractor* contrary to the last station A, and the Diameter to agree with AB; and then will BC meet the limb of the *Protractor* against $202^{\circ} 15'$, if the Bearing is truly laid down.

And thus the Plot may be laid down by the Bearings and examined by the Angles.

Then to this obscure Line, I apply the edge of my *Plotting Scale*, the beginnings of the Divisions coinciding with the present station B, and the Numbers encreasing towards the next C; and then close to the edge thereof against 240, 250, the lengths where the Off-sets were taken, I make Marks with my *Protracting-pin*. This done, I turn my Scale perpendicular to the obscure line, and at 240, I prick off 15 to the left Hand, and against 250 which gives the point C. I prick off 10 to the right Hand, as the Field-book directs. Now continuing the Fences to these Off-sets, I shall have finish'd the second length from B to C.

The second length thus finish'd, I produce it, if occasion require, from C, both ways, till the length each way be at least equal to the *Radius* of the *Protractor*. Then I place the Center of the *Protractor* on C, and because the Degrees of the Angle at C, are less than 180, I lay the beginning of the Degrees of the *Protractor* towards B, the last station, and the Diameter on BC. Then close to the edge of the *Protractor*, with my *Protracting Pin*, I make a Mark against

$140^{\circ} 45'$, the quantity of the Angle at C, and to it draw an obscure right line from C, representing the line from C to D.

Then turn the *Protractor* about, its Center still coinciding with C, because the bearing is more than 180 , the beginning of the Degrees towards S. and the Diameter parallel to the Meridians, and then if you have workt truly, the line CD before drawn will meet with the Limb of the *Protractor* against $340^{\circ} 30'$, the bearing of the line CD.

But if not, the line CD is not in its true Position, and must be corrected before you proceed.

From the laying down these two Angles and Bearings, it appears how Errors, often happening in Practice, may be prevented.

The general Laws I observe herein are three: *viz.*

1. I lay the Diameter of the *Protractor* on that line which brought me to the present station, where the Angle, about to be laid down, was taken.

2. I lay the beginning of the Degrees of the *Protractor* towards the last station, when the Angle is less than 180 Degrees, but the contrary way, when the Angle is more.

3. In laying down or examining the Bearing, I lay the beginning of the Degrees of the *Protractor* Northwards when they are fewer than 180 ; but Southwards, when more.

In like manner I lay down and examine the Angles and Bearings taken at D, L, M, N, O, Q, the 4th, 5th, 6th, 7th, 8th, 9th stations; and also the corresponding lengths and occurrences. But in the last length QA, having at the length 830 laid off an Off-set of 43, it gives exactly that corner of *Hazle-spring*, which was noted down in the first length in the Lane; which proves that the Angles and Lengths enclosing *Hazle-spring* are truly laid down. But if the Extremity of the last Off-set in the length QA doth not coincide with the Extremity of the second Off-set AB, both denoting the South-West Corner of *Hazle-spring*; the Lengths and Angles designed to enclose the same *Hazle spring* are not truly laid down; and therefore must be examined and corrected before you proceed.

Now $\odot 7$, being markt with 7, a Number not greater than 9, the Number of the last station, being the next Work noted in my Field-book; I return to $\odot 7$ in my Draught and there with MN, the line which I measured immediately before I came to N, I make the Angle MNR $162^{\circ} 45'$, and the bearing of NR $274^{\circ} 45'$, as noted in the Field-book. and then proceed to lay down the Off-sets and other Occurrences at their proper Lengths and Distances, as noted in the Field-book.

Having finished N R ; I find next following in my Field-book © 10, which because it is greater than 8, the Number which immediately follows 7, the Number of the last station ; and because I find no station already laid down, markt with a Number so great as 10, and therefore conclude that the station R, where I now am is to be numbred 10 ; and from thence proceed to lay down and examine the Angle and Bearing at R, as usual.

The Laws I observe in these Cases are,

1. To number with black Lead all the stations I have already laid down in my Draught ; and also to express those Numbers successively after one another in a Piece of waste Paper ; which I examine, as oft as I please.

2. If I come to a station whose Number doth not immediately succeed the Number of the last station ; but is greater than the greatest of those Numbers noted in my waste Paper by an Unite ; then at the station now arrived at, I lay down and examine the Bearing and Angle with the line I measured immediately before I came to this station. And this station I number as denoted in my Field-book.

3. If I come to a station, whose Number doth not immediately succeed the Number of the last station ; but is greater than the greatest of those Numbers noted in my waste Paper by more than an Unit ; then some Omission hath arose in my waste Paper, and must be rectified before I proceed.

4. andlastly, If I come to a station whose Number is already entered in my waste Paper ; then I return to that station in my Draught, and there lay down and examine the Bearing and Angle with the Line measured immediately before I came to this station the first time.

