The practical surveyor, or the art of land-measuring made easy ... To which is added, an appendix. Shewing how to draw buildings, &c.; in perspective: of levelling; and also how to measure standing timber / By Samuel Wyld.

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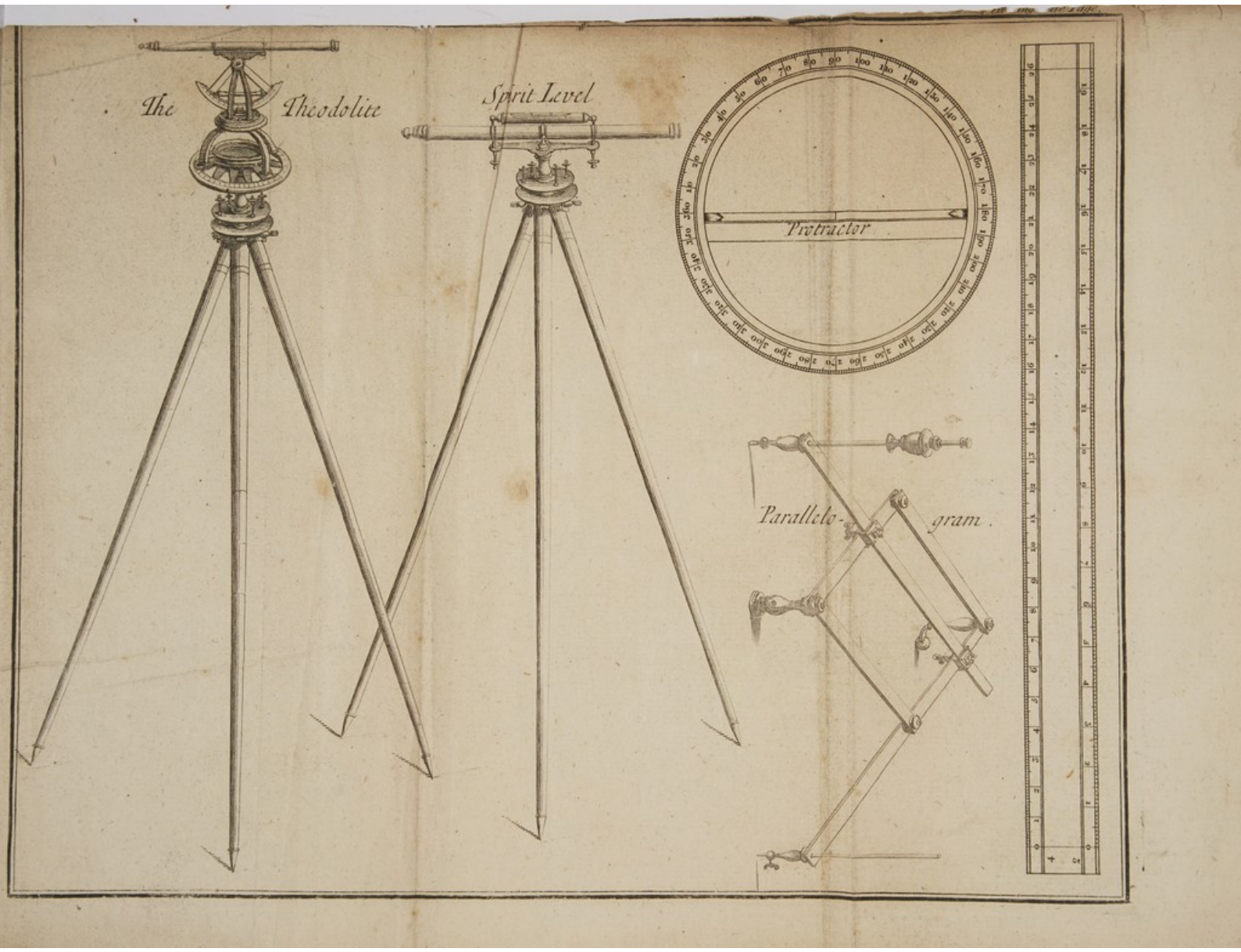
James Wyld

Book of my Ancestor.

No 2

James Wyld Junr.


The Theodolite
Spirit Level
Protractor
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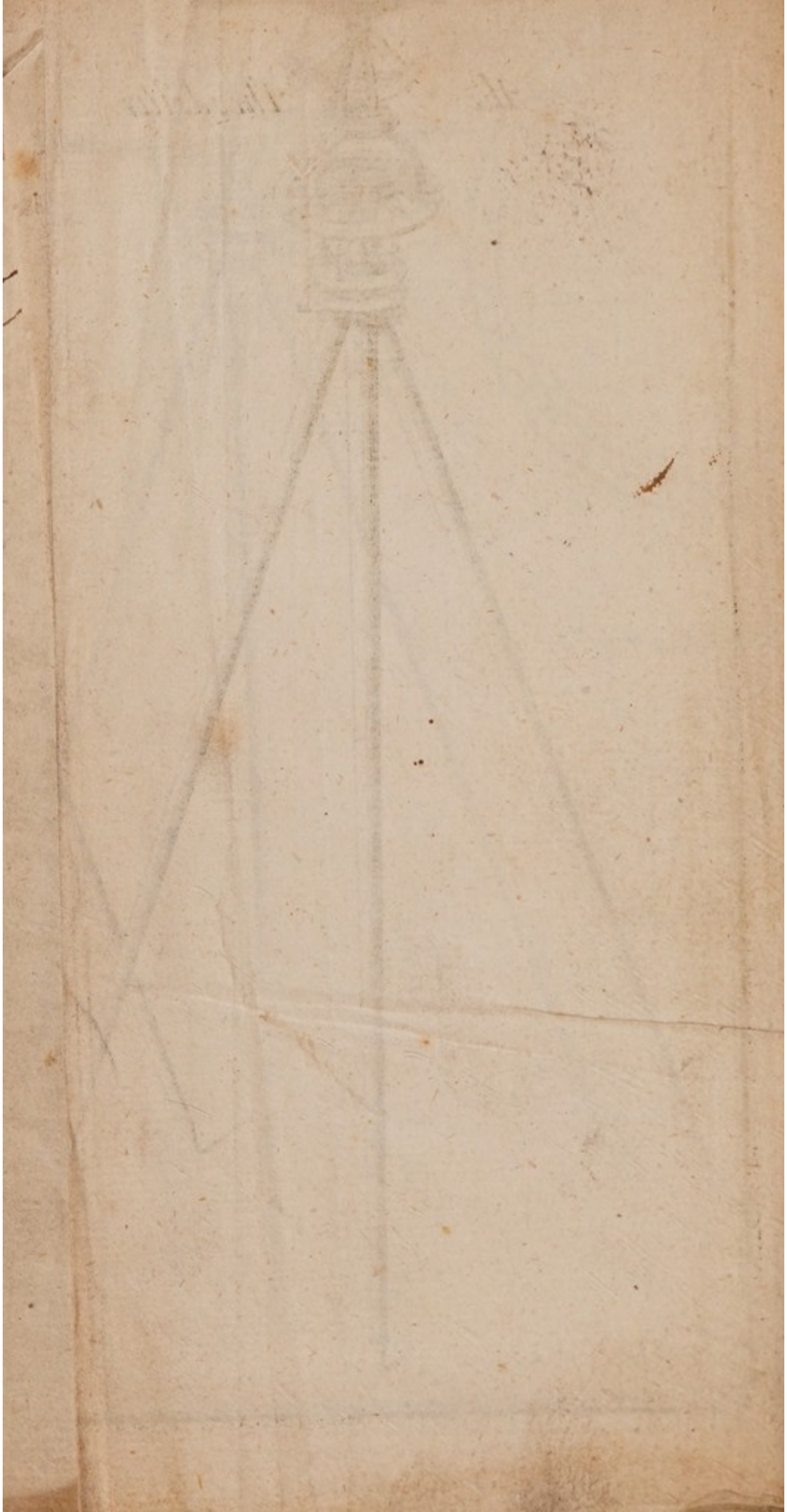

THE

Practical SURVEYOR,

OR THE

ART of *Land-Meaſuring*

Made EASY.

Shewing, by plain and familiar Rules, how to Survey any Piece of LAND whatſoever, by the *Plain-Table*, *Theodolite*, or *Circumferentor*: or, by the Chain only.

And how to Protract, Caſt up, Reduce and Divide the ſame.

LIKEWISE,

An eaſy Method of Protracting Obſervations made with the Meridian; and how to caſt up the Content of any Plot of Land, by Reducing any Multangular Figure to one Triangle.

To which is added,

An APPENDIX.

Shewing how to Draw Buildings, *&c.* in Perſpective: Of Levelling; and alſo how to Meaſure ſtanding Timber.

By SAMUEL WYLD.

The FIFTH EDITION.

Corrected and Enlarged by a Careful HAND; And Illuſtrated with ſeveral COPPER-PLATES.

LONDON:

Printed for W. JOHNSTON in *Ludgate-Street.*

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ADVERTISEMENT.

IN this Edition the Reader will find ſeveral Alterations and Additions which were not in the former, though in general we had the old Plan ſtill in View. The firſt Chapter is entirely New; and we hope, that the Alterations which have been made in the others will be approved of. We have ſpared no Pains to perfect our Deſign, which was to render the Whole more intelligible and uſeful to the Practical Surveyor. The Plan of the Work will beſt appear from the following Table of Contents, and therefore any Account of it here will be ſuperfluous. But we will venture to add, that, if the young Artiſt will take as much Pains in reading as we have taken in writing this Treatiſe, he will become a complete Maſter of the Art of Surveying.

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THE

THE Practical SURVEYOR.

CHAP. I.

Containing such Definitions and Problems, as are very necessary for Beginners before they enter upon Surveying.

SECT I. *Definitions.*

I. *Of a* CIRCLE.

CIRCLE is a plain Figure contained under one Line called the *Circumference*, unto which all Straight or Right Lines drawn from the *Center*, are equal one to the other. A Right Line drawn through the Center and contained on both Sides to the Circumference, is called a *Diameter*: And half the Diameter, or any Line drawn from the Center

the Circumference, is called *Radius*. Thus, the *Fig.* 1. CADBF is a *Circle*; of which the outward Line ADBF is the *Circumference*; the middle Point C is the *Center*; the Straight Line AB is a *Diameter*, and either of the Lines CB, CA, CE, or CD drawn from the Center to the Circumference, is a *Radius*. The Diameter as AB divides the Circle into two equal Parts, CADB, CAFB, each of which is called a *Semicircle*: And the fourth Part of a Circle, as CAD, or CBD, is called a *Quadrant*. An *Arch* of a Circle is any Part or Portion of the Circumference, as AE or ED, FDB, *&c.*

The Circumferences of all Circles, whether they be large or ſmall, are commonly underſtood to be divided into 360 equal Parts, called *Degrees*: And each of theſe Degrees are again ſuppoſed to be ſubdivided into 60 equal Parts, called *Minutes*. So that half the Circumference contains 180 Degrees: a Quadrant is 90 Degrees; and the Bigneſs of every Arch, or the Proportion which it bears to the whole Circle, is expreſſed by the Number of Degrees and Minutes it contains. And ſince all Circles are divided alike, a Degree is not to be accounted a Quantity of any determinate Length, as ſo many Inches or Feet, *&c.* but is always to be reckoned as being the 360th Part of the Circumference of any Circle, without regarding in the leaſt the Bigneſs of the Diameter or Radius of that Circle: And if the Arch AE contains 50 Degrees, the little Arch *a e* contains juſt as many; for each of theſe Arches have exactly the ſame Proportion to their reſpective Circles, one with the other.

Note, Degrees and Minutes are often expreſſed by placing an $^{\circ}$ $'$ over the reſpective Numbers, thus $24^{\circ}\ 30'$ is 24 Degrees and 30 Minutes.

II. *Of*

II. *Of an* ANGLE.

When two ſtraight Lines incline to one another and meet in a Point, they form what is called an ANGLE: the Point where the Lines meet, is called the *Angular Point*; and the two Lines which include the Angle, are called the *Legs*, or the *containing Sides* of the ſaid Angle. Thus, in *Fig.* 2. the Lines AC, BC form an Angle at C; and the ſaid Point C where the Lines meet is called the *Angular Point*.

The *Meaſure* of an *Angle* is an Arch of a Circle deſcribed from the Angular Point, and which is intercepted betwixt its Legs: thus, the Arch D E or *d e* is the Meaſure of the Angle made by the two Lines CA, CB. An Angle is eſteemed greater or leſs according to the Aperture of its Legs, or as the Arch intercepted between them contains more or fewer Degrees. And hence it may be obſerved, that the Bigneſs of an Angle doth not any ways depend upon the Length of the including Sides; for if the Lines C A, C B, one or both be produced ever ſo far, or cut off ever ſo ſhort, the Angle C would not thereby ſuffer any Change, or be made either bigger or leſs; nor is it material whether it be meaſured by the Arch D E or *d e*: for all Arches deſcribed from the Point C, and intercepted between the Lines CA, CB, contain exactly the ſame Number of Degrees and Minutes.

Note, When more than two Lines meet the ſame Point, in order to ſpecify particularly any one of the Angles formed thereby, it is neceſſary it ſhould be expreſſed by three Letters, whereof that at the Angular Point is uſually placed in the middle: Thus, in *Fig.* 3. the Angle formed by the Lines AC, EC, is expreſſed by ſaying the Angle ACF; and the Angle formed by EC and DC, is expreſ-

ſed ECD or DCE : (for it is not material which Letter be placed firſt, ſo that at the Angular Point be placed in the Middle.) But when there are only two Lines meeting at the ſame Point, the Angle may be expreſſed by a ſingle Letter, as the Angle C. *Fig.* 2.

Note, Inſtead of the Word *Angle*, this Character ∠ is often uſed. *Angles* are diſtinguiſhed into *Right*, *Acute*, and *Obtuſe*.

A *Right Angle* is that which contains 90 Degrees, as the ∠ DCA or DCB in *Fig.* 1. and *Fig.* 3. An *Acute* ∠ is that which is leſs that 90 Degrees, as ACE, ECD. An *Obtuſe Angle* is greater than a right Angle, as ECB.

Note, Both Acute and Obtuſe Angles are ſometimes called in general Terms *Oblique Angles* without farther Diſtinction.

III. *Of Perpendicular and Parallel Lines.*

A Line is ſaid to be *Perpendicular* to another when it forms an ∠ with it of 90 Degrees, or when it ſtands uprightly upon it without leaning more to one Side than the other ; as in *Fig.* 1. and *Fig.* 3. the Line DC is *perpendicular* to A B ; alſo the Lines CB, CA, are each of them perpendicular to CD. A Perpendicular is the ſhorteſt Line that can be drawn from an aſſigned Point to a given Line ; ſo DC is the ſhorteſt Line that can be drawn from the Point D to touch the Line AB.

Parallel Lines, are ſuch as are every where equidiſtant one from the other ; and if infinitely produced on either Side, would never meet ; as the Lines AB, CD. *Fig.* 4.

Lines are ſaid to be *Oblique*, when they are neither Parallel nor Perpendicular to each other.

IV. *Of*

IV. *Of a* TRIANGLE.

A TRIANGLE is a Figure comprehended within three Right Lines, called *Sides*. If a Triangle hath all its Sides equal, it is called an *Equilateral Triangle*; if only two Sides are equal, it is called an *Iſoſecles*; and if all the three Sides are unequal, it is called a *Scalene Triangle*. Alſo a Triangle having one of its Angles right, is called *Right-Angled*; and all others are called *Oblique Angled Triangles*. But theſe Diſtinctiens need not be regarded by a Practical Surveyor.

V. *Of Quadrilateral or Four-ſided Figures.*

A Quadrilateral Figure having it oppoſite Sides parallel (and conſequently equal) is called a PARALLELOGRAM, as *Fig.* 5, 6, and 7. If the Sides are all equal, and all the Angles right, as in *Fig.* 5. it is particularly called a *Square*. When the Angles are all right, and only the oppoſite Sides equal, as in *Fig.* 6. it is called a *Right-Angled Parallelogram*; and when the Angles are oblique, as in *Fig.* 7. it is called an *Oblique-Angled Parallelogram*.

A right Line (as C B. *Fig.* 5, and 6, and A D. *Fig.* 7.) drawn in a Parallelogram between two oppoſite Angles, is called a *Diagonal*; and this Diagonal divides the Parallelogram into two Triangles which are exactly equal one to the other, *i. e.* the Triangle A B C is equal to the Triangle B C D. *Fig.* 5, and 6; and the Triangle A C D is equal to A B D. *Fig.* 7.

All Quadrilateral Figures, which are not Parallelograms, are called *Trapezia*.

SECT II.

Shewing how to draw Perpendiculars and Parallels; with the Description and Use of the Parallel Ruler, Protractor, and the Plotting-Scale.

I. *From any assigned Point* C *in a given Line* A B, *to erect a Perpendicular* C D *upon the said Line* A B. *Fig.* 8.

TAKE any convenient Distance, and lay the same from C on each Side, as to *a* and *b*; then having opened the Compass a little wider, from the Points *a*, *b*, describe two small Arches intersecting one another at D, and through the Point of Intersection draw the Line D C, which is the *Perpendicular* required.

If the given Point A be in, or near the End of the Line B A, as in *Fig.* 9, and it be required to erect a Perpendicular A C;

With any Extent A *a* describe an Arch *a d*, then lay off the same Extent from *a* to *b*, and from *b* to *d*: From the Points *b* and *d*, describe two small Arches intersecting each other at C, and through the Point of Intersection draw the right Line C A, which will be the *Perpendicular* required.

Or, if so you can't go far as *d*, lay a Ruler over the Points *a* and *b*, and mark where it intersects the Arch which was described from *b*, then through that Intersection draw the Line C A, as before

Or take any Distance and lay it somewhere from A above the given Line, *Fig.* 10. as to *b*; and from the Point *b* as a Center, describe an Arch greater than a Semicircle as *a* A C; then thro' the Center *b*, and the Point *a* (where the said Arch crosses the given Line) draw a right Line *a* C until it crosses the Arch in C;

C; a Line CA drawn thro' the Point of Interſection C, is the Perpendicular required. This Method may be readily put in practice by a Ruler and a Pair of Compaſſes, without deſcribing any Arch; for, having taken any Extent, and laid it ſomewhere from A to *b*, keep fixed that Foot which is in *b*, and turn the other about until it falls upon the given Line, as at *a*: the Compaſſes reſting in this Poſition, apply a Ruler cloſe to its Legs, and keep it fixed while you turn the Foot which is in *a*, until it touches the Ruler in C; a Line drawn from C to A, will be the *Perpendicular* required, as before.

II. *From a Point given* C, *to let fall a Perpendicular upon a given Line* B D. Fig. 11.

From C deſcribe an Arch that ſhall cut the given Line in two Places, as in *a* and *b*; then from the Points *a*, *b*, deſcribe two Arches interſecting each other in *d*; a Ruler being laid from C to *d*, by the Edge thereof draw the right Line C D, which will be the *Perpendicular* required.

Or, from the Point given C, *Fig.* 10. draw any right Line C *a*, which biſect in *b*, then with the Extent *b c* or *b a* deſcribe an Arch interſecting the given Line B D as in A; then C A is the *Perpendicular* required.

Note, A Perpendicular, from any aſſigned Point, may be drawn without uſing Compaſſes, by the Help of a ſmall *Square* of Braſs, in the Form of a Carpenter's Square; or by a Scale in a Caſe of Inſtruments, that hath a right Angle, *&c.* Thus, if you apply one Side of the Square cloſe to the given Line, ſo as the other Side (or the Corner of it when the Point is given in the Line) may touch the given Point; a Line drawn by this Side of the Square, will be the *Perpendicular* required.

If the Corner of the Square be a little blunt, you muſt make an Allowance when you apply it to a Point in a Line; and when you are drawing a Perpendicular, you muſt ſtop before you reach the given Line, and afterwards continue quite home that Part of the Perpendicular which is already drawn: but how to draw a Perpendicular by the Side of a Square, is obvious to every one.

III. *Of the* PARALLEL RULER; *and how to draw a Line through any aſſigned Point, parallel to another given Line.*

The *Parallel Ruler* may be made of either Wood, Ivory, or Braſs: It conſiſts of two Rulers joined together in ſuch a Manner, that if while one is kept fixed, the other be opened or drawn out, it will always keep parallel to its firſt Situation. Theſe Inſtruments are very uſeful, and ready for what they are deſigned: They are made of various Lengths, from about 5 Inches upwards; but for common Uſe a ſmall one made of Ivory, or ſome hard Wood is the moſt hardy.

Let it be required to draw through a given Point C, *a right Line parallel to another given Line* A B. *Fig.* 4.

Lay the Edge of the Parallel Ruler cloſe to the Line A B, then keeping the lower Part of it from ſlipping, move the upper one till it touches the Point C, and by the Edge thereof draw the Line CD, which will be the *Parallel* required.

If the Point C happens to be farther than the Parallel Ruler will reach at once opening; having opened it as far as you judge proper, keep the upper Leg faſt, while you bring the lower to it; then open the upper a Leg a ſecond, and if it be neceſſary a third time,

time, *&c.* till it reaches the Point C, and draw the Line C D as before ; but great Care is neceſſary in this Operation.

The Parallel Line C D may be drawn without the Help of a Parallel Ruler ; thus,

From the given Point C, take, with a Pair of Compaſſes, the neareſt Diſtance (as C *a*) to the given Line AB ; then with that Extent from ſome Point as *b*, near the End of the given Line deſcribe an Arch : a right Line CD drawn thro' the Point C, ſo as to touch that Arch, will be the Parallel Line required.

IV. *Of the* Protractor ; *and how to make or meaſure an Angle of any Number of Degrees.*

The *Protractor* is uſually made of Braſs, and it may be either a whole Circle, or a Semicircle. The *whole Circle* is divided into 360 Degrees, all which are numbered the ſame Way ; *vide* Frontiſpiece. The *Semicircular Protractor*, I think, is the beſt for common Uſe ; aud this is divided into 180 Degrees, which are numbered both Ways, as in the outer and innermoſt Scale of Number, *Fig.* 12. the Diviſions on the Limb ſerving equally for both. Between theſe, there is another Scale of Numbers, reaching from 180° to 360° : This middlemoſt Scale is placed entirely for the Sake of Surveyors, but at preſent we ſhall have no Uſe for it, nor is it uſually placed upon common Protractors : alſo when this is placed, the innermoſt is commonly omitted : but that the Inſtrument may be fit for all Purpoſes, it is beſt to have all three. Protractors are made of different Sizes, but thoſe for Surveyors ſhould be at leaſt of ſix or ſeven Inches Diameter.

To make an Angle of any given Number of Degrees.

Lay the Center of the Protractor to the Angular Point, and bring the fiducial Edge (or the Edge paſſing through the Center) cloſe to the given Line; then from that End of the Protractor which cuts this Line, count the given Number of Degrees and Minutes in the Limb, and there make a Point; a Line drawn through this Point will form the ∠ required.

Example, If it be required to make an ∠ at the Point C, (*Fig.* 12.) taken in the Line C A, of 45 Degrees; lay the Center of the Protractor to the Angular Point C, ſo that the Edge *a* C lies all the Way cloſe to the given Line AC; then from this Line count 45 Degrees, and there make a Mark (with the Point of a Needle) and through this Mark draw the Line CD, which forms the ∠ required: this Line forms, with the Line C B, an ∠ of 135 Degrees, as is ſhewn by the inner Scale of Numbers. In like Manner, to make an Angle at C with the Line C B, for Inſtance of 34°, or 40′: Having rectified the Protractor as before directed, count 34 Degrees (now in the innermoſt Scale) and for the 40 Minutes eſtimate as near as you can two thirds of a Degree more, and there make a Prick or Point: a Line CE drawn through this Point makes the Angle B C E 34° 40′; whence the ∠ A C E is 145°, 20′, as is ſhewn by the outermoſt Scale.

Note, If the given Line ſhould not be ſo long as the Radius of the Protractor, it will be neceſſary to continue it farther; and then having placed the Center of the Inſtrument exactly to the Angular Point, turn it about till the Beginning of the Diviſions cut the given Line. By this Means the Protractor may be adjuſted more accurately than it can by truſting altogether

altogether to the fiducial Edge ; and remember always to count the Degrees in that Scale which begins on the ſame Side of the Angular Point that the given Line is of.

How to find the Number of Degrees contained in an Angle already made is ſelf-evident ; for, having adjuſted the Protractor to the Center and to one of the Legs of the given Angle, the other Leg (produced if need be) will cut the Degrees which the ∠ contains. Thus, in *Fig.* 12. the ∠ A C D contains 45 Degrees, B C D 135 Degrees, B C E 34 Degrees 43 Minutes, and A C E 145 Degrees 20 Minutes.

Of the Plotting-Scale.

☞ The Sides of all right-lined plain Figures may be meaſured and laid down upon Paper, according to the Proportion which they bear to one another, by the Help of right Lines divided into equal Parts : Theſe Lines are called *Scales of equal Parts* ; and a Ruler having ſeveral of theſe placed upon it, is uſually called a *Plotting-Scale*. Theſe Scales are made of different Sizes, and we uſe either of them indifferently, according to what Dimenſions we would have our *Plan* or *Figure* be of, upon the Paper. Theſe Scales are divided firſt into large Diviſions, which are numbered 0, 10, 20, 30, *&c. Fig.* 13. the firſt of theſe between 0 and the End, is again ſubdivided into ten equal Parts, and this ſerves for a common Diviſion for all the reſt. The ſmall Diviſions may either ſtand for *Units*, and then the large ones will be *Tens*, according to the Numbers ; or the ſmall ones may be *Tens* or *Tenths*, *&c.* and then the large Diviſions will accordingly be *Hundreds* or *Units*, &c. They may alſo ſtand for *Feet*, *Yards*, *Miles*, &c. according to the different Purpoſes they

are

are applied to. A *Builder* would conſider them as *Feet*; a *Land-Surveyor* as *Chains* or *Perches*: and a *Sailor* would make them ſtand for *Miles* or *Leagues*. Moſt Scales are numbered at the End, which Numbers ſhew how many Parts of the reſpective Scales are contained in an *Inch*: As in the Scales A, B, and C, the Numbers 20, 30, 40. ſhew that ſo many Parts of theſe Scales reſpectively are contained in an Inch.

To take any Extent upon the Scale which may repreſent any given Number; *for* Example, 56.

Set one Foot of the Compaſſes in 50, and extend the other to 6, reckoning from 0 towards the End, and that Extent will be 56, which may ſignify 56 *Feet*, or 56 *Perches*, &c. *Note*, The Diviſion for 5 is always drawn out a little longer than the reſt, for eaſe in counting. Let it be required again to take off 456; ſet one Foot of the Compaſſes in 40, which in this Caſe ſtands for 400, (and conſequently the ſmall Diviſions at the End are each of them 10) and extend the other as near as you can eſtimate to $\frac{6}{10}$ of the Diſtance between 5 and 6, which Point is 56, and therefore the whole Extent between the Compaſſes is 456.

N. B. The Manner of uſing all theſe Scales is the ſame, and you may chuſe either of them indifferently, as it beſt ſuits your Purpoſe; but you muſt remember always to uſe the ſame Scale in laying down or meaſuring the Sides of the ſame Figure, and the Figures that are in the ſame Plan or Draught.

When the ſmall Diviſions at the End are accounted ſo many Tens, a Number may be taken off more accurately by ſuch a Scale as D, called a *Diagonal*

Diagonal Scale. Thus, for *Example*, to take off the Number 450.

Set one Foot of the Compaſſes in 4, on the Side of the Scale, which in this Caſe ſtands for 400, and carry it in that Line until you come to the 6th Parallel Line, reckoning upwards from *c* towards *a*; then extend the Compaſſes from that Point to the Point of Interſection of the foreſaid Parallel 6, and the Diagonal 50, (reckoning the Diviſions at the End of theſe Diagonals from *d* to *c*, each of them 10) and that Extent is 456; this may alſo ſignify $45\frac{6}{10}$, or $4\frac{56}{100}$, 4560, *&c.*

If a Line be given, to find how many Parts it contains, according to any aſſigned Scale.

Take the ſaid Line between the Compaſſes, and apply that Extent to the Scale, ſo that one Foot being placed in one of the large Diviſions, the other may fall among the ſmall ones; the Number contained between the Feet of the Compaſſes, ſhews the Length of the Line according to that Scale. Thus a Line which meaſures 36 upon the *Scale* 20, will meaſure 54 upon the *Scale* 30, and 72 upon 40; and ſo upon any other Scale more or leſs according to the Proportion which it bears to thoſe above mentioned.

If the Diagonal Scale be uſed, ſet one Foot of the Compaſſes in ſuch a one of the large Diviſions, that the other may fall among the Diagonals at the End; then carry both Feet parallel to the Side of the Scale, until that which is at the Top interſects one of the Diagonals, and the Number between the Compaſſes (being rightly counted according to the Directions above given) will be the Length required.

By the Scale 20, the Side A B of the Triangle A B C, *Fig.* 14. meaſures 335, A C 276, and B C 204: And by the Scale 40, the Sides *a b*, *a c*, *b a*

of the Triangle *a b c*, will meaſure each reſpectively, the ſame with the Sides of the Triangle A B C: ſo that each of theſe Triangles may repreſent the ſame Quantity of Superficies, as ſuppoſe Acres of Land; though one upon the Paper is four times bigger than the other.

It may not be amiſs here to ſhew, how with three given right Lines to make a Triangle; for *Example*, Let there be given theſe three Numbers 335, 276, and 204. Having drawn a right Line, take 335 off ſome Scale (ſuppoſe that of 20) and lay that Extent from A to B; then having took 276 from the ſame Scale, ſet one Foot of the Compaſſes in A, and with the other deſcribe an Arch at C; from B, with 204 between the Compaſſes, deſcribe another Arch interſecting the former, and to this Point of Interſection draw the Lines A C, B C.

SECT III.

Shewing how to find the Area or ſuperficial Content of any plain right-lined Figure.

MAgnitudes are diſtinguiſhed into *Lines*, *Superficies* and *Solids*: And every Magnitude is meaſurable by ſome other Magnitude of the ſame Kind, taken as a *Standard*; as a *Line* by a *Lineal Foot*, *&c.* a *Superficies*, by a *Square Foot*, *&c.* and a *Solid* by a *Solid Foot*, *&c.* But our Buſineſs here is only to meaſure Superficies; and the Quantity or *Content* of any Superficies is called its AREA.

I. *To find the Area of a right-angled Parallelogram.*

Multiply the Length by the Breadth, and the Product will be the Area or Content. Thus, if in *Fig.* 15. the Side A B be five Feet, and A C 2 Feet, the Area or Contents of the right-angled Parallelogram

Fig. I.

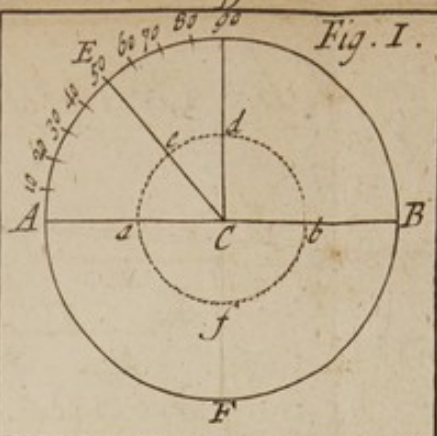


Fig. II.

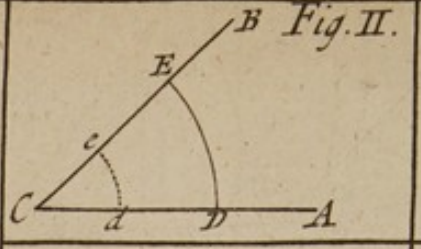


Fig. III.

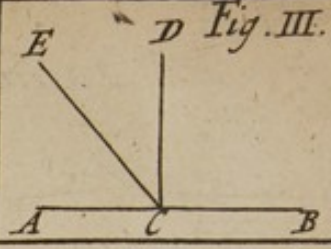
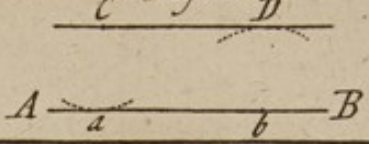


Fig. IV.



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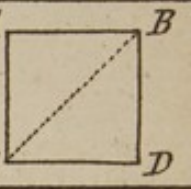


Fig. VI.

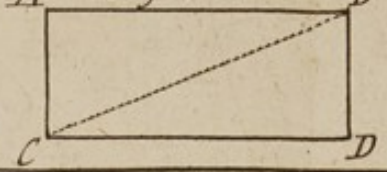


Fig. VII.

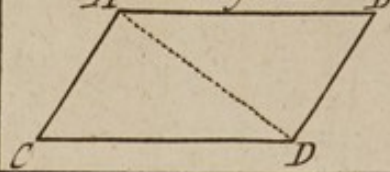


Fig. VIII.

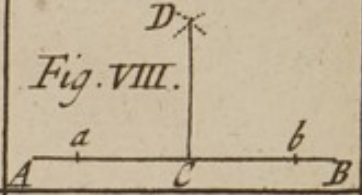


Fig. IX.

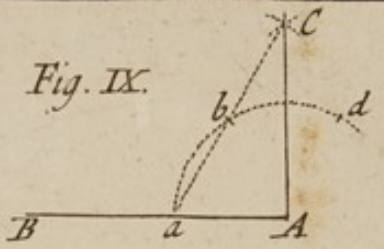


Fig. X.

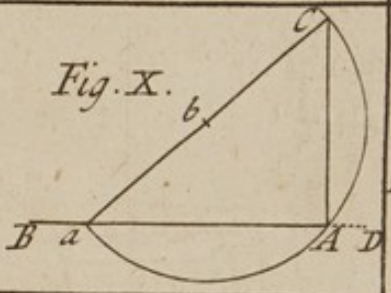


Fig. XI.

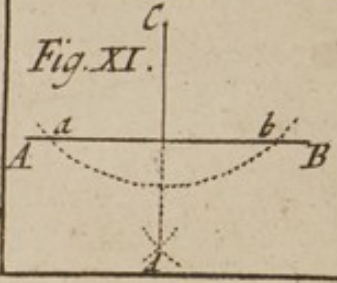


Fig. XII.

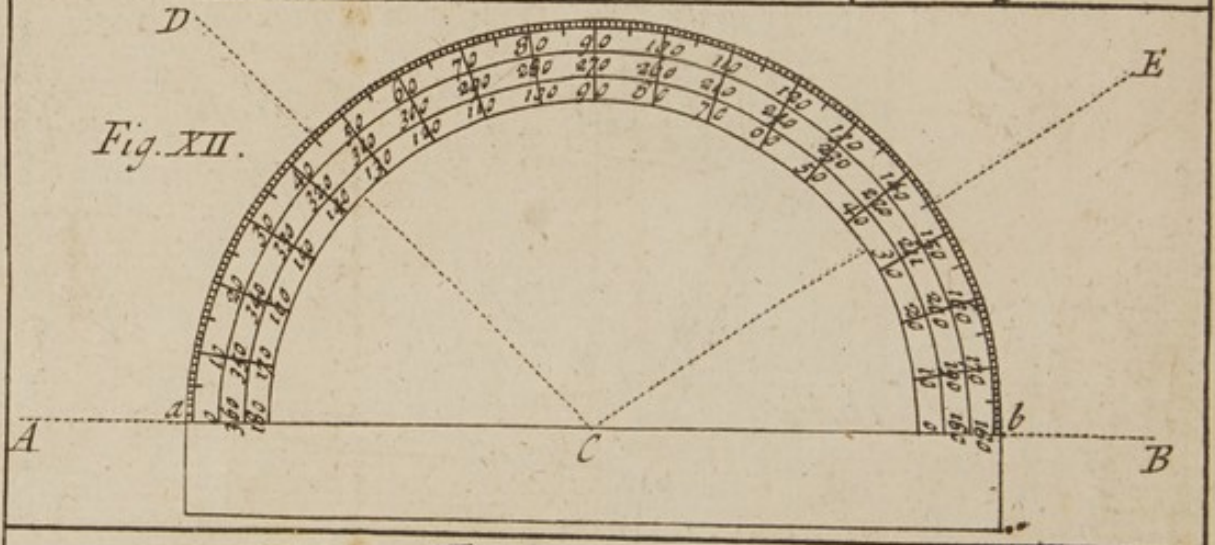
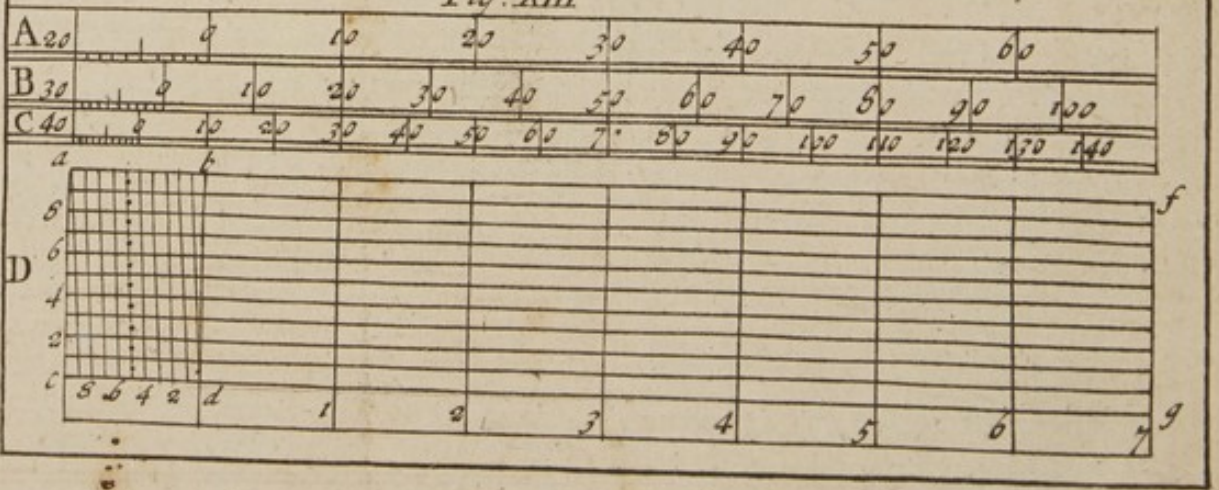
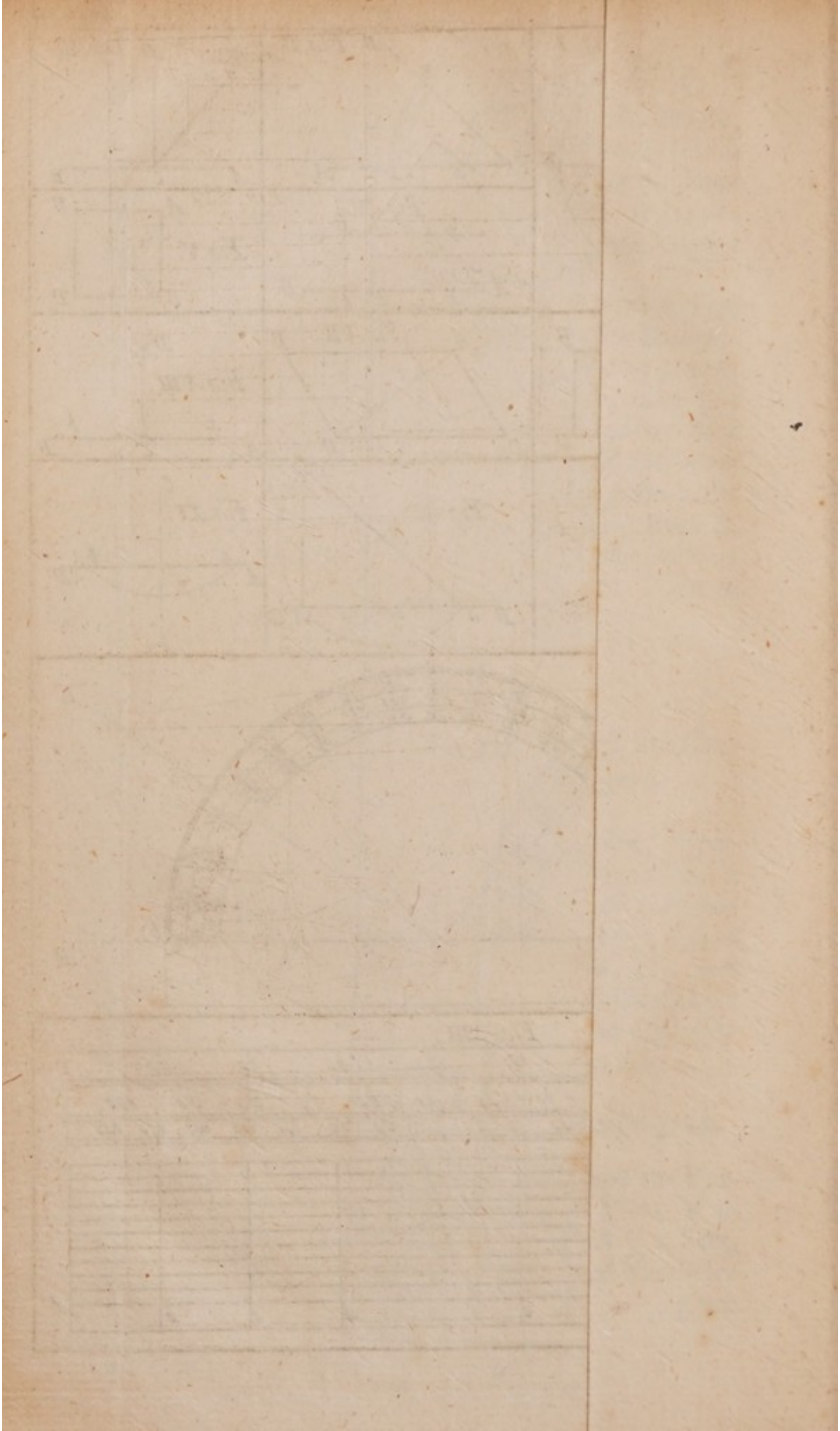


Fig. XIII





gram A B C D is ten ſquare Feet: Alſo if A B in *Fig.* 16. be 10 Feet, and AC 10 Feet, the Content of the Square ABDC is 100 ſquare Feet. If the Dimenſions of the Sides be Inches, or Perches, *&c.* the Products will be accordingly ſquare Inches, or ſquare Perches, *&c.*

The right-angled Parallelogram is the original Figure, from whence we learn to meaſure all plain right-lined Figures. But before we proceed any farther, it may be proper to premiſe the following Lemma.

Lemma 1.

Fig. 17. *Parallelograms* ABDC, ABFE, *which are upon the ſame Baſe* A B, *and between the ſame Parallels* A B, C F, *are equal one to the other*, Euclid. Lib. 1 Prop. 35.

For the Triangle BDF, which is added to one, is equal to the Triangle ACE which is left out of the other. Wherefore, becauſe the Product of AB multiplied by BD, gives the Area of the Parallelogram ABDC; this Product will alſo give the Area of the Parallelogram ABFE. Hence we learn,

II. *To find the Area of any Oblique-Angled Parallelogram.*

Let fall a Perpendicular from one of the Angles upon the oppoſite Side, and multiply this Side by the ſaid Perpendicular; the Product will be the Area required.