Now the next Observation I meet with in my Field-book is again © 10 ; Therefore again at © 10, I lay down and examine an Angle and Bearing as noted in the Field-book, and then proceed to lay down the Lengths and Off-sets of the Line RS, as I find in my Field-book.

Being come to S, I proceed to T, and from T to P, there closing with the Extremity of the Off-set at P. coinciding with the South West Corner of *Spring Close*, and the South East Corner of *Hazle-spring*.

This done, I find next in my Field-book © 04 ; therefore I return to © 4, and there proceed as my Field-book directs, till I come to station 13 ; and because this is a Number greater by an Unit than 12, the Number noted in my waste Paper ; I number it 13, and then proceed

ceed as my Field-book directs to F, G, H, I, and K, there closing in *Woodfield* by the Extremity of the Off-sets there laid down.

This done, I next find $\odot 13$, and therefore because already entered in my waste Paper; I return to $\odot 13$ in my Draught. And then proceed as before shewn, till I have plotted all the Occurrences mentioned in my Field-book; but the remaining part hereof I leave for the Exercise of the Reader.

I think I need not detain the Reader with the manner of transferring the Draught to his Velum; of drawing a Scale and a Compass, ever allowing the Variation of the Needle; of entering the Contents of each piece; and the Ornaments to be met with in other Parts of this, and every other Treatise of Surveying.

I shall only add that the Representation of the Hedges ought to be laid down on the same sides of the Fences, that they are in the Land; and to be broke off where there are to be the Representations of Gates, &c.

That there ought to be imaginary lines, both Vertical and Horizontal, denoted by Letters placed at the top and bottom. and also on the sides, to be referred to by the Table of References; for the ready finding any Field or parcel of Land therein contained.

Lastly, I shall in this place only add, that in all Performances of this kind, Errors for the most part arise from the Defects of instruments; in the Framing, Dividing and Contriving.

Therefore I think it proper to say, that I have seen a *Theodolite*, made by Mr. SISSON, *Mathematical Instrument Maker*, at the Corner of *Beaufort-Buildings* in the *Strand*, for Accuracy and Dispatch, fitter for a Surveyor than any other I have yet seen.

Now followeth the Field-Book.



Observations and Dimensions of
Lands lying in the Parish of - - - -
in the County of - - - - part of the
Estate of - - - -

February the 2d. 1720.
Beginning at the Lane leading from Hardly to
Roughton.

		⊙ 1	
		°	
On Lord Title	20	B 327 00	20 On William Wary
Hedge to Lord		0	Hedge to Wary
ag. Hedge	20	65	25 ag. Hedge
On Woodfield			On Hazle-spring
Hedge to Field			Hedge to Spring
	40	345	50
	00	520	
		540	50
	40	800	00
		825	
327 00		⊙ 2	
180 00		°	
507 00		< 102 45	
304 15		B 304 45	
202 45			
	15	240	
		250	10
304 15		⊙ 3	
180		°	
484 15		> 143 45	
340 30		B 340 30	
143 45		250	Gate
		260	10 Corner
	20	270	
340 30		R ⊙ 14	
180		°	
520 30		> 259 20	
261 10		B 261 10	
259 20			
Corner 10		15	
On Long Mead			
Hedge to Long Mead			
	15	220	
		0 10	

261. 10
180
441. 10
284. 20
156. 50

10

284. 20
180
464. 20
257. 50
206. 50

10

5
156. 50
B 284. 20

165
6

206. 50
B 257. 30

230

10 against Hedge
On Spring Close
Hedge to Spring Close

257. 30
180
437. 30
173
264. 30

In

240
R 7
264. 30
B 173. 00
10 Int.

Spring

Close
On Hazle Spring
Hedge to Spring

135
245
8

07
15

173. 00
180
353. 00
150. 45
202. 15

In William

202. 15
B 150. 45

154
335
550
720 Int.

18
50
35
00 Corner

Wary's
825

Land

150. 45
180
330. 45
90. 45
240. 00

9
240. 00
B 90. 45
90
510
640
755
830

20
05
70
15

43 Corner
Close Hazle-spring

taken from 6
257. 30
180
437. 30
274. 45
162. 45

7
162. 45
B 274. 45

(147)