Fig. 18. Let the *Perpendicular* E *a* let fall upon the *Baſe* AB be 27 *Feet*, and let the ſaid Baſe be 34 *Feet*; then the *Area* of the Parallelogram ABEF will be 918 *ſquare Feet.*

It would be the ſame Thing if the Perpendicular be let fall from any other of the Angles, as from F upon AB produced; but then the Perpendicular

F *b* muſt be multiplied by the Baſe A B (which is equal to *a b)* and not by the whole continued Line A *b*.

Lemma 2.

Fig. 19. *If a Parallelogram* ABDE *and a Triangle* ABC *have both the ſame Baſe* AB, *and are between the ſame Parallels* AB, DE; *the Parallelogram ſhall be double to the Triangle.* Eucl. Lib. I. Prop. 41.

For the Triangle DCA is equal to the Triangle A C *a*, and the Triangle B C E is equal to the Triangle B C *a*. Wherefore, becauſe the Product of AB multiplied by C *a* (which is equal to D A) gives the Area of the Parallelogram ABED; this Product will be double to the Area of the Triangle ABC. Hence,

III. *To find the Area of any Triangle.*

Fig. 20. Let fall a Perpendicular from one of the Angles upon its oppoſite Side, which may be called the *Baſe*; then half the Perpendicular multiplied by the whole Baſe, or the whole Perpendicular by half the Baſe, will be the Area; or multiply the Baſe and Perpendicular together, and half that Product will be the Area. Thus, if the Perpendicular C *a* be 15, and the Baſe AB 39, the Area of the Triangle ABC will be $292\frac{1}{2}$.

Note, The Perpendicular may be let fall from what Angle you pleaſe: thus, the Perpendicular A *b* let fall upon B C produced, being multiplied by the (now) Baſe B C; or the Perpendicular B *d* let fall upon A C produced, being multiplied by A C, will give the ſame Product as before, *viz.* $292\frac{1}{2}$. But it is beſt to draw your Perpendicular from ſuch an Angle, that it may fall within the Triangle;

Triangle, which it will always do, if it be drawn upon the longeſt Side: Alſo in acute-angled Triangles, a Perpendicular drawn from either of the Angles will always fall within the Triangle.

Note, You need not actually draw the Perpendicular, but only take with your Compaſſes the neareſt Diſtance from any Angle to the oppoſite Side, which muſt be produced, if the Angle at the End of the Baſe be obtuſe. *Note* alſo, when the Perpendicular falls without the Triangle, as B *d* or *A b*, you muſt take for your Baſe only the Side of the Triangle AC or BC, and not the whole continued Lines A *d* or B *b*.

IV. *To find the Area of a Trapezium*, as A B C D. *Fig.* 21.

Draw a Diagonal, as BC, between two of the oppoſite Angles, and this will divide the Figure into two Triangles, each of which may be meaſured ſeparately by the foregoing Article; and theſe two Areas will be the *Area* of the *Trapezium*.

Note, You ſhould always draw the Diagonal between two ſuch Angles, that the Perpendiculars drawn upon it from the two other Angles may fall within the Figure: And inſtead of meaſuring the Triangles ſeparately, it is beſt to add the two Perpendiculars together; then half this Sum multiplied by the Diagonal, or the Sum of the two Perpendiculars by half the Diagonal, will be the Area required.

Thus, if BC be 46, A*a* 25, and D*b* 34;

34 2)46
25 23
59
23
177
The Area of the Figure 118
ABCD is 1357

V. *To find the Area of any multangular rectilineal Figure, as* ABCDEFGHI. *Fig.* 22.

Reduce the given Figure into Triangles, by drawing as many Diagonal Lines as are neceſſary, which Diagonals muſt be drawn ſo as not to interſect one another; then having firſt found the Area of the Trapezium ABEI, find ſeverally the Areas of the Triangles CDE, EFG, and GHI; theſe four Sums being added together, will be the *Area* of the whole Figure. A little Practice will ſuggeſt the moſt convenient Way of drawing the Diagonals; but which ever Way they are drawn, provided they do not interſect one another, and that the entire Figure be reduced into Triangles, the whole Area or Content will be had the ſame.

CHAP.

CHAP. II.

Shewing how to measure any Piece of Land by the Chain and the Plain-Table.

AN *Acre* of Land is appointed (by the Statute of 33 *Ed.* I.) to contain 160 ſquare Perches or Poles; there is no Matter what Form it lies in, ſo that it contains 160 ſquare Poles. But before the Plan of any Piece of Land can be laid down, or protracted upon Paper, in order to find the *Area* or Quantity of Acres it contains, we muſt firſt know the Length and Poſition of the ſeveral Lines which bound the ſame. In order to find the Poſition of the Hedges, Fences, or Boundaries, which incloſe a Field, ſeveral Kinds of Inſtruments have been invented; but in this Chapter we ſhall conſider only the *Plain Table*, as being the ſimpleſt and eaſieſt for Beginners.

For meaſuring the Lengths of Lines in the Field, Surveyor s make uſe of *Gunter*'s *Chain*, which is certainly the beſt adapted for that Purpoſe that can be. This Chain contains in Length four Poles or 66 Feet, and is divided into 100 equal Parts or *Links*, each Link being therefore $7\frac{92}{100}$ Inches. So that one ſquare Chain contains 16 ſquare Perches, and ten ſquare Chains make exactly one Acre: that is, a right-angled Parallelogram, being one Chain in Breadth and ten in Length, or two in Breadth and five in Length, is exactly an Acre. See the following Tables.

1. *Table of Long Measure.*

Inches	*Link*	*Foot*	*Yard*	*Perch*	*Chain*	*Mile*
Inches 7. 92	12	36	198	792	63360
Links	1.515	4.56	25	100	8000
	Feet	3	16. 5	66	5280
		Yard	5. 5	22	1760
			Perch	4	320
				Chain.	80

Feet inches
66×12 = 792 = 1 Chain
∴ 100 lks = 792 Inches
& 1 link = 792 D.

2.

Length of an Acre	*Breadth of an Acre*		*Pts. of a Link.*
Chains	*Chains*	*Links*	
1	10	00	
2	5	00	
3	3	33	333
4	2	50	
5	2	00	
6	1	66	666
7	1	42	285
8	1	25	
9	1	11	111

3. *A Table of Square Measure.*

	Inch	*Links.*	*Feet*	*Yards*	*Poles*	*Chaains*	
Inch	1						
Links	62. 7264	1					
Feet	144	2295	1				
Yards	1296	20655	9	1			
Poles	39204	625	272.25	30. 25	1		
Chains	627264	10000	4356	484	16	1	
Acre	6272640	100000	43567	4840	160	10	1

Sq: feet Sq: lks Sq: Poles Sq: links

Lks Ft.
50 = 33.
×50 × 33
2500 & 1089

If 1089 = 2500 ∴ 1 = 2,29569

4.

4. *A Table, shewing how many Chains, Links, and Parts, are contained in any Number of Feet, from* 1 *to* 1000.

Feet.	*Chain.*	*Links.*	*Pts. of Links.*	*Feet.*	*Chain.*	*Links.*	*Pts. of Links.*
1	0	1	515	200	3	03	030
2	0	3	30	300	4	54	545
3	0	4	545	400	6	06	060
4	0	6	060	500	7	57	575
5	0	7	575				
6	0	9	090	600	9	09	090
7	0	10	606	700	10	60	606
8	0	12	121	800	12	12	121
9	0	13	636	900	13	63	636
10	0	15	151	1000	15	15	151
20	0	30	303	2000	30	30	303
30	0	45	454	3000	45	45	454
40	0	60	606	4000	60	60	606
50	0	75	757	5000	75	75	757
60	0	90	909	6000	90	90	909
70	1	06	060	7000	106	06	060
80	1	21	212	8000	121	21	212
90	1	36	363	9000	136	36	360
100	1	51	515	10000	151	51	515

The Use of these Tables is plain by Inspection, therefore particular Directions are needless.

SECT. I.

Of the Chain, Off-set Staff, and the Arrows.

THE *Chain* is used in all Manner of Business in the Field, and it contains in Length, as aforesaid, 4 *Poles* or 66 *Feet*, divided into 100 *Links*, each Link being $7\frac{92}{100}$ Inches. At the End

of every tenth Link is faſtened a Piece of Braſs, in order to count the odd Links the more readily: That which is in the Middle is a plain Piece, but the others are diſtinguiſhed by Holes or Notches: the firſt from either End of the Chain having one Hole or Notch, the ſecond two Holes or two Notches, *&c.* until they meet in the Middle, which is a plain Piece without any Mark as aforeſaid: the greateſt Number of Marks being four, each of which being counted from the neareſt End of the Chain ſignifies 10 Links; thus, *one* Mark is 10, *two* 20, *three* 30, *&c.* But when you have got beyond the Middle or 50, then *four* ſignifies 60 Links, *three* 70, *two* 80, and *one* 90. Alſo you may tie a large red Rag at 50 Links, and others of a lighter Colour at 25, from each End of the Chain, eſpecially when the Graſs is long.

But becauſe of Furze, Water, Bruſhwood, *&c.* we are generally forced to meaſure the Station Lines in the Field, at ſome Diſtance from the Hedges or Fences; and therefore the Breadth between the ſtation Line and the Fence we meaſure by a Staff of the exact Length of 10 Links or $6\frac{6}{10}$ Feet. This is called an *Off-ſet Staff*, and is divided into 10 equal Parts, which are called Links, becauſe their Uſe is the ſame with the Links of the Chain.

You muſt alſo provide two ſtraight Staffs of about 5 Feet each, and 9 *Arrows* of ſmall Sticks above a Foot long each; theſe you may mark at the Top with Bits of red Cloth, and at the Bottom you may put ſmall Iron Ferrils, pointed ſharp at the End, that you may ſtick them eaſily into the Ground.

Note, Before you make uſe of the Chain, you ſhould examine its Length with the Off-ſet Staff, ſtretching it on level Ground, after the ſame Manner as when you meaſure with it. Alſo a Surveyor ſhould have by him ſome few odd Links, ſome Rings and a Pair of Pliers, that in Caſe of the Chain's breaking, he may be able readily to mend it.

Directions

Directions for measuring with the Chain.

Having set up an upright Staff at each of the Stations, betwixt which you are to measure, let the Leader of the Chain take the nine Arrows in his Hand, and one of the five-feet Staffs; let him always draw the Chain tight, and let the Follower, standing at the first Station, direct him to place his Staff at the Chain's End in a right Line with the two Stations, and there let him stick one of his Arrows, and then go on.

Let the Follower, being come to the Arrow, take it up, and put his Staff in the Place thereof, and direct the Leader to place his Staff as before; then let the Leader, standing at his Staff, look back towards the last Station, and he will see the two Staffs and the Station in one right Line, if they have directed right; but if not, the Leader must move sideways till he brings his own Staff, the Follower's and the Station-Staff into a right Line; and so must each direct the other, till the two Staffs and two Stations are in one right Line. And you must be always careful, that they who carry the Chain. deviate not from a straight Line; otherwise neither the Form nor Content of the Plot can be true.

Let them thus proceed till they have measured to the Station, or till the Leader is nearer the Station than one Chain's Length; then will the Number of whole Chains measured be expressed by the Number of Arrows pricked down, suppose 7; and the Leader holding the End of the Chain to the Station, the Follower will see how many Links are contained between the Station and last Arrow, suppose 60.

Now enter in the Field-Book, the Chains and Links without any Distinction between them, and

they will be 760, implying either 760 Links, or 7 Chains 60 Links; but the Links muſt always poſſeſs two Places after the Chains, as 7 Chains 4 Links muſt be written 704, and not 74; and 8 Chains muſt be written 800: Alſo as ſoon as you have meaſured each Length, enter it down immediately in the Field-Book, and never truſt to your Memory; alſo at the End of each Length, enquire of the Leader and Follower how many Arrows each have in their Hands, and, if the Sum of the Arrows are not nine, the leaſt meaſured Length is doubtful, and muſt be re-meaſured before you proceed.

When the Length is above nine Chains, let the Leader go on, and ſet his Staff down at the tenth, and let the Follower put his Staff in the Place of the Leader's, and give the Leader the nine Arrows, and then proceed as before; but enter theſe 10 Chains immediately in the Field-Book, and, if the Length be 10 Chains more, enter 20, *&c.*

Note, It is uſual to allow 5 Links from the Stem of the Quickſet Hedge, for the Breadth of the Ditch, except the Cuſtom or Agreement is otherwiſe; but the Cuſtom of the Place generally is the Surveyor's Rule.

Note, It is uſual to have 10 Arrows, and then the two 5 Feet Staffs are omitted; but when the Graſs is long, the Ground uneven, or the Diſtances between the Stations pretty conſiderable, the two long Staffs are very convenient for the two Men who carry the Chain to direct each other by.

SECT.

SECT II.

Of the PLAIN TABLE: *And now by that Inſtrument to take a Plan of one or ſeveral Fields, by placing it at one or more Stations about the Middle, from whence the Angles may be ſeen.*

THE *Plain Table* is a ſmooth Board made in the Form and about the Bigneſs of a common Sheet of writing Paper: Sometimes they are made large enough to hold an imperial Sheet. For faſtening and keeping the Paper cloſe down, a wooden Frame is fitted round the Edge of the Table. This *Frame* ought to be fitted ſo as to keep the Paper tight down, and likewiſe ſo as it may be eaſily put on and taken off; and to prevent tearing the Paper in faſtening it on, the upper Edge of the Table and the lower Edge of the Frame ſhould be a little obtuſe, and not ſquare; and if it be neceſſary the Frame may be faſtened underneath, by Pins or Screws going through the Table. The Frame is uſually divided into Degrees anſwering to a certain Point in the Table, taken as a Center; but this is of little or no Uſe, and quite foreign to the Deſign of the Plain Table. There is commonly annexed to this Inſtrument a *Compaſs Box* with a *Needle* in it touched with a Load-ſtone; but this alſo is of no great Uſe: for the Bearing of any Line may be found (which is the only Uſe here of the Needle) ſufficiently exact by a little Pocket Compaſs.

The Plain Table is uſually made ſo as to be taken to Pieces, I ſuppoſe for the Conveniency of Carriage, but, laying aſide that Conſideration, it would be much better in one entire Board, and then alſo it would ſerve as a very good *Drawing-Board.*

There

There is alſo belonging to the Plain Table an *Index*, having a *plain Sight* fixed upright at each End: In the lower Part of one Sight is a vertical Slit, and in the correſponding Part of the other is a wide Opening, having in the Middle of it a vertical Hair or String, to cut the Object when you look through the Slit in the other Sight; and for the Conveniency of looking backwards without turning the Index, over the wide Opening in one Sight, is a fine Slit, and over the narrow Slit in the other is an Opening with a vertical Thread in the Middle as before deſcribed of the other Sight. *Note*, The vertical Threads and Slits ought to ſtand exactly over the fiducial Edge of the Index (which is always filed ſloping from above) if produced through the Bottom of both Sights.

The Index is commonly made two Feet long, but the exact Length need not be regarded, if it be but convenient according to the Bigneſs of the Table. The outward Edge of the Index is commonly divided into Inches, and on the Surface betwixt the Line of Inches, and the fiducial Edge, is a diagonal Scale; and alſo ſometimes Lines of artificial Numbers, Sines and Tangents: But theſe Lines might, with as much Propriety, be drawn upon the Off-ſet Staff. Inſtead of all theſe, it would be better to have Scales of equal Parts of different Dimenſions, and then you would always have at Hand ſuch a Scale as would beſt ſuit your Purpoſe.

Underneath the Table is faſtened a Braſs *Socket*, which fits a Braſs *Pin* fixed in the Head of a *three-legged Staff*. This Staff ſupports the Table at a proper Height, and the Table is faſtened to it by a Screw in the forementioned Socket.

Note, You ſhould always take Care that the Table, when you uſe it. qe pretty nearly horizontal or level; which you may know by applying to

it

it a little Square, having a Line and Plummet faſtened to the upright Side; then by drawing out or in, one or more of the Legs of the Staff, as you ſee Occaſion, you may rectify the Table ſufficiently near for your Purpoſe. Sometimes to the Head of the Staff is faſtened a *Ball and Socket*; but this is rather a Detriment than of any real Uſe, for the Ball is ſubject to ſhake or turn horizontally; and as there is no other Way of moving it, but by the immediate Application of the Hand, the ſame End will be obtained as ſoon and as well by moving the Legs of the Staff.

Directions for uſing the Plain Table.

Let *Fig.* 23. be ſuppoſed to repreſent two Fields or Encloſures, a Plot of which is deſired; and firſt of the Field *a l m o b.*

Having put your Plain Table in order, and obſerved the Needle to play well. (if you make Uſe of one) put a Sheet of fair Paper thereon, and preſs down the Frame, ſo that the Paper lies ſmooth; then you may imagine the Paper on the Table to repreſent the Surface of the Land, and the Lines you ſhall draw thereon, to be the Boundaries of the reſpective Fields or Encloſures in ſome Proportion or other. If you make an Inch long on the Paper, to repreſent the Length of one Chain on the Land; and if 5 Chains in Length, and 2 in Breadth, contain the Quantity of one Acre on the Land; then 5 Inches in Length, and 2 in Breadth, ſhall alſo contain the Quantity of one Acre on the Paper.

This being premiſed, we will proceed to lay down upon the Paper, the Lines which encloſe theſe two Fields, according to their juſt Length and Poſition; which therefore ſhall include the ſame Quantity of Superficies as thoſe on the Field, in Proportion as the Square of 1 Inch to the Square of 1 Chain.

But

But if we make half, or a quarter of an Inch, or half a Quarter, (by which the following Dimenſions were laid down) on the Paper, to repreſent one Chain, it will be the ſame Thing in Effect, only the Plot will be thereby rendered leſs.

Firſt, place the Table ſomewhere about the Middle of the Field, from whence, if poſſible, you can ſee all the Angles, as at ⊙ 1 ; and make a Hole in the Ground, over which by the Help of a Plummet and String, ſet the Center of the Table, by applying the String to the Head of the Staff. Having ſet the Inſtrument horizontally, turn it about till the Needle hangs over the Flower de Luce in the Box ; (or if it is more convenient, turn the length-way of the Table to the length-way of the Plot, that it may, if poſſible, lie on one Sheet of Paper ; and note, on a Bit of waſte Paper, the Diviſion in the Box the Needle hangs over when at reſt) and then ſcrew the Table faſt. Aſſign on the Paper a Point, or ſtick a Pin at ⊙ 1, (to repreſent the Hole in the Ground or preſent Station) to which Point, apply the fiducial Edge of the Index, and turn it about, keeping the Edge cloſe to the Point or Pin at ⊙, till through the Sights you ſee the Hair cut a Staff or Mark, ſet up exactly in one of the Angles, as at *a* ; then by the Edge of the Index, draw an obſcure Line from the Point ⊙ toward the Angle *a*, (with the Point of the Compaſſes or with a Pencil) without regarding the Length, ſo it be but long enough.

Let the Mark be left at *a*, and cauſe others to be ſet up round the Field, at every Angle therein, as at *l*, *m*, *o*, *b* ; to every one of which direct the Sights, and when the Hair therein cuts the Mark (keeping the Edge of the Index cloſe to the Point ⊙) draw the ſeveral Lines ⊙ *l*, ⊙ *m*, ⊙ *o*, ⊙ *b*.

Now ſee whether the Needle continues to hang over the ſame Point in the Box as when you firſt planted

planted the Table; alſo lay the Edge of the Index to the Line ⊙*a*, and if then the Hair in the Sights cuts the Mark at *a*, and the Needle hangs over the ſame Point as at firſt, you may conclude the Table hath not been moved out of its firſt Poſition, which is carefully to be obſerved.

In the next Place we proceed to meaſure the Lines ⊙*a*, ⊙*l*, *&c.* Thus, apply the Ring at the End of the Chain to the Hole under the Table, and let the Chain be ſtretched at Length towards one of the Angles as at *a*; and when you have meaſured up thereto, (obſerving the Directions before laid down for meaſuring with the Chain) you will find the Length of the Line ⊙*a* to contain 3 Chains 60 Links, which note in a Bit of Paper.

Having meaſured the Line ⊙*a* on the Ground. take the Length thereof, *viz.* 360 Links from the Scale of equal Parts (which you judge is moſt convenient for your Purpoſe) and lay the ſame (on its Repreſentative upon the Paper) from ⊙ to *a*. After the ſame Manner meaſure with the Chain the Length of the ſeveral Lines ⊙*l*, ⊙*m*, ⊙*o*, ⊙*b*; then transfer the Length of each Line on the Ground to its Repreſentative on the Paper, making Marks where the End of each Line falls, as at *a*, *l*, *m*, *o*, *b*.

Laſtly, join the Points *a*, *l*, *m*, *o*, *b*, with Ink Lines, becauſe they ſhould not rub off, (and for this Purpoſe a Drawing-Pen is requiſite) as the Lines *al*, *lm*, *mo*, *ob* and *ba*, which conſtitute the Boundaries of the Field, *a l m o b*.

Note, It is generally the moſt expeditious Way to meaſure one Line from the Inſtrument to an Angle, and the next from the Angle to the Inſtrument; and ſo backwards and forwards till all are finiſhed, noteing down as you meaſure them, the Length of each Line on a Piece of Paper; then obſerving which Line you began with, ſet on its true Length on the Paper

on

on the Table, and the reſt of the Lines in their Order.

A young Beginner may take the Pains to meaſure a-croſs ſome Part of the Plot on the Paper, as the Diſtance from *a* to *o*, or from *a* to *b*, with his Scale and Compaſſes; then meaſuring the ſame Diſtance on the Ground with the Chain, he will find them both exactly to agree, if the Plot be truly laid down.

Having finiſhed this Field, cauſe a Staff to be ſet up with a Paper thereon in the next, in a Place from whence you can view all the Angles; but if ſuch a Station cannot be found, chuſe the moſt convenient, as at ⊙ 2.

The Table ſtanding at ⊙ 1, in the Field *a l m o b*, in the ſame Poſition as at firſt, (which it muſt do, or the Plot of the next Field cannot be truly laid down in reſpect of the laſt) lay the Index to the Point ⊙, and turn it about thereon, till the Hair in the Sights cuts the Staff or Mark in the next Field at ⊙ 2; and holding the Index faſt in that Poſition, draw a Line by the Edge thereof from ⊙ 1, towards ⊙ 2 in the next Field, and take care to continue it long enough: then remove the Table, and place a Staff with a Mark thereon, in the Hole over which the Center of the Table was placed, and meaſure with the Chain the neareſt Diſtance between ⊙ 1, in the Field *a l m o b*, and ⊙ 2 in the next Field (drawing the Chain through the Hedge in a ſtraight Line) and ſet on the Diſtance 621 (by the Help of the Scale and Compaſſes) from ⊙ 1 to ⊙ 2.

Now take away the Staff, and plant the Center of the Table over the Hole, in which the Staff ſtood at ⊙ 2, and ſticking two Pins, or the Points of two ſmall Needles in ⊙ 1, and ⊙ 2: apply the Edge of the Index thereto, ſo that it may lie exactly on the Line ⊙ 1, ⊙ 2; and keeping it in this Poſition, turn the Table about till the Hair or Thread in the Sights cuts the Staff or Mark in the laſt Field; then ſcrew

the

the Table faſt that it ſtir not out of its Poſition, till you have finiſhed the Obſervations in this Field: (But obſerve to turn that Part of the Table marked with ⊙ 1, towards its Repreſentative in the laſt Field.)

When the Needle hath ſettled, and is at reſt, obſerve whether it hangs over the Flower-de-Luce or ſame Diviſion in the Box, as at ⊙ 1 in the laſt Field; which it will do if you have made your Obſervation juſtly, and the Needle be good; and if you were to move the Table to never ſo many Stations, the Needle will ſtill point to the ſame Diviſion in the Box, which you ſhould carefully obſerve; becauſe the removing the Table from one Station to another is the greateſt Difficulty in this Way of Surveying.

Having cauſed Marks to be ſet up in ſo many of the Angles in this Field, as you can conveniently ſee, from the preſent Station, as at *k*, *i*, *h*, *g*, lay the Index to the Point ⊙ 2, and direct the Sights to *k*, *i*, *h*, *g*, drawing Lines by the Edge of the Index towards every one of them; then meaſuring the Length of the ſeveral Lines ⊙*k*, ⊙*i*, ⊙*h*, ⊙*g*, with the Chain, ſet on the ſeveral Lengths of theſe Lines on the reſpective Lines on the Paper (as before directed) marking the Points *k*, *i*, *h*, *g*, where the Ends of the Lines fall from ⊙; laſtly, join the Points *l k*, *k i*, *i h*, and *h g*, with Ink Lines, and they will be the Bounders of ſo much of the preſent Field, as you can conveniently ſee from this Station.

But there is no Occaſion to meaſure to the Angles *l* or *m* with the Chain, except that it may be ſome Satisfaction, as aforeſaid, to ſee the Lines on the Paper and thoſe on the Ground to agree.

Obſerving the former Directions for removing the Table, let it be placed in its true Poſition at ⊙ 3 in this Field; then direct the Sights to the Angles *f*, *e*, *d*, *c*, and when the ſeveral Diſtances from ⊙ 3, to *f*, *e*, *d* and *c*, are ſet on the Paper, join the Points

Points *g f*, *f e*, *e d*, *d c* and *c b*, with Link Lines; ſo is the true Plot of theſe two Fields *a l m o b*, and *l k i h g f e d c l o m*, laid down on the Paper in ſuch Proportion as the Scale you made uſe of is to the Chain.

But obſerve that if the Hedge *b c*, had been ſo thick, that from ⊙ 3, you could not have ſeen the Angle *d*, or other Obſtruction had hindered your Sight or Meaſuring thereto. you muſt have removed the Table to another Station; but when you can (as commonly you may) by holding aſide the Boughs or otherwiſe, ſee the Mark, and by drawing the Chain through the Hedge, meaſure the Line from ⊙ 3, to the Angle *d*; it is better not to remove the Table: For the fewer Stations you make, the Work will be eaſier done, and alſo more truly laid down.

It would be needleſs to give Directions how to ſurvey a Field from a Station taken in any Angle thereof, from whence the reſt may be ſeen; as if it had been more convenient, in the Field *a l m o b*, to have planted the Table at the Angle *a*, the Sights muſt have been directed from thence to the reſt of the Angles *l*, *m*, *o*, *b*; and the Lines meaſured on the Ground, from *a* to *l*, *m*, *o* and *b*, whoſe Length laid down on the Paper from *a* would give the ſame Points *l*, *m*, *o*, *b*, as if the Station had been in the Middle of the Field; and the Bounders being drawn, they would be in the ſame Poſition as before.

If you would draw a Meridian, or a North and South Line through the Plot; turn the Table about, till the Needle hangs over the Flower-de-luce in the Card, and laying the Index at right Angles to the long Sides of the Table, draw a Line cloſe by the Edge, which ſhall be a Meridian Line; and if you croſs this Line by another at right Angles, that ſhall ſhew the Eaſt and Weſt Points.

Note,

Note, Having removed the Table to a new Station, if the Index be laid close to the Line drawn betwixt that Station and the last, the Table may be thereby rectified to a greater Exactness than can be done by the Needle, which at best is uncertain and liable to be out of order; and, as before intimated, the Needle is not properly an Appendage of the Plain Table, though we have here all along supposed it annexed to this Instrument, for the Sake of complying with Custom.

SECT III.

Directions for casting up the Content of any Piece of Land.

THE next Thing that lies before us is the Manner of calculating the Quantity of the Superficies, or the *Area*, enclosed by the Lines on the Paper, as they represent the Boundaries in the Field; that is to say, how many Acres and Parts of an Acre are contained therein.

The Manner of finding the *Area* and *Content* of any plain right-lined Figure hath been already laid down in Sect. 3. of Chap. I. It hath been also shewed, that the Method of finding the Content of all plain right-lined Figures is deduced from the right-angled Parallelogram, the Area of which is found by multiplying the Length by the Breadth: Wherefore because 10 square Chains make 1 Acre, if the Side A B of the right-angled Parallelogram ABCD (*Fig.* 15.) be 5 *Chains*, and A C 2 *Chains*, the *Area* of ABCD is just 1 *Acre*. Also if the Sides of the Square ABCD, *Fig.* 16. be each 10 Chains, the Content of the said Figure will be 100 square Chains, or 10 Acres.

But becauſe almoſt all Fields to be met with in Surveying are irregular, and bounded with ſeveral unequal Lines, we muſt firſt take the Plot thereof by ſome Inſtrument, and lay it down on Paper; then, by drawing diagonal Lines, we may reduce the Figure into Triangles, *&c. Vide Fig.* 24.

The Lengths of the ſeveral Lines in the Field are uſually ſet down in Links, without diſtinguiſhing them into Chains and Links, as 6 Chains 54 Links is writ 654, which ſignifies 654 Links; for as a Link is the loweſt Denomination, and the only one uſed, there is no Neceſſity for writing down the Word *Links*. And as a Chain contains in length 100 Links, therefore in 1 ſquare Chain there are 10,000 ſquare Links, and 100,000 ſquare Links in an Acre. Wherefore having the Content of a Field given in ſquare Links, if we cut off 5 Figures to the right Hand, what is left on the other Side (if there be any) will be Acres. Thus, if a Field contains 1654321 ſquare Links, the Area thereof will be 16 Acres and $\frac{5}{10}\frac{4}{0}\frac{3}{0}\frac{2}{0}\frac{1}{0}$ Parts of an Acre, or 16.54321 Acres. The Chain is made 66 Feet in Length, and divided into 100 equal Parts on Purpoſe, to ſave the Trouble of Diviſion in computing the Number of Statute Acres.

Note, The Content of every Field is uſually ſet down in *Acres*, *Roods* and *Perches*. An *Acre* contains 4 *Roods*, and one *Rood* 40 ſquare *Poles* or *Perches*. Wherefore, the Content of a Field being given in ſquare Links, and having found the Number of Acres contained therein as above, multiply the 5 Figures, which were cut off by 4, and from this Product cut off again 5 Figures, what is left will be Roods; then the Remainder ſo cut off being multiplied by 40, from this laſt Product alſo cut off 5 Figures, and thoſe on the left Side will be Perches, which is the loweſt Denomination uſually ſet down of the Contents of Land.

To find the Number of Acres contained in 1654321 ſquare Links, the Operation will ſtand thus:

A. 16.54321
4

R. 2.17284
40

P. 6.91360

Acres *Roods* *Perches.*

Anſ. 16 : 2 : 6 or rather 16 : 2 : 7 becauſe the 91360 make almoſt another Perch.

To find the Content of any Piece of Land, the following is a GENERAL RULE.

Firſt reduce the given Figure into Triangles, then meaſure the Baſes and Perpendiculars falling upon them, of each Triangle, and multiply ſeverally the ſaid Baſes by the Half of their Perpendiculars, or the whole Perpendiculars by half the Baſes, and the Product will be the Contents of the ſeveral Triangles in ſquare Links. Add the Contents in Links of each Triangle together, and the Sum will be the Content of the whole Field in ſquare Links, which you may reduce into Acres, Roods and Perches, as before directed.

Thus, in *Fig.* 24. the Area of the Triangle *l m o* (whoſe Baſe *l o* is 660, and Perpendicular *m y* let fall upon it from the oppoſite ∠ *m* is 252) is 83160, which may be found either by multiplying half 660 by 252, or 660 by half 252.

252	126
330	660
7560	7560
756	756
83160	83160

The diagonal Line *l b* divides the Trapezia *l o b a* into two Triangles, *l o b* and *l b a*, which might be ſeparately caſt up as the Triangle *l m o*; but the quicker Way is to add the two Perpendiculars *o z* and *a x* together, and by that Sum multiply the Line *l b*, which is a common Baſe to both Triangles, and halve the Product for the true Content of the Trapezia. See the following Work.

Baſe 660——*l o*	Perp. 290——*a x*
Perp. 252——*m y*	Perp. 272——*o z*
1320	562 Sum
3300	Baſe 800——*l b*
1320	449600
166320	

166320
449600 } Product.

615920 double Content.

Acres — — 3.07960 true Content.

4

Roods——— .31840

40

Poles —— 12.73600

Acres

Acres	Roods	Poles	Parts of a Pole.
3	0	12	$\frac{73600}{100000}$

The Baſe *l o*, multiplied by the Perpendicular *m y*, produces 166320, which is double the Content of the Triangle *l m o* in ſquare Links. Alſo the Perpendicular *a x*, added to the Perpendicular *o z*, makes the Sum of both 562, which multiplied by 800, the common Baſe to both Perpendiculars, produces 449600, which is double the Content of the Trapezia *l o b a* in ſquare Links.

Therefore (for avoiding Fractions) the double Content of the Triangle *l m o* 166320, added to the double Content of the Trapezia *l o b a* 449600, gives 615920 the double Content of the Field *a l m o b* in ſquare Links, the half of which (*viz.*) 307960 is the true Content of the Field *a l m o b* in ſquare Links, which reduced into Acres, *&c.* as before directed, gives 3 Acres, 12 Poles, and a little above half a Pole, for the true Content of the Field *almob*; but the Parts of a Pole are ſeldom regarded.

In the ſame Manner the Field *b c d e f g h i k l m o*, *Fig.* 24. being divided into Trapezias and Triangles, add both the Perpendiculars of each Trapezia together, and by that Sum multiply the Diagonal or Baſe: Alſo multiply the Baſe of each Triangle by the Perpendicular, and ſet the Product of each Trapezia and Triangle in an orderly Manner, one under another, and add them altogether into one Sum, the half of which Sum will be the Content of the Field in ſquare Links, which reduce into Acres, *&c.* as aforeſaid.

But remember to meaſure the Baſes and Perpendiculars by the ſame Scale that the Plot was laid down by, and contrive to reduce the Field into as large Trapezias and Triangles as poſſible; for the fewer you make, the exacter will the Work be caſt

up; and draw the Baſe-lines neat and ſmall, and exactly from Angle to Angle. You need not actually draw the Perpendiculars, but only take the neareſt Diſtance from the oppoſite Angle to each Baſe, which may be readily done thus: Set one Foot of the Compaſſes exactly in the angular Point, and extend the other till it touches the Baſe; then turning it about, if it cuts the Baſe, obſerve the Middle, as near as you can gueſs, between theſe two Points; the Diſtance betwixt this middle Point, and that wherein the other Foot of the Compaſſes ſtands, will be the Length required, to as great an Exactneſs as you could meaſure it, if the Perpendicular had been drawn.

Note, You ſhould always make uſe of as large a Scale, as the Bigneſs of your Plot will admit; and if you uſe a diagonal Scale, the Lengths of the ſeveral Lines may be laid down and meaſured on the Paper to a greater Exactneſs.

SECT. IV.

Shewing how to make the Plot of any Field or Encloſure, on the Paper fixed on the Plain Table, by going round the ſame, and taking Offſets to the Bounders, &c.

THE former Method of planting the Table at one Station or more, in the Middle of the Field, and meaſuring from thence the Diſtance to every Angle, is eaſieſt for a Beginner, but is not convenient in many Caſes; becauſe he may be hindered by Furze, Water, *&c.* from meaſuring the Lines to all the Angles; and in many Fields where the Fences are as irregular as the Side *a e* in the Field, *Fig.* 25. he will be obliged to meaſure a great Number of ſuch Lines.

'Tis

'Tis therefore beſt to plant the Inſtrument at the moſt remarkable Angles, and meaſure round the Field; for by this Method all Sorts of Land may be meaſured (ſo the Plan be not too large for one Sheet of Paper) either within or without the Plot, as Convenience ſhall determine.

Note, This Mark ⊙ always repreſents a Station, ... a prick Line repreſents the Station Line, and ——— a black Line the Boundary.

Let *Fig.* 25. repreſent a Field to be plotted by the Plain Table.

Firſt, ſet up a Mark at *a*, and draw a Line on the Table, to repreſent *a b* in the Field; then meaſure the Diſtance to the Hedge from ⊙ 20 Links, which ſet from ⊙ to *f*; alſo meaſure the Diſtance from ⊙ a, to ⊙ *b*, 840 Links, which ſet on the Line *a b*.

Having drawn the Line *a b*, place the Table at *b*, and lay the Edge of the Index cloſe to the Line *a b*, and turn the Table about till you ſee the Mark at *a*, and there ſcrew it faſt; then turn the Index about on *b*, till you ſee a Mark at *c*, and draw *b c*, with the Point of the Compaſſes, or a black-lead Pencil; alſo direct the Sights to the Barn, and draw the obſcure Line *b z*, not regarding its Length ſo it be but long enough.

When the Needle hath ſettled, take Notice what Diviſion in the Box it points to, for to that Diviſion it will point at every Station through the Plot, if your Work be true, and the Needle good, as aforeſaid; but becauſe it is not convenient to truſt to the Needle when we can do without it; I ſhall here lay down a ſurer Way to correct an Error, before it is communicated to the following Part of the Work.

In the next Place, meaſure the Diſtance from ⊙ *b* to the Hedge 17 Links, which ſet from ⊙ to *g*, and draw the Boundary *f g*; alſo meaſure the Diſtance

from ⊙ to *b*, which ſet on the Paper from ⊙ to *b*, and continue the Bounder *f g*, in a ſtrait Line, as you ſee in the Field.

Remove the Table from *b*, and ſet up a Staff with Paper thereon in the Hole, over which the Center of the Table ſtood, according to former Directions, and meaſure with the Chain from *b* towards *c*; but when you come over-againſt the Bend in the Hedge at *i*, meaſure the Diſtances from the Chain Line *b c* to that Bend 7 Links, which ſet from the Chain Line *b c* to *i*; and draw the Boundary *i h*, through *h*, till it cuts the Boundary *f g*, conſtituting that Corner of the Field. Meaſure on to *c* 620 Links, which ſet from *b* to *c*.

The Reaſon why we made the Station *b*, ſo far from the Corner, is to avoid planting the Inſtrument too often; for if we had continued the Station Line *a b* into the Corner, we muſt have made another Station at *i*, otherwiſe we could not ſee to the Angle at *c*; for the fewer Stations we make, the exacter will be the Work, as aforeſaid.

Now in order to examine the Length of *b c*, and alſo its Poſition in reſpect of *a b*, do thus: Plant the Inſtrument at *c*, and lay the Index on the Line *b c*, and by turning the Inſtrument about, direct the Sights to *b*, and there ſcrew it faſt; then turn about the Index on the Point *c*, towards the Mark at the Angle *a*, in the Field, and if the Edge does not cut the Point *a* in the Table, the Line *b c* is falſe, either in Poſition or Length, and therefore muſt be corrected before you proceed.

The Line *b c* being truly laid down, and the Table ſtanding at *c*, in the ſame Poſition, lay the Index to the Point *c*, and turn it about thereon, till the Hair in the Sights cuts the Mark at *d*, and draw the Line *c d*; alſo direct the Sights to the Middle of the Barn, the Index being turned about on the

ſame

ſame Point *c*, and draw the obſcure Line *c x*, croſſing the other obſcure Line *b z*; ſo ſhall the Point of Interſection determine the Situation of the Barn in the Middle of the Field, which you may prove by meaſuring on the Ground thereto, from any Part of the Field.

Next meaſure the Diſtance from the ⊙ at *c* to the Hedge 6 Links, which ſet from ⊙ to *k*, and draw the Boundary *i k*, continuing the Line through *k*; alſo meaſure the Diſtance to the other Hedge *c l*, from ⊙ *c*, 15 Links, which ſet off to *l*.

Remove the Table from *c*, and place a Mark there, and meaſure the Diſtance from *c* to *d*, 481 Links, which Diſtance ſet on the Line *c d*; then plant the Table at *d*, and having laid the Index on *c d*, turn the Table about till you ſee the Mark at *c*, and then ſcrew the Inſtrument faſt.

Next examine the Length and Poſition of *c d*, in reſpect of *b c*, as before directed; then turning the Index about on *d*, direct the Sights to *e*, and draw the Line *d e*; ſet off the Diſtance from ⊙ *d* to the Hedge at *m* 10 Links, and from *m* draw the bounding Line *m l*, continuing it ſtrait through *l*, till it croſſes *i h*, as you ſee it do in the Field.

Leave a Mark at *d*, and plant the Table at *e*, having firſt meaſured the Length of *d e* 364 Links, which ſet on its proper Line from *d* to *e*; on which Line *d e* lay the Index, and, turning the Table about till you ſee the Mark at *d*, there ſcrew it faſt; and having proved the Line *d e* to be truly laid down in reſpect of *c d*, turn the Index about on *e* till you ſee the Mark ai *a*, and draw the Line *e a*, which will cut through the Point at *a*: Alſo direct the Sights to the Angle *p*, and draw ⊙ *p*: and to *q*, drawing ⊙ *q* on the Paper.

Then

Then measure with the Chain the Distances ⊙*p* and ⊙*q*, setting those Distances on their proper Lines, and draw the Boundary *p o*, and *q p*.

Now measure on the Line *e a*, and when you come against the Bend in the Hedge at *r*, measure the Distance from the Chain Line *e a* to that Bend 8 Links; which set on the Paper to *r*, and draw the Boundary *q r*.

In the same Manner measuring on the Line *e a*, set off the Distances from the Chain Line to the Angles in the Bounder *s* and *t*, and draw the Boundaries *r s*, *s t*, and *t f*, which crosses the Line *g f*, near *f*; and when you have measured the Line *e a*, on the Ground, you will find it of the same Length as that before drawn on the Paper.

If the Distance from the Station to the Bends in the Hedge be great, 'tis the safest Way to plant the Center of the Table over the Station Line, as at *w*; and, laying the Index on the Line *e a*, direct the Sights to *e*, or *a*, by turning the Table about, and in that Position screw it fast; then direct the Sights to the Bends in the Hedge, as, to *s*, or *t*, drawing Lines towards them, and setting off the Distances in the same Manner as is done from ⊙ *e*.

In order to examine the Lengths and Positions of each Line before you proceed on to the next, if you do not think it convenient to leave Marks at all the Stations round the Field; if you turn about the Index on the Point, representing the present Station, till you see any one of the Marks before laid down, and if the Edge of the Index cuts that Point on the Paper, your Work is right; so you might have left a Mark at the first Station *a*, and by that prove the Lengths and Positions of all the other Lines, as well as by the last but one you passed by.

But

But if you could not see the Mark at *a*, at all the other Stations, you may make use of any other Mark, as some Part of the Barn; or you may set up a Mark in some convenient Place, from whence you can see all the Angles.

But if the Mark you last used is at too great a Distance from you, or lies almost in a strait Line with that you last laid down; then use some other Mark in its Stead, whose Position you have before found at one of the foregoing Stations.

Or, instead of a Mark thus set up, you may use any remarkable Tree, Steeple, *&c.* that is not at too great a Distance from you, whether it be in the Land you are then surveying or not.

How to measure an inaccessible Distance.

Lastly, in the same Manner as you found the Position of the Barn in the Middle of the Field, *Fig.* 25. you may measure any other inaccessible Distance; so if the Barn was so situated that you could not come nearer thereto, by reason of Water, or other Impediments, than the Line *b c*, yet you would know its Distance from *b* or *c*.