	40	Gate
15	230	05
50	230	
35	260	
	350	10 ag. Hedge and Corner of Spring-close
R	⊙ 10	
	0	
	> 180.00	
	B 274.45	
	0	On Tho. Coles
30	60	
20	100	20
00	160	40
274.45		
180	⊙ 10	
	0	
454.45	> 246.25	
208.20	B 208.20	
246.25	10 Int.	
In Tho.	Coles	Land Hedgeto Spring Close
	300	100
	340	10
	370	
208.20	⊙ 11	
180	0	
388.20	> 208.20	
180	B 180.00	
208.20	00	18
	630	15 Corner
	680	
180.00	⊙ 12	
180.00	0	
360.00	> 275.00	
85.00	B 85.00	
275.00	20	Corner on Spring-close Hedge to Spring Close
	400	00
	870	20 Corner Close-spring-close
taken from ⊙ 3	⊙ 4	
0	0	
340.30	> 167.15	
180		
520.30		
353.15	B 353.15	
161.15		
On Woodfield	10	10 Corner of Long Mead Hedge to Long Mead
Gate 20	440	00

353° 15'
180
 533° 15'
82. 00
 451. 15
360
 91. 15

82° 00'
180
 262
163
 99

163° 00'
180
 343
93. 15
 249. 45

93° 15'
180
 273. 15
195. 40
 77. 35

195° 40'
180
 375. 40
246. 30
 129. 10

R 13
 91° 15'
 B 82 00
 20; Int.

20

550

14
 V 99° 00'
 B 163 00
 00

550

15
 V 249. 45
 B 93. 15

35
 430
 600
 610

835

16
 V 77 35
 B 195 40

00
 320
 500
 650
 742

17
 V 129. 10
 B 246. 30
 00
 610

In Woodfield
 15 Corner of Hazle-
 (Wood
 Hedge to Wood
15

10. Gate
 On Wood-Close
 Hedge to Woodfield
30

00 Corner
 130
 100
 50 ag. Hedge
 and corner of Woodfield
 On Lord Titles Land
 Hedge to Title
10 Corner

00
 210
 00
 135 corner

15
 15 corner

ag. Hedge
On Hazle Wood
Hedge to Wood

353. 115
180

$$\begin{array}{r} 533.44 \\ 350.30 \\ \hline 182.45 \end{array}$$
$$\begin{array}{r} 350^{\circ} 30' \\ 180 \\ \hline 530.30 \\ 2.00 \\ \hline 528.30 \\ 360 \\ \hline 168.30 \end{array}$$
$$\begin{array}{r} 2^{\circ} 00' \\ 180 \\ \hline 182.00 \\ 360 \\ \hline 542.00 \\ 307.40 \\ \hline 234.20 \end{array}$$

ag. Hedge
On Buts. close
Hedge to Close

$$\begin{array}{r} 307^{\circ} 40' \\ 180 \\ \hline 487.40 \\ 2874.00 \\ \hline 100.40 \end{array}$$

20	150
20	260
75	275
	380
70	400

25 1 510

$\odot 13$
 $\Delta 180^{\circ} 00$
 $B \ 353.15$
 20

$\odot 18$
 $V_{\Delta} 182^{\circ} 45'$
 $B \ 350 \ 30$

$$\begin{array}{r} 360 \\ 445 \\ \hline \odot 19 \\ \triangleright 168 \quad 30 \\ B \quad 2. \quad 00 \end{array}$$
$$\begin{array}{r} 100 \\ 255 \\ 350 \\ 440 \\ 520 \\ 595 \\ 663 \\ \hline \textcircled{20} \end{array}$$
$$\begin{array}{r} 60 \\ 170 \\ 215 \\ \hline 450 \\ \textcircled{21} \\ > 200.40 \\ B 287.00 \end{array}$$

Gate
00 ag. Hedge and
corner of Long Mead
On W. livers Meadow

287.00
180
467.00
186.20
280.40

(150)
R 22
280.40
B 186.20
10 Int.

In Walters Meadow
110 Corner
On Long Mead
Hedge to Long Mead
15
190
10

27

360
540
735

23

186.20
180
366.20
166.15
200.05

200.05
B 166.15

10 Int.

In Long Mead

Corner 10
On Trout Beck

20

00 50
10 150
10 235
245

24

166.15
180
346.15
111
235.15

235.15
B 111.00

10 40
20 105
00 255
25 345
460

25

111.00
180
291
229.20
61.40

61.40
B 229.20

30 80
30 120
150

30

35

25 160
170
10 200

50

40

25

111.00
180
261
192.30
128.30

128.30
B 162.30

15 145
50 190

		(151)	
	10	430	
	30	535	
		585	
162° 30'		⊙ 26	
180		0	
342.30		▷ 91. 00	
251.30		B 251.30	
91		70	
	45	175	
	00	270	
251.30		⊙ 27	
180		0	
431.30		▷ 141. 00	
290.30		B 290.30	
141. 00			
	67	205	
	70	280	
	15	360	
290.30		⊙ 28	
180.		0	
470.30		▷ 291. 00	
179.30		B 179.30	
291. 00			
	10	00	
On Tho. Cole			
Hedge to Cole			
	10	150	
	20	300	
	10	400	
	10	510	
		⊙ 22	
		▷ 180°00'	
		B 186. 20	
	In	Roughton	Common
	Corner 00	30	
		65	
287° 00'		⊙ 29	
180		0	
467		▷ 104 50	
2. 10		B 2. 10	
464. 50			
360			
104. 50			
On Butts Close			
	86	230	
	00	480	
	65	635	
		⊙ 30	
		▷ 89° 00'	
		B 93. 10	
		65 Int.	
	In	Butts Close	
		100	On Roughton Common
		350	65
			100