The Instrument being planted at *b*, and the Sights directed to a Mark at *c*, and also to the Barn; and the Lines *b z*, and *b c*, drawn on the Paper as before directed; then the Instrument being removed from *b*, and planted at *c*, and the Sights directed to a Mark left at *b*, and also to the Barn; and the Line *c x*, also drawn on the Paper, cutting the other Line *b z*: Then shall the Point of Intersection determine the Distance of the Barn from *b* or *c*, which you may find by measuring from *b* or *c*, or any other Part of the Line *b c*, by the same Scale with which you laid down the Line *b c*.

But it is convenient to make the Stations *b* and *c* at such a Distance from one another, that the Angle

at

at the Point of Interſection may not be too Acute, leſt you be not able to diſtinguiſh nicely the Point of Interſection.

If *Fig.* 25. was a Wood, ſo that you could not meaſure the Station Lines within, you may as well make them on the Outſide; for the Plot will be the ſame, only the ſmall Pieces of Ground between the Station Lines and Boundaries are excluded by the Boundaries from being any Part of the Plot. Particular Directions in this Caſe are needleſs; *ſee the Figure.*

When you are about to meaſure a Plot of Land, and in doubt whether it will lie on one Sheet of Paper, you may place a Line or two croſs the Plot, as you walk about to chuſe the moſt convenient Stations (reckoning ſo many Steps to a Chain, as you find by Experience carries you a Chain's Length) and thereby gueſs what Scale to make uſe of.

It is alſo convenient to make a particular Remark at the firſt Station in each Field, that you may readily find it when you come round to it again, in order to cloſe the Plot.

Alſo as ſoon as you have drawn the Plot of a Field, it is neceſſary to write the Name ſomewhere in the Middle thereof.

There is another Way of Plotting a Field by the Plain Table (though ſcarce fit for Practice) by meaſuring one Line only, which in ſhort is this:

Plant the Table at *a*, *Fig.* 26. and direct the Sights to the ſeveral Angles round the Field, keeping the Index cloſe to the Point *a*, and by the Edge thereof draw a Line towards every Angle; then place a Staff at *a*, and plant the Table at the other Station *b*, meaſuring the Diſtance between the two Stations, which Diſtance ſet on the Line *a b*; lay the Index on the Line *b a*, and turn the Table about till you ſee the Mark at *a*, and fix there the Inſtrument.

Then

Then lay the Index to the Point *b*, and turn it about thereon, directing the Sights to the ſeveral Angles round the Field as before at *a*, and towards every one of them draw a Line, which will interſect the Lines before drawn at *a*; ſo ſhall the Points of Interſection determine the Place of all the Angles round the Field, and Lines drawn from Point to Point ſhall give the Boundaries of that Field.

But if you be not very exact and curious in drawing the Lines, and alſo if the Stations are not contrived in ſuch Manner as may prevent the Lines interſecting one another at very acute Angles, you may commit groſs Miſtakes.

And here it may be obſerved in this as well as any other Caſe of the like Nature, that all Things that are to be determined by the Interſection of right Lines, are beſt determined when thoſe Lines interſect each other neareſt right Angles: And therefore when Triangles are laid down from one given Side, and the Length or Poſition of the other two, and theſe two make with each other a ſmall Angle, it is difficult to determine the Point where they interſect ſo exactly as it ought to be.

SECT. V.

Shewing how to meaſure any Piece of Land by the Chain only.

THOSE who are not provided with other Inſtruments, may make a Shift to meaſure a Piece of Land by the Chain only, after the following Manner, though it be ſomewhat laborious and tedious.

Let

Let Fig. 22. *repreſent a Field, whoſe Content in Acres is deſired without any Plot thereof.*

Firſt, Set up Marks (or upright Sticks) at the ſeveral Angles A, B, C, D, E, F, G, H, I; and obſerve as you go along, betwixt which Angles it will be moſt convenient to run a diagonal or baſe Line, as the Line A E; ſo that a Perpendicular from the oppoſite Angles as B and I, may fall upon this Diagonal or Baſe in a convenient Manner: And *Note*, it is beſt to make the *Baſe* the longeſt diagonal Line in a Trapezium. or the longeſt Side of a Triangle; for then the Perpendiculars will be ſhorter, which in this Method of Surveying is an Advantage.

Having a Sheet of Paper in Readineſs, on which to draw an Eye-draught of the whole Work, make ſome Mark near the Angle at A, and lay the Chain thereto, ſtretching it in a ſtrait Line towards the oppoſite Angle E; then draw a ſtrait Line on the Paper to repreſent the Line A E, which you are about to meaſure; and proceed with the Chain towards the Angle E.

When you have meaſured 4 Chains on the Line A E, you will perceive yourſelf almoſt over-againſt the Angle B; therefore having laid the Chain a fifth Time, ſet down an Arrow at the End of the Chain next E, and let it lie on the Ground in the Direction of AE; then endeavouring to find a Point in the Baſe A E from which a right Line drawn from the Angle B, may ſtand at right Angles upon the Baſe A E.

For this Purpoſe provide a ſmall Braſs Croſs, with four plain Sights thereon, having a Socket on the Backſide, which put on the Head of a ſhort Staff, and ſet the Staff in the Ground cloſe to the Chain; then ſet two of the Sights in the Direction of A E, by looking backwards and forwards through thoſe

Sights

Sights till you can ſee the Mark in each Angle A and E; ſo ſhall the Mark in the Angle B be ſeen through the other two Sights, if the Staff be ſet in a Perpendicular from B; but if not, move the Staff backwards and forwards by the Side of the Chain, in the Line AE, till through two of the Sights you ſee A and E, and through the other two the Mark at B; then will the Staff be ſet in the Point *a*.

But, if you have not ſuch a Croſs, get a Bit of Board made exactly ſquare, in form of a ſquare Trencher, and from Corner to Corner draw ſtrait Lines thereon; then ſtick a Pin faſt and upright in the Line near every Corner, and make an Hole in the Middle of the Board, ſo that you may turn it on the Head of a Staff; this, for once, may ſupply the Want of the Croſs.

Having found the Point *a* in the Line A E, there ſet down a Staff, and take Notice how many Chains and Links it is diſtant from A, *viz.* 418; therefore apply a Scale to the right Line on your Eye-draught, and near 418 make a Mark at *a*; but you need not regard whether it be exact or not, ſo it be within 20 or 30 Links, becauſe the true Lengths of each Line are meaſured on the Ground.

Then meaſure on the Ground, in a ſtrait Line, the neareſt Diſtance between *a* and B 600 Links, and erect a Perpendicular on the Point *a* on the Paper, as near as you can gueſs, by applying the End of a Scale to the Line *a* A; and by the Edge thereof draw the Line *a* B, ſetting cloſe thereto 600 Links, the Length of the Perpendicular; but you need not regard whether the Line *a* B on the Paper be made of its juſt Length or not; but only that the Form of the Eye-draught may be ſomething like that of the Field, a Reſemblance thereof being all that is requiſite in this Caſe.

Next return to the Arrow, and meaſure forwards on the Line A E till you are near againſt the Angle

gle I; and by a few Trials you will find the Point *e* at the Diſtance of 616 Links from A. Then meaſure the Perpendicular *e* I, and ſet the true Length thereof 368, cloſe to its Repreſentative on the Eye-draught,

Now look towards the Fences A B and A I, and becauſe they are ſtrait Lines, draw B A, A I, on the Eye-draught, , ſo is that Side of the Field finiſhed.

From *e* proceed with the Chain in a ſtrait Line to E, and you will find the whole Length from A to E to be 1375 Links: Then make that right Line on the Paper nearly the Length of 1375, and draw the right Lines E B and E I, cutting the Ends of the Perpendiculars *a* B and *e* I: So ſhall the greateſt Part of the Field be expreſſed on the Paper, by the Trapezium A B E I.

From E meaſure in a ſtrait Line towards C, and when you come to *b*, meaſure the Perpendicular *b* D 60 Links; then meaſure out the Line E C to C 800 Links, and draw the Sides E D, D C, on the Eye-draught, to the Extremity of the Perpendicular *b* D. Now number the Angles round the Field, and if you can ſee the Marks at each, compare them with thoſe on the Eye-draught, and thereby diſcover what Part of the Field you have already meaſured, and what remains to be done.

In the ſame Manner as you meaſured the Triangle E D C, meaſure the Triangles E F G and G H I; then if there be ſo many Angles expreſſed on the Eye-draught, as there are Marks at each Angle round the Field, and if the true Length of each Baſe and Perpendicular, as meaſured in the Field, be expreſſed on the Repreſentative of the Eye-draught, you may proceed to caſt up the Work.

The ſame Lines in the Field, *Fig.* 22. are meaſured on the Land with the Chain, as we ſhould have done

done on the Paper, with the Scale, if the true Plot of the ſame Field had been firſt made by the Plain Table or other ſtanding Inſtrument; and therefore muſt be caſt up in the ſame Manner, for you have the true Length of each Baſe and Perpendicular given on the Eye-draught: So the Sum of the two Perpendiculars *a* B, and *e* I, multiplied by the Baſe A E; alſo the Baſes and Perpendiculars of the other three Triangles multiplied together, theſe four Products added into one Sum, the Half thereof will be the Content of the Field, *Fig.* 22, in ſquare Links, which reduce into Acres, *&c.* as directed in Sect. 3.

This Method of meaſuring a Field by the Chain is only proper for plain, level Ground, and ſmall Encloſures: But even then, if the Fences are very irregular, it is better to go round and meaſure the Angles; taking Off-ſets from the Station lines to the Fences.

Indeed if the Fences be tolerably regular (but there are many Fields, whoſe Sides are not ſo ſtrait as *Fig.* 22.) you may make a Plot thereof tolerably well, by obſerving at how many Chains and Links the Perpendiculars join the Baſe of the Triangles or Trapezias, and erecting Lines on thoſe Points perpendicular to the Baſe; which being made of their true Lengths, as meaſured on the Ground, the Sides of the Field may be drawn from the Extremities of the Baſe to the End of each Perpendicular. Alſo obſerve, if any of theſe Baſes be more than 10 Chains, leave a Staff at the tenth, and take the Direction of the Line by that Staff, becauſe the Station will be at too great a Diſtance; and, if the Length be 20, ſet up another Staff, and ſo on.

Or, you may make a Plot of the Field, *Fig.* 22. without meaſuring the Perpendiculars, after the following Manner; which I take to be a better Method (at leaſt in many Caſes) than the preceding.

1. Meaſure the Sides A B, B E, E I, I A, and the Diagonal A E of the Trapezium A B E I, which note on a Piece of Paper; and note alſo at how many Chains and Links the Point C in the Line E B falls from E or B, according to which End of the Line E B you began meaſuring: After the ſame Manner write down where the Point G falls in the Line E I; next, meaſure the Sides E D, D C; E F, F G; and G H, H I; and then the Work that was to be done, and the Field is finiſhed. But becauſe the Angle A D C is very obtuſe, and lies but a little Way from the Baſe C E; inſtead of meaſuring the Sides E D and D C, I would chuſe rather to find the Point *b*, and meaſure the Length of the Perpendicular *b* D; and for the ſame Reaſon I would meaſure the Perpendicular *c* F; Alſo for a like Reaſon, inſtead of meaſuring the Perpendicular I *d*, I would meaſure the Sides G H and H I, as before directed. For this ſhould be always remembered, that the more Dimenſions are taken in the Field, the truer will be the Area of the Plot. Every Surveyor therefore ſhould meaſure as many Lines and Perpendiculars as poſſible with his Chain, and not truſt more to Angles than is abſolutely neceſſary, as they are very ſubject to lead him into Error. If you cannot come cloſe to the Fences, you muſt take Off-ſets, as directed in the laſt Section. The Dimenſions of the foreſaid Lines being thus takan, you may make a Plot of the ſaid Field after the following Manner. Having drawn a Line croſs the Paper, lay thereon the Length of A E taken from a Scale of equal Parts; then from the ſame Scale take the Lengths of A B, E B, and therewith form the Triangle A B E (by the Directions in Page 14.) After the ſame Manner, with the Sides E I, A I, upon the Baſe A E, make the Triangle A I E; then will the Trapezium A B E I be compleated. Now there remain to be done, only the Triangles E D C, E F G,

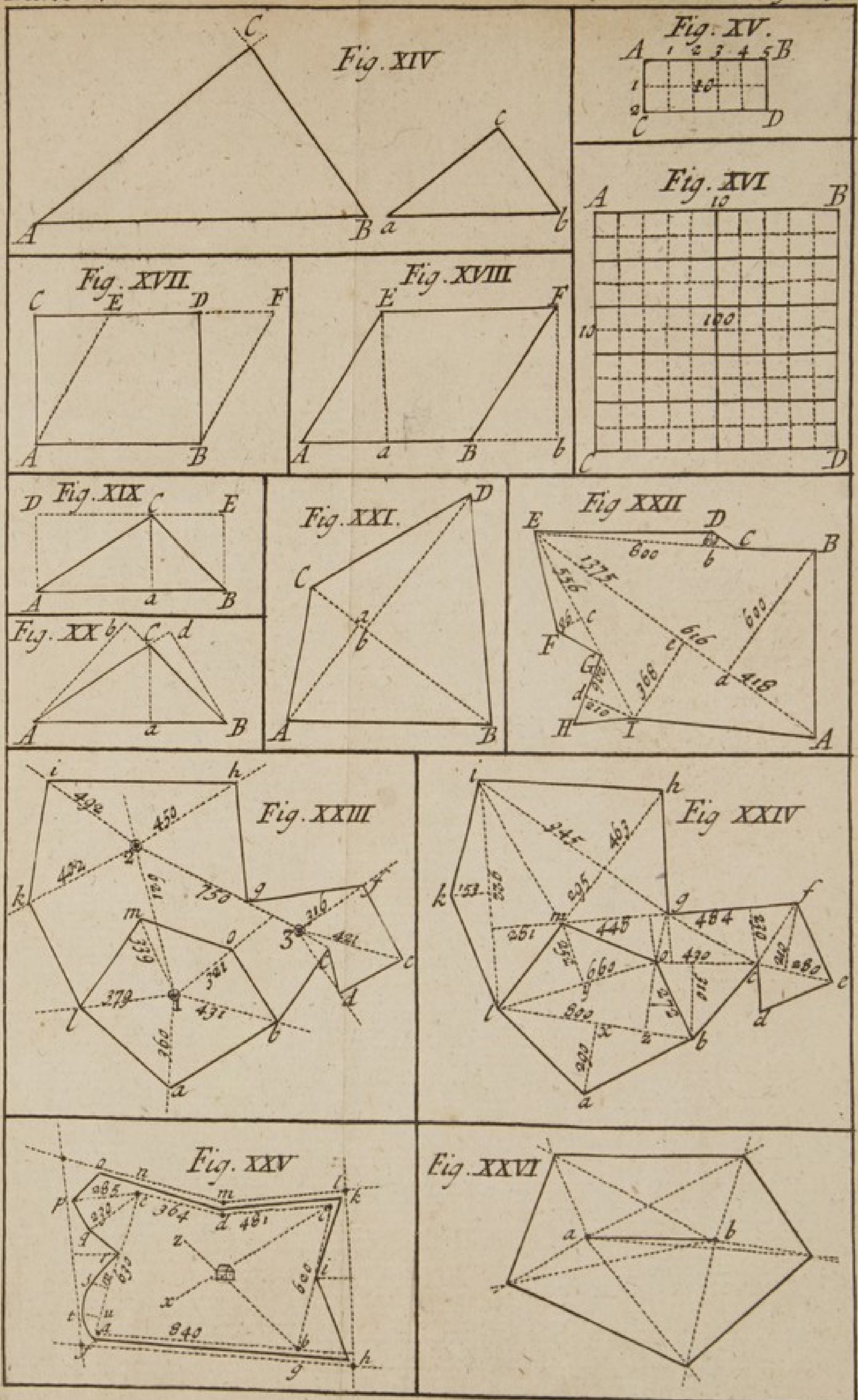


Fig. XIV
Fig. XV.
Fig. XVI
Fig. XVII.
Fig. XVIII.
Fig. XIX
Fig. XX
Fig. XXI.
Fig. XXII
Fig. XXIII
Fig. XXIV
Fig. XXV
Fig. XXVI

E F G, and G H I, which may be compleated after the ſame Manner, or the Triangles EDC and EFG may be made by Help of the Perpendiculars *b* D and *c* F, according to which Method you took in meaſuring them. The Field being thus laid down upon Paper, the Contents of it may be found by Sect. 3. of this Chapter.

CHAP. III.

Of the Theodolite: And the Use thereof in surveying a Field, by taking the Angles which the Fences make with each other.

THE Plain Table is very useful for taking the Ground-Plot of Buildings, and measuring Gardens, or small Enclosures, where the Shortness of Lines, and Multiplicity of Angles would be apt to breed Confusion in protracting; but by no Means fit for surveying large Tracts of Land; because the least Moisture, or Dampness in the Air, makes the Paper not only sink, but run up when dried again, and thereby the Lines drawn thereon are disordered, making the Content less than it should be; and, in the least Rain or Mist, the Instrument becomes altogether useless. Also, when the Plot proves larger than will lie on one Sheet of Paper, there must more be pieced thereto with Glue or Paste, which wetting only some Parts of the Paper, is liable to the aforesaid Inconveniencies; neither can several Sheets of Paper be joined together after the Plot is drawn thereon, so as to meet exactly, and lie so flat as it ought to do. And if to these Inconveniencies be added the Tediousness of compleating the whole Plot in the Field, when a Surveyor has his Assis-

tants

tants about him, we ſhall have Objections enough to induce any Perſon to make uſe of fitter Inſtruments.

SECT I.

The Deſcription of the Theodolite.

THE Uſe of ſurveying Inſtruments, by what Name ſoever they are called, is to meaſure horizontal Angles; and for this Purpoſe the ſimpler they are made the better, as being eaſier managed, and leſs liable to be out of Order: Beſides the *Plain Table* (whole Uſe is properly no more that what may be performed by a Joint-Stool having an Index to turn it upon, though may be not ſo readily) ſeveral Kinds of Inſtruments have been made for ſurveying; as the *Semicircle*, *Perambulator*, and ſome others with hard Names which I cannot at preſent recollect; but all theſe are contained either in the *Theodolite*, or differ from it only in Name. Alſo the Theodolite itſelf, notwithſtanding the Simplicity of that Inſtrument in its own Nature, hath undergone various Alterations, which ſtill were called new Improvements: It would be needleſs to attempt enumerating all theſe; it will be ſufficient here to deſcribe ſuch an Inſtrument as may be moſt ſimple and fit for Practice.

The THEODOLITE is a Circle of Braſs divided into Degrees, which are all numbered one Way (and commonly from the Left to the Right, ſuppoſing yourſelf to ſtand in the Center) to 360°, *vide Fig.* 27. An Angle cannot properly be ſo great as 180 Deg. But the Limb of the Theodolite is numbered to 360, that it may readily expreſs the Arch within the Field that reaches from any two adjacent Sides one to the other; by which Means the Diſtinction of

what is called in these Cases external and internal Angles is avoided. As at the Angle *g Fig.* 28. the Arch, reaching between the two Sides forming that Angle, contains within the Field 233 Degrees. I have seen some of these Instruments of various Sizes, from 4 Inches Diameter to 20 or 24. But about 9 or 10 Inches Diameter I take to be a good Size. This is big enough for the Purpose of Surveying, and is likewise portable. Upon the Center of the Instrument is a moveable *Index*, having on the Middle a *Compass Box*, with a *Needle* of about 4 or 5 Inches in Length, which is covered with Glass to preserve it from being disturbed by the Air. Within this Box is a Brass Ring divided into Degrees, which are always numbered the contrary Way to the Degrees on the Limb of the Instrument. The Index reaches as far as the Divisions on the Limb, having on the End of it a fine Line to cut the said Divisions; also the End of the Index is usually so divided as to point out on the Limb every *Minute* of a Degree, which is near enough for the Purpose of Surveying. Sometimes there is a Line drawn on the opposite End of the Index, which may serve to examine the Instrument by, and whether the Index turns exactly round the Center. Upon the Index are usually fixed two upright Plain Sights, like those described in *Sect.* 2. *Chap.* 2. as belonging to the Index of the Plain Table; also underneath the Instrument are fixed two other Sights, exactly like the former, at the Points of 360 and 180. But these last are needless; also, instead of Plain Sights, I think it much better to have a *Telescope* over the Index, having in it a vertical Hair to cut the Object. The Telescope must have some Motion up and down; and it had best turn upon an Axis fixed at right Angles to it. Also in measuring hilly Lands it would be useful to have an Arch with Degrees, shewing the Elevation or Depression of the Index;

But

But this ought to be done in as ſimple a Manner as poſſible, without embarraſſing the Inſtrument with unneceſſary Work.

The Index ought to move eaſily and without ſhaking; alſo the whole Inſtrument ſhould be firm and ſteady.

The whole Inſtrument is fixed upon a three-legged Staff, after the ſame Manner with the Plain Table: Alſo there is commonly (if not always) annexed to it a Ball and Socket. The Head of the Staff had beſt be of Braſs, becauſe Wood is liable to ſink and ſwell, and by that Means to ſhake. The Inſtrument when it is uſed ought always to be pretty nearly horizontal; otherwiſe the Angles meaſured by it will not be true; but it is difficult to judge when it lies in this Poſition, eſpecially when it ſtands upon uneven Ground. Therefore ſome Kind of Level ought to be annexed to the Inſtrument; a ſhort Plumb-line fixed properly underneath may do very well, for here no great Exactneſs is required; or there may be two ſhort Bubbles fixed in the Compaſs-Box at right Angles to one another; but then there muſt be ſome other Method for adjuſting the Inſtrument, than by opening the Legs. This may be done very well by what the Inſtrument Makers call a *Rack*; but the two Plates, with a Ball and Socket between them, fixed to the Head of the Staff, is a better Way. In the upper Plate are four adjuſting Screws, bearing upon the lower one, by which the Inſtrument may be readily brought to its right Poſition.

The Inſtrument ought to turn eaſily upon the Staff, and without ſhaking, and alſo there ought to be ſome Contrivance to faſten it readily in any Poſition, without twiſting it to one Side. The common Way of a Screw turning againſt the middle Pin is not a good Method, and by the new improved Way (as it is called) of drawing it down upon a Cone, a

ſmall Force will turn it round out of its Place, if great Care be not taken. Inſtead of theſe Methods, it may be eaſily faſtened by two crooked ſmall Bars of Braſs fixed to the Socket, ſo as to graſp the Center Pin in four Places or Points. This Method will not be liable either to turn the Inſtrument to one Side in faſtening of it, or of letting it turn round when the ſaid Braſs Bars are once ſkrewed.

The ſame *Staff* may alſo ſerve for a *Plain Table*, a *Spirit-Level*, &c.

If what hath been here ſaid concerning the Theodolite may influence the Inſtrument-Makers, it may prove of an Advantage to Buyers who are often unacquainted with the Nature of Inſtruments.

The Manner of taking an Angle with the Theodolite.

Let the Circle *Fig.* 27. repreſent the Limb of the Theodolite, and let C A, C B, repreſent two Station Lines in the Field. Having planted the Center of the Thodolite over the angular Point C, being the Index to 360° ; then turn the Inſtrument about till you ſee the vertical Hair in the Teleſcope (or in the Plain Sights, if you uſe theſe) cut a Station Staff placed at A ; this heing done, faſten the Inſtrument, and turn the Index till it cuts the Staff at B; then the Degrees upon the Limb ſhew the ∠ D C E which is oppoſite and equal to the ∠ B C A, to be 70 *deg.* and ſo of any other.

The Degrees are numbered in this Manner for the Conveniency of having the End of the Index, which is next the Obſerver, always point out the Angle. If they were to be read from the Center, the Obſerver muſt have gone always to the oppoſite End of the Index to find his Angle. This laſt Method is the moſt natural and intelligible to a Beginner, but the other is moſt convenient for Practice.

In

In working with the Theodolite we only meaſure the Length of the Lines, and Quantity of the Angles in the Field, which we note in a Field-Book for that Purpoſe; and by theſe Directions we may draw the exact Plan of the Land, which is called Protracting.

Provide a Field-Book ruled with three Columns, in the middle Column inſert the Quantity of the Angles, and Length of the Station Lines; in the outer Columns the Off-ſets from the Station Lines to the Boundaries, and on each Side note the Remarks which you meet with in the Survey.

SECT. II.

Shewing the Uſe of the Theodolite in meaſuring a Field, by taking the Quantity of the Angles which the Fences or Boundaries make with each other.

THE Theodolite, as before mentioned, is uſually numbered on the Limb, from the Left to the Right, and the Box from the Right to the Left; and therefore the Circuit is moſt conveniently made (according to the common Phraſe) *contra ſolem*, i. e. with the Fences on the right Hand.

Let *Fig.* 28. repreſent a Field of which a Plot is deſired: Firſt chuſe ſome convenient Place therein to begin the Work, as at ⊙ *a* near the Corner of the Field; and ſet up a Staff with a Mark thereon, as a Piece of Paper, or a white Rag, ſo that you may plainly ſee it at the next Station; then lay the Chain in a ſtrait Line from *a* towards *b*, having firſt ſet up a Staff at *b*.

The Chain lying in this Direction on the Ground, meaſure with the Off-ſet Staff from ⊙ *a* the Diſtance

to

to the Hedge 56 Links, and enter in the middle Column of the Field-Book 0, and in the right Hand Column 56, denoting an Off-ſet laid off from ⊙ *a*, 56 Links to the right Hand of the Station Line.

Meaſure forwards on the Station Line *a b*, till you come againſt the next Bend in the Hedge, then let the Chain lie on the Ground in a right Line between the Stations *a* and *b*, and with the Off-ſet Staff meaſure the Diſtance from the Chain to that Bend in the Hedge 140 Links.

Take Notice at what Length of the Station Line each Off-ſet is laid off; as here at the Length of 540 Links on the Station Line I lay an Onſet of 140 Links; therefore in the middle Column of the Field-Book enter 540, and againſt it in the Column on the right Hand write 140 denoting that at the Length of 5 Chains 40 Links, in the Station Line, you laid an Off-ſet to the right of 140 Links.

Alſo take Notice that theſe Off-ſets are to be meaſured from the Station Line to the Hedge or Boundary in ſuch Manner that the Line repreſenting the Off-ſet may ſtand at right Angles with the Chain or Station Line.

Here I would adviſe a young Beginner not only to enter theſe Obſervations in the Field-Book, but alſo on a Piece of waſte Paper to draw firſt a Line that ſhall repreſent the preſent Station Line, and then upon that to ſet the Off-ſets as he meaſures them in the Field, drawing the Boundaries as he goes along, not regarding the Length of any Line; a Reſemblance of each Line being ſufficient, becauſe the true Lengths are entered in the Field-Book: For laying this Sketch before him, when he protracts his Work, he will find it an uſeful Inſtruction, in drawing his Angles, and laying the Corners of the Field in their true Poſition, with other little Difficulties to be met with in Practice; but, when he is

ac-

accuſtomed to a right Method of keeping the Field-Book, this Trouble may be ſpared.

Now proceed to meaſure on the Station Line to the next Bend in the Hedge, and there take an Off-ſet at 8 Chains 26 Links; therefore againſt 826 in the middle Column of the Field-Book write, in the next Column on the Right, 36 Links the Length of the Off-ſet.

The Hedge continuing ſtrait to ⊙ 2, meaſure up thereto, and enter the Length in the Field-Book 1120, and meaſure the Diſtance to the Hedge 36 Links, which enter in the Column of Off-ſets againſt 1120, and draw a Line croſs the Field-Book.

Now remove the Staff from *b*, and cauſe it to be ſet up in a convenient Place, as at *c*; then plant the Center of the Theodolite exactly over the Hole, in which the Staff ſtood at *b*, (by the Help of a String and Plummet, which you may faſten under the Middle of the Inſtrument) making the three-legged Staff which ſupports the Inſtrument to ſtand firm on the Ground. Then bring the Index to 360 on the Limb, and turn the whole Inſtrument about till the Hair in the Sights cuts the Staff at *a*, and there ſkrew it faſt that the Motion of the Index may not cauſe it to ſtir from this Poſition; then turn the Index about till the Hair in the Teleſcope cuts the Staff at *c*, ſo ſhall the Index on the Limb ſhew the Quantity of the Angle *a b c*, *viz.* 102 *Deg.* 20 *Min.* which note in the Field-Book.

Now, that you may be ſure you meaſured this Angle right, turn the Teleſcope back to the Staff at *a*, and, if the Hair cuts it, you are right; otherwiſe not.

Having meaſured this Angle, let the Staff be brought from *a*, and place it in the Hole, over which the Center of the Inſtrument ſtood at *b*; but leave ſome Mark at *a*, that you may find it again when you come round the Field to cloſe the Plot:

Lay

Lay the Chain from *b* towards *c*; and at ⊙ meaſure the Off-ſet to the Hedge 20 Links; at 236 in the Station Line, lay the Off-ſet 36; at 428 in the Station Line, the Off-ſet is 92; and at 796 the End of the Line, the Off-ſet is 30 to the Corner; therefore againſt 30 in the Column of Off-ſets write *Corner*, denoting that the Off-ſet laid off at right Angles from the Station Line reached the Corner of the Hedge.

Place the Inſtrument at *c*, and as before directed, meaſure the Angle *b c d* 110 *Deg.* 40 *Min.* which note in the Field-Book for the Quantity of the Angle at *c*.

When you have meaſured the Angles, and made the neceſſary Obſervations at each Station, draw a Line croſs the Field-Book, as you will ſee in the Form thereof; alſo take Notice, that the Minutes are eſtimated by the Help of *Nonus*'s Invention, which cannot be ſo well deſcribed as by the Sight of the Inſtrument; only this may be ſaid, that we can thereby eſtimate the Quantity of an Angle to 1 Minute, which is as exact as they can be laid down on Paper by the Protractor.

Bring the Staff from *b*, and ſet it as upright as you can at *c*; alſo ſend another forwards to *d*; then meaſure on the Line *c d*, and lay the Off-ſet to the Corner at 434, againſt which Off-ſet write *Corner* in the Field-Book; then meaſure up to *d*, entering the Length 468 in the Field-Book.

Plant the Inſtrument at *d*, and bring the Index to 360 on the Limb; then turn it about till the Hair in the Teleſcope cuts the Staff at *c*, and there fix the Inſtrument; then direct the Teleſcope to *e*, and note the Quantity of the Angle at *d*, which the Index cuts on the Limb, *viz.* 230 *Deg.* 50 *Min.* which accordingly note in the Field-Book.

In the ſame Manner proceed with the reſt of the Lines and Angles round the Field, till you come to

Station

Station *a*; but there is no Neceſſity for meaſuring the laſt Angle, or even the laſt Line, but for the Sake of proving the Truth of the Work, which indeed is convenient.

When the Inſtrument was planted at *f*, and you had meaſured the Quantity of that Angle; the Inſtrument remaining in the ſame Poſition, if you had directed the Teleſcope to the Tree in the Middle of the Field, and noted the Degrees, *&c.* which the Index cut on the Limb; and done the ſame at *g*, and noted theſe *Deg. &c.* in the Field-Book, in the Column of Remarks; you might protract the true Situation of the Tree in reſpect of any other Part of the Field.

See the Form of theſe Obſervations as noted in the Field-Book.

The Field-Book.

Remarks	Off-sets	Station Lines	Off-sets	Remarks
		a ⊙ 1		
		0	56	
		540	140	
		826	36	
		1120	36	
		b ⊙ 2		
		° ′		
Angle		102.20		
		0	20	
		236	36	
		428	92	
		796	30	*Corner*
		c ⊙ 3		
		° ′		
Angle		110.40		
		434	30	*Corner*
		468		
		d ⊙ 4		
		° ′		
Angle		230.51		
		420	30	

The

The Field-Book continued.

Remarks	Off-sets	Station Lines	Off-sets	Remarks
		e ⊙ 5 ° ′		
	Angle	79.00		
		0	40	
		134	36	
		296	33	
		588	100	
		820	12	
A Tree bears from ⊙ 6 ° ′ 38. 30	*Angle*	f ⊙ 6 ° ′ 84.30		*Corner*
		40	120	
		200	24	*Corner*
		706	16	
Tree bears from ⊙ 7 ° ′ 57. 30	*Angle*	g ⊙ 7 ° 233		
		380	80	
		648	40	

Scholium.

If the Angle at *a* had been alſo taken, we might examine whether the Angles were all rightly meaſured: thus, Multiply 180° by a Number leſs by two than the Number of the Angles in the Field; then

if

if this Product be equal to the Sum of all the Angles in the Field added together, it may be concluded that they have been measured right, otherwise there must have been a Mistake somewhere. The Number of Angles in this Field is 7, therefore multiply 180° by 5, the Product will be 900°. The six Angles that are measured make together 840° 20′, and, if no Error hath been committed, the ∠ *a* will measure 59° 40′, which added to 840° 20′ will make the whole Sum 900°. But as there may be Mistakes committed in measuring the Station Lines, (which Mistakes do not come within this Rule) the Surveyor had best depend upon the closing of the last Line with the first Station. If this happens exactly, there is a very great Odds on his Side, that the Field had been measured right: But if the last Line does not so close, if the Error be not in the Protracting (which may happen) the Field must be re-measured till the Mistake be found. And it may be a useful Lesson for a Surveyor to protract each Day as he goes along what he had been doing in the Field. This will prevent his running a great Length in a Mistake, which if he lets alone, may cost him a great deal of Labour to find out.

SECT III.

The Manner of Protracting the preceding Observations.

AS the Lines are measured in the Field by the Chain, and the Angles by the Limb of the Theodolite; so the Lines are laid down upon Paper from a Scale of equal Parts, and the Angles by a Protractor.

The *Protractor* should be 7 or 8 Inches in Diameter; and if it be a whole Circle, which is best for Beginners,

Beginners, it ſhould be numbered into 360 *Deg.* the ſame Way with the Limb of the Theodolite; only with this Difference, that the Numbers upon the Protractor ſhould ſtand ſo as to be read from the Center. Sometimes in the middle Bar is a Slit about an Inch long, having one Edge a little ſloping; this Edge is divided into 12 Parts, each of which ſtands for 5 *Min.* The Point denoting 0 *Min.* is in the Diameter paſſing through 0 or 360 *Deg.* and 180 *Deg.* A Line paſſing from the Center through the Point denoting 60 *Min.* upon the ſaid Edge makes an ∠ with the Diameter of 1 *Deg.* ſo that if the Center of the Protractor be put to a Point in a given Line, and the Inſtrument be turned about its Center, until 5′, 10′, 15′, 20′, 30, or 40′, *&c.* cut the ſaid Line, the Diameter of the Protractor will accordingly form therewith the Angles 5′, 10′, 15′, 20, or 30′, *&c.* reſpectively; then the whole Degrees may be pricked off by the Limb. Thus, if I was to make an ∠ of 52° 35′: Having put the Center of the Protractor to the angular Point, I turn the Protractor about till 35 *Min.* cuts the given Line, then I will make a Prick or Point in the Paper exactly againſt 52 *Deg.* a Line drawn through this Point will form, with the given Line, the ∠ required. Theſe Inſtruments, I think, are called by the Makers *Diagonal Protractors*; but I believe they are ſeldom uſed by practical Surveyors, becauſe the Operation by them is ſomewhat tedious.

Inſtead of the common Scales, you may have one divided all the Way at the Edge, like that in the Frontiſpiece. This is uſeful and expeditious, eſpecially for finding the Points in the Station Lines where the Off-ſets come. If your Protractor is a Semi-circle, you may have ſuch a Scale cut on the outward Edge of the diametrical Bar.

Provide a Skin of Parchment, if the Plot is deſired to be on Parchment, according to the Large-

neſs of the Work you are about to lay down ; or if on Paper, let it be large enough to hold all your Work ; the ſtrong Cartridge Paper for this Purpoſe is accounted beſt by ſome Surveyors.

Having conſidered which Way the Plot will extend, draw an obſcure Line on the Paper to repreſent the firſt Station Line, and mark the End thereof with ⊙ *a* (*Fig.* 28.) ſo ſhall that Point repreſent the firſt Station in the Field : Lay the Edge of your Plotting-Scale cloſe to this obſcure Line, the Beginning of the Numbers coinciding with ⊙ *a*, and encreaſing towards the next Station ; then lay the Field-Book open before you, and becauſe the Off-ſets in the firſt Length are taken at the Diſtances 0, 540, 826, 1120 ; therefore againſt theſe Numbers on the Scale, make Marks in the obſcure Line, cloſe to the Edge of the Scale.

This done, turn the Scale perpendicular to the obſcure Line, ſo that the ſeveral Off-ſets may ſtand thereon at right Angles as aforeſaid ; and apply it ſucceſſively to theſe ſeveral Points, and there prick off the Length of the ſeveral Off-ſets on the ſame Side of the obſcure Line as noted in the Field-Book; ſo at ⊙ prick off 56 ; at 540, the next Length, prick off 140 ; at the next Point, which is at the Length 826, prick off 36 ; and at 1120, the End of the Line, prick off 36 ; or theſe Off-ſets may be taken with the Compaſſes from a common Scale.

Now if Lines are drawn from Point to Point, they ſhall repreſent the Boundaries of this Side of the Field ; and becauſe the Hedges, eſpecially in old Incloſures, are generally in the Form of a Curve rather than ſtrait Lines ; therefore if you draw the Boundaries from Point to Point with a Quill Pen with your Hand only, they will be more naturally expreſſed, than if you lay a ſtrait Ruler from Point to Point, (except the Diſtances are very long, or you take a Multitude of Off-ſets ;) and to be exact,

'tis ſometimes neceſſary to expreſs the Nature of theſe little Irregularities in the Fences, by a Sketch on one Side of the Field-Book.

The Length of the firſt Station Line being 1120, mark that Diſtance from ⊙ *a*, with ⊙ *b*; and let the obſcure Line be produced each Way as long as the Radius of the Protractor.

Lay the Center of the Protractor to the Point ⊙ *b*, and turn it about thereon, till the Diameter lies on the Line *a b*, the Beginning of the Numbers on the Protractor being laid towards ⊙ *a*, contrary to the Theodolite in the Field.

Hold the Protractor cloſe down to the Paper in this Poſition, and becauſe the Angle at *b* is 102 *Deg.* 20 *Min.* therefore with a protracting Pin or Needle, make a Mark againſt 102 *Deg.* 20 *Min.* cloſe to the Limb of the Protractor, through which Mark from *b*, draw the obſcure Line *b c*.

So is the Station Line *b c*, laid down in the ſame Direction as in the Field, and the Angle *a b c*, the ſame.

Lay the Plotting-Scale to the obſcure Line *b c*, the Beginning of the Numbers coinciding with the preſent Station, and the Numbers encreaſing towards the next; then cloſe to the Edge thereof, againſt 0, 236, 428, 796, the Lengths where the Off-ſets were taken, make Marks with the protracting Pin; and turn the Scale perpendicular to the obſcure Line, and prick off the ſeveral Off-ſets, 20, 36, 92, 30.

And now if Lines are continued from the Fences before drawn to theſe Off-ſets, they ſhall repreſent the Boundaries on this Side of the Field.

The Off-ſet at the End of the ſecond Station Line, at *c*, reaches into the Corner; but thoſe at *b* muſt be continued till they meet one another, and this might be expreſſed in the Field-Book or Sketch, that you may not miſtake the Corner of the Field.

Lay the Center of the Protractor to *c*, the Diameter being held close to the Line *b c*, and against 110 *Deg.* 40 *Min.* on the Limb of the Protractor, make a Mark, through which draw the Line *c d*.

At the Length 434, in this Line lay the Off-set 30 Links, to which continue the Boundaries before drawn; so is this Side of the Field finished.

Note, The next ∠ at *d* being 230° 50′, subtract this Number from 360, and note the Remainder 229° 10′; then turn the Protractor the contrary Way, *viz.* so that the Arch may be to the outside of the Field; and counting from *c*, make a Point at 229° 10′, through which Point draw the Line *d e*.

Or if the Protractor be numbered to 360, on a Circle concentric to the outward Circle, and the Numbers on both encrease the same Way, (as the Limb of the Theodolite) then, the Protractor being turned reversely as above, the Angle 230 *Deg.* 50 *Min.* may be pricked off from the inner Circle.

But if you use a circular Protractor, it may be laid always one Way, *viz.* the Beginning of the Numbers towards the last Station, contrary to the Theodolite in the Field; and this in my Opinion is the best Way.

But if you use a semicircular Protractor, observe to lay the Diameter on that Line which brought you to the present Station; and to 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.

So at *d* lay the Diameter of the Protractor on the Line *c d*, the Beginning of the Numbers being laid the contrary Way to *c*; and against 230 *Deg.* 50 *Min.* on the inner Circle of the Protractor, make a Mark, through which draw the Line *d e*.

In the same Manner lay down the Angle at *e*, and draw the Line *e f*, continuing the Boundaries as before directed.

When you have marked the Angle at *f*, let the Protractor lie in the ſame Poſition, and make a Mark againſt 38 *Deg.* 30 *Min.* as noted in the Field-Book for the Bearing of the Tree from that Station, and through that Mark draw an obſcure Line from *f*.

Do the ſame at *g*, continuing the obſcure Line from thence till it croſſes that drawn from *f*, ſo ſhall the Interſection of theſe two Lines determine the Situation of the Tree in the Middle of the Field.

In the ſame Manner may any other inacceſſible Diſtance be meaſured by the Theodolite.

When you have marked the Angle at *g*, and drawn the Line *g a*, it will cut through the Point *a*, and the Length of the Line *g a* will be the ſame as that noted in the Field-Book, which proves the Plot to be truly laid down. But if the laſt Line had not paſſed through *a*, or was not of the ſame Length on the Paper as that noted in the Field-Book, ſome Error muſt have been committed in the Field, or in Protracting.

SECT. IV.

How to meaſure Angles by the Chain.

FOR this Purpoſe provide three round Station-Staffs four or five Feet long a-apiece; and alſo take Care that the Ring in the Middle of the Chain, and alſo thoſe at each tenth Link, be at their due Diſtance from the Chain's End

1. In order to meaſure the Angle *d o e*, *Fig.* 29. ſet one of your Station-Staffs as upright as you can at *o*; and putting the Ring at one End of the Chain over it, let one of your Aſſiſtants take the other End

in his Hand, and ſtretch out the Chain towards *d*; whilſt you ſtanding at *o*, direct him to move ſideways till the Station-Staff which he has in his Hand, be brought into one right Line with *o*, *d*, as at *a*, and there let him leave the Staff.

Then let him with the End of the Chain in his Hand, move towards *e*; and, as before, direct him to plant the third Staff upright in the Line *o e*, at *b*.

Meaſure the Diſtance *a b* in Links and tenth Parts, if leſs than one Chain, and enter them in the Field-Book $88\frac{1}{2}$.

When you plot this Angle, take with a Pair of Compaſſes from a large Scale, the Diſtance of one Chain; and having drawn a Right Line *d o*, ſet one Foot of the Compaſſes in *o*, and with the other deſcribe an Arch *a c*; then from the ſame Scale take $88\frac{1}{2}$ Links; and ſetting one Foot of the Compaſſes at *a*, let the other fall in the Arch *a c*, and make a Mark at *b*: Laſtly, through this Mark, from *o* draw the Line *o e*, conſtituting the Angle *d o e*.