167° 10'
 180 00

 347. 10
 220. 30

 126. 40

R

750
 835

 31
 < 100° 00'
 B 167. 10
 0

 590

 32
 > 126° 40'
 B 220. 30
 0
 85

100
 15

20 On Home-clofe
 Hedge to Home-clofe
 15

10
 10 ag. Hedge
 On Hazle-Wood
 Hedge to Wood
 10

415

 31
 < 180° 00
 B 93. 10
 20 int.
 In Home

Gate
 Clofe
 On Roughton-common
 30
 75
 10

R

93° 10
 180

 273. 10
 180. 30

 92. 40

33
 > 92° 40
 B 180. 30
 00
 625

10 On Mottle Mead
 Hedge to Home-clofe
 15 ag. Hedge
 On Hazle Wood
 Hedge to Wood
 20

180° 30'
 180

 360. 30
 238. 20

 122. 10

735

 34
 > 122° 10'
 B 238. 20
 00
 310

10
 10

238° 20'
 180

 418. 20
 308. 30

 109. 50

35
 > 109° 50'
 B 308. 30
 00
 485

10
 10

	(153)	
93° 10	⊙ 33	
480	> 171.10'	
	B 102.	
273. 10	10 Int.	
102. 00	In Mottle	Mead
171. 10		On Roughton Com-
	300	25 (mon
	315	
102° 00	⊙ 36	
180	> 200. 00'	
282. 00	B 82. 00	
82.	70	65
200	150	10
	380	60
	600	15
	770	15
	808	10
	⊙ 37	
82° 00'	> 136.30	
180	B 125.30'	
262. 00	00	15
125.30	100	30
136.30	260	30 ag. Hedge
	⊙ 38	
125° 30	> 103.40'	
180	B 201. 50	
305. 30	00	On-Lord Titles Land
201. 50		Hedge to Lord
103.40	255	60
	270	
	⊙ 39	
201° 50'	> 102.30'	
180	B 279. 20	
381. 50	00	30 On Hazle Field
279. 20		Hedge to Mottle-
102.30	295	35 (Mead
	605	15 Corner
	620	
	⊙ 40	
279. 20	> 282.05'	
180	B 177.15	
459. 20		
177. 15	370	10
282. 05		
	⊙ 41	
177. 15	> 85° 25'	
180	B 271.50	
357. 15	00	15
271. 50	235	15
85.25		

			(154)	
	R		⊙ 42	
			V 180° 00'	
			B 271. 50	
			20	15 ag. Hedge
				On Hazle Wood
				Hedge to Hazlewood
			375	15
271. 50			⊙ 42	
180			V 268. 50'	
451. 50			B 183. 00	
183. 00			15 Int.	
268. 50				
	In	Hazle		Field
On Hazle Wood				
Hedge to Wood				
	25		375	
Corner 10			760	
			790	
183° 00'			⊙ 43	
180			V 153° 30'	
363			B 209. 30	
209. 30	270		230	
153. 30 Corner 00			445 Int.	
	In	Wood		Clese
	25		650	
Corner of	30		860	
Hazle Wood				
and Woodfield				
201° 50'			⊙ 39	
180			V 196. 35'	
381. 50			B 185. 15	
185. 15			30	20 Corner
196. 35			30 Int.	
				On Lord Titles Land
				Hedge to Lora
			400	165
			365	100
			1100	10
185. 15				
180			⊙ 44	
365. 15			V 193° 45'	
171. 30			B 171. 30	
193. 45			200	110
			345	30
			440	70
			520	20

171. 30

180

351. 30

270 30

81

R

(155)

⊙ 45

> 81° 00'

B 270. 30

15

100

340

650

740

990

46

< 112° 30'

B 338. 00

00

200

⊙ 45

> 180 00'

B 171. 30

15

35 Int.

255

300

⊙ 47

> 100. 30

B 251.

25

240

330

310

640

680

45 On Woodclose

Hedge to Woodclose

65

95

75

80

13

10

15 ag. Hedge

On Hazlewood

10 Corner

On Lord Titles Land

Hedge to Title

30

100

230

175

125

00

110 ag. Hedge

On Woodfield

F I N I S.

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Appendix Plate 1.