Obſerve to plot your Angles by a large Scale, as an Inch, or two Inches, and the Length of the Sides by a ſmaller, as a Quarter or half an Inch: Alſo obſerve, that when the Length of the Chord *a b* is longer than one Chain, then it is beſt to lay out a Sextant, or two Sextants, in the following Manner.

The Manner of meaſuring Angles with the Chain, by laying off Sextants, is deduced from this known Property of the Circle; *viz. The Radius of every Circle is equal to the Chord of one ſixth Part* (or a Sextant) *of its Periphery.*

2. Let it be required to meaſure the Angle *b a c*, *Fig.* 30: Firſt, ſet up a Staff at *a*, and lay the Chain ſtrait in the Direction of *a b* to *i*, and at 50 Links ſet down an Arrow at *o*; then let your Aſſiſtants hold the Ends of the Chain at *o*, and *a*, whilſt

whilſt you with the Middle in your Hand, ſtretching both Halves ſtrait, ſet down an Arrow at *e*, conſtituting the equilateral Triangle *o a e*; ſo have you laid out the Angle *o a e*, a Sextant.

But if you have two Chains, you may (which is better) lay out the Sextants, ſo that each Side of the equilateral Triangle be one Chain.

Now the Chain's End being ſtill held at *a*, ſtretch it through the Point *e to d*, where alſo ſet down an Arrow: Laſtly, meaſure the Diſtance from the Arrow at *d*, to a Staff ſet up one Chain's Length from *a* at *u*; ſo ſhall the Diſtance *d u* be 76 Links, and four Tenths of a Link; therefore enter in the Field-Book 1ˢ. 764ᵖ. implying 1 Sextant and 764 Parts.

In order to plot this Angle *b a c* thus meaſured, chuſe ſome Line divided into 1000 Parts, and making this Line Radius, ſet one Foot of the Compaſſes in *a*, and with the other deſcribe the Arch *i z*; the Compaſſes continuing at the ſame Extent, ſet one Foot in *i*, and with the other croſs the Arch at *d*, and there make a Mark.

Then take 764 Parts from the ſame Line, divided into 1000 Parts, which you make Radius; and ſetting one Foot of the Compaſſes in the Mark at *d*, let the other croſs the Arch at *u*, and there make a Mark: Laſtly, from *a*, draw a Line thro' the Mark at *u*, and you will conſtruct the Angle required.

If you have not a Line (which is beſt) actually divided into 1000 Parts, uſe the largeſt diagonal Scale you have; ſo you may take off 76 Parts exactly; and the four Tenths you muſt gueſs at by moving the Compaſſes near half Way in the Diagonal towards 77; alſo obſerve, the 10th of a Link is meaſured on the Land by the Off-ſet Staff, having a Link or two thereon, divided into ten Parts.

3. If the Angle be more than two Sextants, as in *Fig.* 31; then having, as before, laid off the Sextant *e o a*, let your Assistants hold the Ends of the Chain at *a* and *e*, while you with the Middle in your Hand, set down an Arrow at *x*, constituting another Sextant *e a x*.

Then the Chain being held at *a*, lay it through *x*, and at the other End *d* set down an Arrow: Lastly, measure *d u*, which suppose to be 42 Links and 5 Tenths; therefore enter in the Field-Book 2^{s}, 425^{p}, signifying 2 Sextants and 425 Parts.

If you would protract the Angle of *Fig.* 31; with the Length of the Line divided into 1000 Parts, describe the Arch *i y*, and thereon lay *i n*, *n d*, each equal to the Radius or divided Line; and afterwards lay 425 equal Parts from *d* to *u*, and draw *a u*; which gives the Angle required.

Observe, if you were about to measure the Angle, *Fig.* 31. and had set up one of your three Staffs where the Station-Lines meet in the angular Point *a*, another at *i*, and the other at *u*, in the Lines *a b*, *a c*; before you proceed to measure the Angle *i a u*, you must be sure that the Staffs at *a*, *i*, and *b* are exactly in the same strait Line; and also the Staffs at *a*, *u*, and the Mark at *c*, in another strait Line.

So when the Staff at *a* is planted as nearly perpendicular as you can, move yourself backwards; the farther the better, till you see the Staff at *a*, and that at *i*, in one strait Line with the Mark at *b*; there stand, and direct your Assistant to place his Staff, so that the Staff at *a* exactly cover that at *i*, from the Top to the Bottom.

Note, You must take Care that the Staffs are upright, so as to lie in the same Plane.

4. If an Angle be external, and so contain more than three Sextants, as *b a e*, *Fig.* 32. put the Ring at one End of the Chain over the Staff at *a*, and taking the

the other End in your Hand, ſtretch out the Chain at length towards *d*, and move ſideways, till you perceive yourſelf in a Right-Line with *a b*, and there at the End of the Chain ſet down an Arrow at *d*, ſo that *d*, *a*, *b* are in the ſame right Line; then ſet down the other Staff at *c*, at the End of one Chain alſo; ſo that the Staffs at *a* and *c* be in the ſame Plane with the Mark at *e*. Now meaſure the Angle *d a c*, in the ſame Manner as aforeſaid, and to it add the Sextants, ſo will the Sum be the Meaſure of the external Angle *d a c*.

So if the Angle *d a c*, be 947, then will the external Angle *b a c*, be 3 Sextants, 947 Parts; and if the Angle *d a c*, be 1°. 947, then *b a c* will be 4°. 947, *&c.*

When you protract the external Angle *b a e*, firſt continue the Line *b a*; then from the Angle ſubtract 3 Sextants, and make the Angle *d a e*, equal to the Remainder.

But if you go on the Outſide of a Field or Wood, you may then work as though you were within the Wood, by meaſuring the Angle vertically oppoſite to thoſe that are internal: So in *Fig.* 33. if you meaſure the Angle *o a u*, inſtead of *b a e*, it will do your Buſineſs when you come to protract, as well as if you had meaſured *b a e* on the Inſide; for, if two Right-Lines croſs one another, the contrary or vertical Angles are equal. *Euclid*, 15. 1.

Angles meaſured by the Chain, may be laid down by a Protractor made on Purpoſe, having Sextants and Links divided thereon; and then to be uſed in the ſame Manner as other Protractors.

The Manner of keeping the Field-Book, is in all Reſpects the ſame as that uſed in the 2d *Sect.* of this *Chap.* except that when the Angles are meaſured by the Theodolite, you note the Quantity of each by Degrees and Minutes: In this Caſe, when meaſured by the Chain, you note the Quantity by Sextants and Parts.

So

So if you were to measure the Field, *Fig.* 28. by the Chain; instead of noting 102° 20′, for the Quantity of the Angle *b*, you must note 1 Sextant 734 Parts; and instead of 230° 50′, for the external Angle *d*, you must note 3 Sextants, 886 Parts; but the Station Lines, Off-sets, &c. will still be the same.

There are other Ways of working with the Chain; but these before mentioned are the best and exactest, and contain as much Variety as any one will commonly put in Practice: You may also thereby measure an inaccessible Distance, and do several other Things; but these are only for a Shift, when we have no other Instruments: And the same may be said of measuring Angles.

SECT V.

Of the Circumferentor.

THE *Circumferentor* is only a Compass-Box and Needle, having two plain Sights perpendicular in the meridian Line of the Box; or, instead of the plain Sights, a Telescope may be mounted over the Box, so that it may be elevated or depressed to an Object as there shall be Occasion. This Instrument is supported by a three-legged Staff, like the Theodolite and the Plain Table. If the Index of the Theodolite be taken off, and fitted to a three-legged Staff, it will then be a perfect Circumferentor: So that he who hath the former of these Instruments, hath the other also contained in it.

In surveying Harbours, Sea-coasts, Counties or large Commons, where the Lines are very long; or thick overgrown Woods, where we may be forced to make a Multitude of Angles, and the Sight of the two Lines constructing the Angle, may be hindred

hindred by the Bruſh or Underwood ; in theſe and ſuch Caſes, where no great Exactneſs is required, the Angles may be meaſured by the Needle only ; and this Method, it muſt be owned, is very expeditious, becauſe the Trouble of obſerving the back Stations is ſaved. Yet in ſurveying Lordſhips, Incloſures, or plain Paſture Land, (a ſmall Piece of which got or loſt is of a conſiderable Value, and each particular Field ought to cloſe exactly) the Angles are, without doubt, more ſurely meaſured by the Limb of the Theodolite ; becauſe the Degrees in the Box cannot be ſo nearly eſtimated, and the Needle is liable to be drawn aſide by ſome hidden magnetic Power.

The Poſition or Bearing of a Line obſerved by the Needle is expreſſed by ſuch a Number of Degrees and Minutes as it is diſtant from, or Quantity of the Angle, which that Line makes with the Meridian.

If a Perſon wholly unacquainted with the Uſe of this Inſtrument, will take the Pains to try this following Method, it may be an Help to conceive the Manner of uſing it in the Field.

Upon a Sheet of Paper let there be drawn right Lines parallel one to another at any Diſtance, and upon a Table let there be fixed a Pin with a Point upwards ; let the Pin ſo fixed be run through one of the Lines on the Paper ; upon the Point of the Pin, let there be put a magnetic Needle, and let it traverſe about till it reſts of itſelf ; then turn the Paper about on the Table till the Needle hangs directly over the Line, in which the Pin is placed, which is diſcovered by fixing the Eye over its Center ; then with ſealing Wax faſten the Paper to the Table by the four Corners ; ſo may the Paper be ſuppoſed to repreſent the Surface of the Earth, and the Lines the magnetic Meridian, (which mark at the Top with North, and at the Bottom with South.)

If the Pin be removed into any other of the Lines, and the Needle be made to traverſe thereon, it will, when at reſt, hang directly over the Line in which the Pin is placed, if the ſaid Line be drawn parallel to the firſt Line, over which the Needle hung when the Paper was fixed.

The Needle then points always to, or lies in the Direction of the Meridian, by virtue of the magnetic Power; ſo if I had faſtened to the Table a Sheet of blank Paper, and had laid a Ruler in the ſame Direction with the Needle when at reſt, and had drawn a meridian Line, and then removed the Needle to another Part of the blank Paper, and drawn another ſuch a Line by the Direction of the Needle, that Line would have been parallel to the former.

When we take an Angle in the Field by the Needle, the meridian Line is always one Side of the Angle; and the Hedge, Wall or Fence along which the Teleſcope is directed, is the other Side of the Angle, and they are ſuppoſed to meet at the Center of the Inſtrument.

Set one Foot of a Pair of Compaſſes in ſome one of the Meridians on the Paper, and deſcribe a Circle, then the ſaid meridian Line is its Diameter: Divide this Circle into 360 Degrees, which is eaſily done by the Protractor, and let the Numbers begin at N. or North, and encreaſe to the left, towards E. or Eaſt.

Then this Circle repreſents the Box of the Inſtrument in the Field, and the Line N. S. repreſents the Needle.

From the Center of the Circle, draw a long Line any Way at Pleaſure, and let this Line repreſent an Hedge or Station-Line in the Field; and to find its Bearing or Angle that it makes with the Meridian, look what Degree, *&c.* it cuts on the Circle; and that will be the Quantity of the Angle or Bearing from the Meridian.

So

So the Needle uſed in the Field points out the magnetic Meridian, and the Diviſions in the Box moved under it meaſure the Angle, that any Line in the Field makes with that Meridian.

The Box of the Circumferentor is commonly numbered from the right to the left; the Numbers beginning at N. or North, which is marked alſo with a Flower-de-luce, encreaſing towards E. or Eaſt; and the Direction is to be taken from the North End of the Needle.

The Uſe of the Circumferentor in Surveying Land.

Let it be required to obſerve the Bearing of the ſeveral Station-Lines which incompaſs the Wood, *Fig.* 34.

Firſt plant the Circumferentor at ſome convenient Station, as at *a*; the Flower-de-luce in the Box being from you, direct the Sights to a Mark at the next Station *b*, and note the Diviſion which the North End of the Needle points to in the Box when at reſt, which is 260 *Deg.* 30 *Min.* therefore note this Number 260 *Deg.* 30 *Min.* in the Field-Book, for the Bearing of the Line *a b*.

Obſerving former Directions for removing the Theodolite from one Station to another, and meaſuring the Station-Lines and Off-ſets from thence to the Boundaries as you paſs along the Station-Lines, let the Inſtrument be removed from *a*, and planted at *b*, the next Station; then keeping the Flower-de-luce in the Box from you, turn the Inſtrument about till the Hair in the Sights cuts a Mark at the next Station *c*; then will the North End of the Needle point to 292 *Deg.* 12 *Min.* which note in the Field-Book for the Bearing of the Line *b c*.

The Inſtrument being planted at *c*, and the Sights directed to *d*, the Bearing of that Line *c d* will be 331 *Deg.* 45 *Min.*

In

In the ſame Manner proceed to take the Bearing of other Lines round the Wood, obſerving this general Rule, *viz. Keep the Flower-de-luce in the Box from you, and take the Bearing of each Line from the North End of the Needle.*

The Numbers in the Card of ſome of theſe Circumferentors are made to encreaſe towards the right, but that before-mentioned is beſt; for when you turn your Inſtrument to the Eaſtward, the Needle will hang over the Weſtward Diviſion on the contrary Side.

Inſtead of planting the Circumferentor at every Station in the Field, the Bearings of the ſeveral Lines may be taken if it be planted only at every other Station.

So if the Inſtrument had been planted at *b*, and the Flower-de-luce in the Box kept towards you when you look back to the Station *a*, and from you when you look forwards to the Station *c*, the Bearings of the Lines *a b*, and *b c*, would be the ſame as before obſerved: Alſo the Bearings of the Lines *c d*, and *d e*, might be obſerved at *d*; and *e f*, and *f a*, at *f*; ſo that inſtead of planting the Inſtrument 6 Times, you need in this Caſe plant it but 3 Times, which ſaves ſome Labour.

But ſince you muſt go along every Station-Line, to meaſure it or ſee it meaſured, the Trouble of ſetting down the Inſtrument is not very great, and then alſo you may examine the Bearing of each Line as you go along; and if you ſuſpect an Error in the Work by the Needle's being acted upon by ſome hidden magnetic Power, or from your own Miſtake, in obſerving the Degrees that the Needle points to, you may correct ſuch Error at the next Station before you proceed.

As when the Inſtrument was planted at *a*, and the Sights directed to *b*, the Flower-de-luce from you,

you, the North End of the Needle pointed to 260 *Deg.* 30 *Min.* now being come to *b*, direct the Sight back to a Mark at *a*, keeping the Flower-de-luce towards you : So ſhall the North End of the Needle point to 260 *Deg.* 30 *Min.* as before at *a*, and then you may be ſure the Bearing of the Line *a b* is truly obſerved.

But if the Needle doth not point to the ſame Number of Degrees, *&c.* there hath been ſome Error in that Obſervation, which muſt be corrected before you proceed.

If you have a Suſpicion that the Needle doth not play well, when the Inſtrument is planted at any Station, as at *a*, direct the Sights to the Mark at *b*, and note the Degrees, *&c.* pointed at by the Needle in a Piece of waſte Paper ; then with a clean Knife, Key, or any Bit of poliſhed Steel, move the Needle by applying it to the Box, and examine when it hath ſettled again what Degrees it then points at, the Sights being ſtill directed to the preceding Mark at *b* ; and if the Degrees are the ſame, they may be entered in the Field-Book ; but if not, the Cap and Pin muſt be cleanſed with ſome brown Paper and a little Putty, and thereby freed from ſuch Duſt or Dampneſs that hath gotten to it. If after all the Needle does not play freely, place in the Box another Pin, or uſe another Needle, or do both, and theſe Neceſſaries a Surveyor ought to have in his Pocket while he is in the Field.

If you would meaſure the Quantity of any Angle by the Needle, place the Inſtrument at the angular Point, and take the Bearing of the two Lines conſtructing that Angle, and ſubtracting the leſſer out of the greater, the Remainder is the Quantity of that Angle, if leſs than 180 Degrees ; but if the Remainder is greater than 180 Degrees, ſubtract it out of 360 Degrees, and that laſt Remainder is the Angle.

The

The Manner of entering the Off-ſets in the Field-Book is before ſhewn in the Uſe of the Theodolite; it will be ſufficient, in this Place, to inſert the Bearing of each Line or Quantity of the Angle which each makes with the Meridian, together with their Lengths, in order to protract or lay them down on the Paper Plot of the ſame Length, and in the ſame Direction as in the Field. *Vide Fig.* 34.

As this Inſtrument is ſo very ſubject to Error, the Practitioner ſhould never uſe it, except Neceſſity oblige him to it; for, as an Angle can hardly be taken by it to a Degree, the Errors will be remarkably large, if the Lines are of any Length.

SECT. VI.

The Manner of Protracting the aforeſaid Obſervations made by the Circumferentor.

Links	Bearings	Lines	
a b	260°	30 ——	1242
b c	292	12 ——	1012
c d	331	45 ——	1050
d e	59	00 ——	1428
e f	112	15 ——	645
f a	151	30 ——	1806

Firſt, Draw Lines parallel to one another quite through the deſigned Draft, at Diſtances not exceeding the Breadth of the Diametrical Part of your Protractor, as in *Fig.* 34, and mark them with N. and S. for North and South; then conſidering which Way the Plot will extend, aſſign a Point in ſome one of the parallel Lines, to repreſent the firſt Station in the Field, as at *a*; to which Point lay the Center of the Protractor, and by the Help of the Diviſions continued beyond the Ends of the Diameter of the Protractor

tractor, lay the Diameter upon, or parallel to those North and South Lines; the Beginning of the Numbers on the Protractor towards that Part of the Line marked with N. or Northwards, when the Degrees are fewer than 180, but Southwards when more: The Protractor being thus placed, look in the Field-Book for the Bearing of the first Line *a b*, which is 260 *Deg.* 30 *Min.* therefore with the Beginning of the Numbers on the Protractor towards *f*, close to the Limb against 260 *Deg* 30 *Min.* make a Mark; and through that Mark from an assigned Point at *a*, draw a Line *a b*, on which Line set 12 Chains 42 Links, as noted in the Field Book.

So will the Line *a b*, on the Paper, have a Bearing like to that which you observed the Line *a b* to have in the Field, in respect to the Meridian: But the Protractor, to lay down these Observations, must be numbered contrary to the Box of the Circumferentor; and if it be a Semicircle it must be numbered, first to 180, and then on the inner Circle, whose Numbers must increase the same Way as the outer Circle to 360; the Bearings greater than 180 are pricked off from this inner Circle, and the Beginning of the Numbers must be laid Northward or Southward as the Degrees of Bearing are less or more than 180. If your Protractor be a whole Circle, the Beginning of the Numbers may be kept always one Way, as the Numbers of the Circumferentors were in the Field; but the Diameter must be always laid upon a Parallel to the Meridian Lines, and may be marked with N. S. at the Ends as a Direction to keep it in its true Position.

Having made the Line *a b* of its true Length and Position, the next Thing to be done is to lay the Offsets therefrom, which gives the Boundary of that Side of the Wood, *Fig.* 34.

Lay the Center of the Protractor to the Point *b*, and because the Bearing of the Line *b c* is more than

180; lay the Beginning of the Numbers of the Semi-circular Protractor towards S; and againſt 292 *Deg.* 12 *Min.* make a Mark, through which Mark from *b*, draw the Line *b c*, ſetting the Offſets therefrom, and draw the Boundary of that Side of the Wood.

In the ſame Manner lay down the other Lines *c d*, *d e*, *e f*, and *f a*; ſo will the Line *f a* cut thro' the Point *a*, and be of the ſame Length on the Plot as that meaſured in the Field, if the Obſervations be truly made.

Then if you drew the Station-Lines, and Offſets, with a black-lead Pencil, and the Boundaries with Ink, you may with a Piece of Bread rub off thoſe Lines, ſo ſhall the Boundaries of the Wood only remain, which gives the exact Figure thereof.

SECT. VII.

The Manner of caſting up the ſmall irregular Pieces of Ground, which lie between the Station-Lines and Hedges.

IT very rarely happens that the Sides of a Field are all ſtrait Lines, and therefore any Method for meaſuring them from one or more Stations in the Middle, can ſeldom be put in Practice; the beſt Way being to go round, and meaſure the ſeveral Angles from Stations near the Boundaries, but at ſuch a Diſtance from thence that we may ſee clearly from one Station to another, and have plain Ground to meaſure the Diſtances free from the Incumbrance of Bruſhwood, Trees, *&c.* So ſhall the greateſt Quantity of the Land be included between the regular Station-Lines, which is caſt up as before directed, by dividing the ſame into the largeſt Trapezias and Triangles poſſible; and meaſuring the Baſes

and

Plate 3.

Page 82.

Fig. 27

Fig. 29

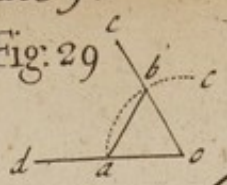


Fig. 30

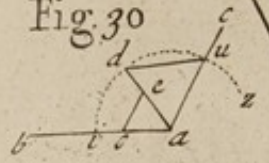


Fig. 31.

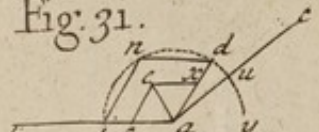


Fig. 32

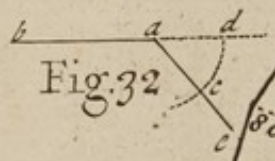


Fig. 28.

Fig. 33.

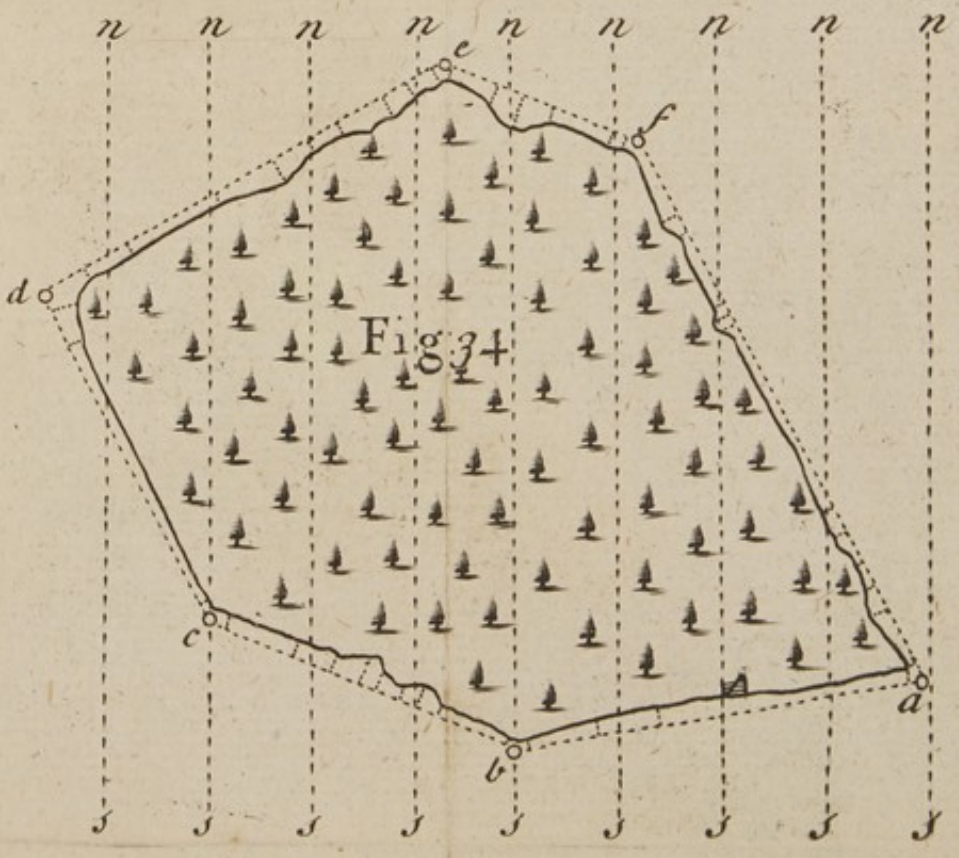


Fig. 34.

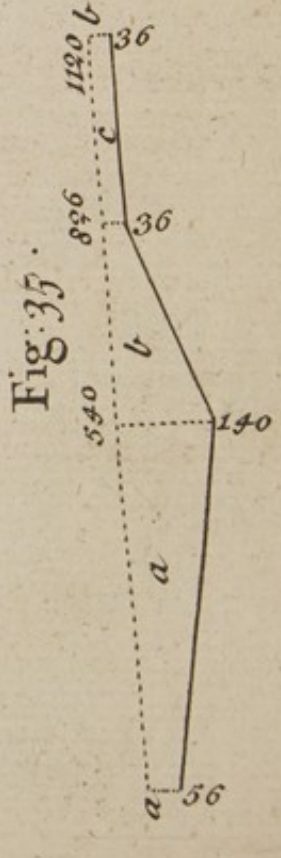


Fig. 35.

and Perpendiculars by the ſame Scale that the Plot was laid down by.

But in order to caſt up the ſmall irregular Pieces comprehended between the Station-Lines and Boundaries; if you reduce them into Triangles, &c. as they will be a great many in Number, ſo you may commit very conſiderable Errors in laying of them down firſt, and taking them off afterwards, eſpecially if the Scale you protract by be very ſmall. For the Removal of this Inconvenience, I ſhall here ſhew a Way whereby you may caſt up theſe ſmall Quantities, however ſmall the Scale may be, as exactly as any of the greater Parts of the Field.

Suppoſe the ſmall irregular Pieces between the Station-Lines and Boundaries, *Fig.* 28. were to be caſt up.

Firſt lay the Field-Book before you, where you will find the Length of the firſt Off-ſet (as meaſured in the Field with your Off-ſet Staff) from ⊙ 1 at *a*, to be 56 Links, and the ſecond at 540 in the Chain-Line, 140, forming the ſmall Trapezium *a*. *Vide Fig.* 35.

Now, if you add the Off-ſet 56 to the next 140, the Sum will be 196, the Half of which is 98, the equated Breadth; multiply the Length 540 by 98, the Product is 52920, the Content of the Trapezium *a*, in ſquare Links.

Add 140 to 36, the Sum is 176, the half Sum 88; ſubtract 540 from 826, the Remainder is 286, the Length of the Trapezium *b*; therefore multiply 286 by 88, the Product is 25168, the Content of the ſmall Trapezium *b*.

Subtract 826 from 1120, the Remainder is 294, the Length of *c*; and becauſe both the Off-ſets are alike, multiply 294 by 36, the Length of the perpendicular Off-ſet, the Product is 10584, the Content of the ſmall Piece *c*.

In the ſame Manner deal with the reſt of theſe ſmall Pieces round the Field, and ſet down the Product of each in an orderly Manner one under another; ſo ſhall the Sum give the exact Content of theſe ſmall Pieces, which, added to that within the Station-Lines, gives the true Content of the Field in ſquare Links, which reduce into Acres, *&c.* as before directed.

Note, The Performance of this being tedious, in the next Chapter will be laid down a more expeditious Method for caſting up the Content of any Piece of Land.

CHAP. IV.

Shewing the Use of the Theodolite in Surveying Land, by the Help of the Needle and Limb together.

SECT. I.

IN this Method of Surveying Land, the Angle which every Line makes with the Meridian is measured by the Limb of the Theodolite, and therefore much preferable to that before-mentioned in the preceding Chapter by the Needle only; because the Degrees and Minutes are better estimated on the Limb of the Instrument than 'tis possible they should be in the Box of the Circumferentor; and this gives the Theodolite the Preference to any other Instrument, because we can work by the Limb only, without regarding the Needle at all: but if it be more convenient to make use of the Needle, we may do it in the following Manner, being the usual Method for surveying large and spacious Tracts of Land.

The Needle being observed to play well, when it hath settled in the Direction of the Meridian and is at rest, the Box may be moved round the fixed Center by turning the Index on the Limb and the Point marked with 360 in the Box, brought directly against the North End of the Needle, with greater Exactness than a Degree, and its Parts can be esti-

mated in any other Part of the Box; beſides, we have this Advantage, which is very conſiderable, that we can make Uſe of a ſhort light Needle, whoſe Friction being leſs, plays better than a longer and heavier.

Let the Lines ⊙ *a*, *b c*, *d e*, *e f*, in *Fig.* 36. repreſent the Station-Lines near the Boundaries of a Field; then the Angle which each makes with the Meridian, may be obſerved in the following Manner.

Firſt, having ſet up a Mark at ⊙, meaſure forwards with the Chain on the Line ⊙ *a* to *a* 600 Links.

Plant the Inſtrument at *a*, and bring the Index to 360 on the Limb, and turn the whole Inſtrument about (whilſt the Needle hangs in the Direction of the Meridian) till 360 in the Box is brought directly againſt the North-End of the Needle, and there fix the Inſtrument; then is the Teleſcope ſet in the Direction of the Meridian alſo, and in this Poſition is the Inſtrument to be planted at every Station.

Now turn about the Index till the Hair in the Teleſcope cuts the Mark left at ⊙, and note in the Field-Book the Degrees and Minutes which the Index cuts on the Limb. *viz.* 207 *Deg.* 20 *Min.* being the Quantity of the Angle which the Line *a* ⊙ makes with the Meridian.

Remove the Inſtrument from *a*, leaving a Mark at that Station, and proceed with the Chain to *b*, and there plant the Inſtrument; then bring the Index to 360 on the Limb, and 360 in the Box exactly to the North End of the Needle as aforeſaid, and direct the Teleſcope to the Mark left at *a*, and note the Degrees and Minutes cut on the Limb by the Index, *viz.* 285 *Deg.* 10 *Min.* which is the Bearing of *b a* or Quantity of the Angle which that Line makes wi thhe Meridian.

It would be needleſs to repeat the Manner of meaſuring the other Lines and Angles in this Figure; but obſerve that when the Inſtrument is fixed in the Direction of the Meridian, we frequently obſerve the Needle by moving it from the Point at 360 with a Knife, *&c.* then if it ſwings backward and forward freely without jogging or ſtopping, and ſettles again to 360 exactly, we may conclude the Inſtrument is right in the Direction of the Meridian to make an Obſervation.

If you ſuſpect the Needle to be acted upon by ſome hidden magnetic Power, as when you are ſurveying in mountainous Lands, where there may poſſibly be Iron Mines in the Earth, which will attract the Needle, you may obſerve whether or no it be drawn aſide in the following Manner.

As when the Inſtrument was planted at *e*, the *North* End of the Needle pointing to 360 in the Box; after the Bearing of *e d* was noted, direct the Teleſcope forwards to *f*, and note the Angle which the Index cuts on the Limb, *viz.* 200° 50′: Then the Inſtrument being planted at *f*, becauſe the Bearing of *e f*, obſerved at *e*, is more than 180°; ſubtract 180 therefrom, and to the Remainder 20° 50′ ſet the Index on the Limb: But, if the Bearing of *e f* had been leſs than 180, add 180 thereto, and to that Number bring the Index on the Limb. Now turn about the whole Inſtrument till the Hair cuts the Staff left at *e*, and then, if the North End of the Needle points to 360, as at the laſt Station, the Bearing of that Line is truly obſerved.

For, the magnetic Power that attracts the Needle being ſuppoſed at a great Diſtance, the Direction on ſuch a Piece of Land as is commonly ſurveyed by the Theodolite, will be the ſame: But if the attractive Power be near the Inſtrument, the Needle will incline thereto.

The Bearings, *&c.* of the ſeveral Station-Lines in this Field are, *viz.*

Lines	*Links*	*Sta.*	*Deg.*	*Min.*
a ⊙	600 ——	*a*,	207	20
b a	500 ——	*b*,	285	10
c b	1000 ——	*c*,	190	00
d c	500 ——	*d*,	91	55
e d	500 ——	*e*,	125	20
f e	1600 ——	*f*,	20	50
⊙ *f*	500 ——	*o*,	289	15

SECT II.

An eaſy Method of protracting any Obſervations made in the Field by the Needle.

BY the Method here laid down, a Plan of any Field may be drawn on the Paper from one Meridian only, and all the Angles therein laid down by once applying the Protractor to that Meridian, and the Help of a parallel Ruler, being very exact and expeditious.

Provide a circular Protractor, whoſe Numbers increaſe the ſame Way as on the Limb of the Theodolite, and a parallel Ruler of a convenient Length: Then draw a Right-Line N. S. *Fig.* 36. (with a black-lead Pencil) for a Meridian, and aſſign a Point therein, as at ⊙, to which Point apply the Center of the Protractor, and turn it about till the Diameter lies on the Line N. S. with 180 towards N. (that Part of the Limb of the Theodolite being now kept Northward in the Field.

The Protractor being held in this Poſition, lay the Field-Book before you, and againſt 207 *Deg.* 20 *Min.* the Bearing of the firſt Line *a* ⊙, cloſe to the

the Limb of the Protractor, make a Mark with the protracting Pin or Needle, and close to that Mark write *a* with a black-lead Pencil.

Hold the Protractor in the same Position, and against 285 *Deg.* 10 *Min.* the Bearing of the next Line *b a*, make a Mark with the protracting Pin, and close to that Mark set *b*.

In the same Manner, keeping the Diameter of the Protractor close to the Meridian as it was at first laid; make a Prick with the protracting Pin, close to the Limb of the Protractor, against the Bearing of each respective Line as noted in the Field-Book, and close to each Prick set the Letter or Number of that Line; so against 190 *Deg.* the Bearing at *c*, make a Prick and write *c*; against 91 *Deg.* 55 *Min.* write *d*; against 125 *Deg.* 20 *Min.* write *e*, *&c.* *Vide Fig.* 36.

Having marked the Bearing of each Line round the Protractor, lay it aside, and apply the Edge of your plotting Scale to ⊙ at the Center, and *a* marked by the Limb of the Protractor; the Beginning of the Numbers coinciding with ⊙, and increasing towards *a*; and prick off 6 Chains the Length of the Line ⊙ *a*, and with Ink draw the Line ⊙ *a a*.

Lay the parallel Ruler to the pricked Line *p* ⊙ *b r*, so that the Edge cuts the central Point at ⊙ and the Point at *b*, as marked by the Limb of the Protractor; and move it parallel till the Edge cuts the Point at *a* in the Line *p a b r*, and with the Point of your Compasses draw the occult Line *p a b r* by the Edge of the parallel Ruler; then because the Length of the Line *a b* is 5 Chains, lay the plotting Scale to *a*, and prick off 5 Chains, and draw the Line *a b*.

When you had drawn the occult Line *p a b r*, through the Point *a*, you might set *a b* thereon towards *p* as well as towards *r*; but if you observe in what Direction the Letter *b*, as marked by the

Limb

Limb of the Protractor, ſtands from the central Point ⊙, in the ſame Direction muſt the Line *a b* be ſet from the Station Point *a*; alſo when the Ruler is laid to the Station *b*, you cannot be at a Loſs whether you ſhould draw the Line *b c* upwards or downwards, if you obſerve in what Direction the Letter *c* ſtands from the central Point ⊙; therefore in the ſame Direction draw *b c* from *b*.

Lay the parallel Ruler to the central Point ⊙ and the Mark at *c*, and move it parallel in that Direction, till the Edge cuts the Point *b* at the End of the Line *a b*; and by the Edge of the parallel Ruler draw an occult Line, ſetting thereon from *b* 10 Chains, and draw the Line *b c*.

Again lay the Edge of the parallel Ruler to the Point at the Center ⊙ and to the Mark at *d*, and move it up to *c*, and draw *c d*.

In the ſame Manner deal with the other Lines and Angles, ſo ſhall the laſt Line *f* ⊙ cut through the Point ⊙, and its Length be 5 Chains, as noted in the Field-Book, which proves the Plot to be truly laid down.

In theſe Obſervations the Station-Lines only are inſerted; the Off-ſets from thence to the Boundaries are omitted, becauſe the Manner of plotting them hath been laid down before.

When the Boundaries of the Field are drawn, and the Name thereof entered in the Middle of the Plot, you may with a Piece of Bread rub off the Marks that were made with the Pencil round the Edge of the Protractor and meridian Line, ſo will the Plot be ready for caſting up.

But, if ſeveral Fields are to be plotted together, you muſt draw a Line through the firſt Station Point in each, parallel to the Meridian in the firſt Plot, from which the Plot of each Field may be laid down in the ſame Manner as *Fig.* 36.

Obſerve,

Obſerve, neither the Circle nor Figures, expreſſing the Angle which each Line makes with the Meridian, are uſed in Practice, though inſerted in the Scheme to demonſtrate the Nature of the Work. Note alſo, if you lay the Edge of the thin plotting Scale cloſe to the Edge of the parallel Ruler, and move it forwards on the Paper with the parallel Ruler, till the Edge of the Scale cuts the Point at *a*, and bring the Beginning of the Numbers on the Scale to the Point *a*, you may draw the Line *a b* by the Edge of the Scale held in that Poſition to 500 the Length of the Line, without drawing any other but the Station-Line itſelf. Or, the ſaid Scale may be drawn on the Edge of the parallel Ruler itſelf.

SECT. III.

An expeditious Method of calculating or caſting up the Area of a Plot of Land in Acres, &c.

ACcording to the Rules before-mentioned in *Chap.* 2. the whole Plot muſt be reduced into Trapezias and Triangles, and the Length of each Baſe and Perpendicular meaſured by the Scale; but ſince it is often neceſſary to lay down the Plot by a ſmall one, as $\frac{1}{4}$ of an Inch or leſs; if you err 8 or 10 Links in taking off the Length of the Baſes and Perpendiculars (which may eaſily happen, if the Lines be not drawn very neat and ſmall) and there being ſeveral ſuch Baſes and Perpendiculars, the Error may be conſiderable in the whole Plot: and then alſo the Baſe and Perpendicular of each of theſe Triangles muſt be multiplied together ſeverally, and their Products added together for the whole Content.

Whereas

Whereas by this Method the whole Plot (let it conſiſt of many Sides or few) is caſt up by applying the Scale but to one Baſe and one Perpendicular, and conſequently by one Multiplication, and the Truth of the Work is demonſtrated by the Lemma, Page 15. *viz. That Parallelograms (and conſequently Triangles) conſtituted upon the ſame Baſe, and between the ſame Parallels, are equal.*

Let the four-ſided Figure *a b c d*, *Fig.* 37. be reduced to a Triangle, whoſe Area ſhall be equal to that of the four-ſided Figure.

Firſt extend one of the Sides as *c d*, then lay the parallel Ruler to the Points *a* and *d*, and move it parallel till the Edge cuts the Point *b*, then by the ſame Edge make a Mark in the extended Line *c d* at *e*: Laſtly, lay a ſtrait Ruler to the Points *e* and *a*, and draw the Line *e a*, ſo ſhall the Area of the Triangle *a c e* be equal to the Area of the four-ſided Figure *a b c d*.

For the Triangles *a d e*, and *a d b*, having the ſame Baſe *a d*, and lying between the ſame Parallels, are equal; and therefore the Triangles *a b o d o e* are equal: Wherefore if the Triangle *b o a* is left out of the four-ſided Figure *a b c d*, and the Triangle *d o e* taken in, and the Areas of theſe two Triangles being equal, it follows, that ſuch an equal Quantity of Space is left out in one Part of the Figure as is taken in on the other, and the Area muſt ſtill be the ſame.

Again, let *Fig.* 38. be reduced into a Triangle.

Firſt extend the Line *f o*, and apply the parallel Ruler to the Points *o* and *b*, and move it parallel up to the Point *a*, and, where the Edge cuts the extended Line *f o*, make a Mark at *g*; then lay the Ruler to the Point *g* and *c*, and move it up to *b*, and make a Mark in the extended Line or Baſe at *b*.

Lay

Lay the Ruler to the Points *b* and *d*, and move it to *c*, then make a Prick in the Baſe at *i*.

Lay the Ruler to the Points *i* and *e*, and move it to *d*, and make a Mark in the Baſe at *k*.

Laſtly, draw the Line *k e*, ſo ſhall this ſeven-ſided Figure be reduced to a three ſided one whoſe Areas are equal; ſo may the Triangle *f e k* be caſt up by one Multiplication only.

But note, inſtead of laying the Ruler to the Points *i* and *e*, if you had laid it to *d f*, and moved it up to *e*, and drawn the Line *z d*; the Triangle *z d i* would have contained the ſame Area as *f e k*; and this often is neceſſary to prevent the Sides of the reduced Triangle being extended too long, and making the Angles thereof too acute.

Apply the ſame Scale by which the Plot was laid down to the Baſe, and meaſure its Length, alſo meaſure the Length of the Perpendicular; multiply theſe two Numbers together, the Half of their Product will be the Content of the Plot in ſquare Links, which reduce into Acres, *&c.* as before directed.

Alſo obſerve that we commonly chuſe to extend one of the ſhorteſt Sides of the Plot for the Baſe of the Triangle, as the Side *f o*, which we draw with a black-lead Pencil, as *o k*, as well as *k e*, *i d*, or *z d*, and rub them off again with a Piece of Bread, as ſoon as the Content of the Field is entered with its Name in the Middle thereof.

If in uſing the parallel Ruler at the firſt Trials you find it apt to ſlip on the Paper, which you may do if you be not very careful to hold it cloſe down to the Surface, that Inconvenience may be prevented, if you make Uſe of three ſmall Pins or Needle, thus: Stick the three Pins in the three firſt Angles, as at *o*, *a* and *b*, then apply one of the inner Edges of the parallel Ruler to the firſt and third *o* and *b*, and move the other inner Edges to the ſecond at *a*; take

out

out the Pin at the ſecond, and put it in the Baſe or Line extended where the Ruler cuts it at *g*; again, lay the Ruler to this Pin at *g*, and to another at the fourth Angle at *c*, and move the Ruler to the fifth Angle at *d*; take out the Pin at *d*, and ſtick it in the Baſe at *h*, and proceed in this Manner with the reſt till the Plot is reduced.

SECT. IV.

Shewing how to reduce the irregular Boundaries of a Field to ſtrait Lines, in order to find the Area thereof.

LET *a b c d e f g h i k*, *Fig.* 39. repreſent the Boundaries of a Field, whoſe Content is deſired.

Firſt, produce ſome one of the longeſt Sides, as *ik*, then lay the parallel Ruler from the Angle *i* to *g*, the next but one, and move it up to the Point *h*, and where it cuts the Line produced, make a Mark at *r*, and draw the ſtrait Line *r g*, and it will reduce that Side of the Figure, bounded by the two Lines *i h* and *h g*, to another bounded by *r g* one Line only.

In like Manner *r g* being produced, and the parallel Ruler laid from *g* to *e*, and moved up to the Angle *f*, the Edge cuts the extended Line *r g* at *y*; 2dly, lay the Ruler from *y* to *d*, and move it up to *e*, and it will cut the extended Line *r g* at *z*; 3dly, lay the Ruler from *z* to *c*, and move it up to *d*, and where it cuts the extended Line *r g*, make a Mark at *x*; laſtly, draw the ſtrait Line *y c*, ſo ſhall the Side *g c* which conſiſted of the four Lines *g f*, *f e*, *e d*, and *d c*, be reduced to the Side *y c*, conſiſting of one Line only; and in like Manner might we proceed, if the Lines were never ſo many: So may the ten-ſided Figure be reduced to a four-

ſided

ſided one, and then to a Triangle which may be caſt up by one Multiplication only.

This is the ſame Metnod with that before laid down for reducing a many-ſided Figure to a Triangle ; but if you have not a parallel Ruler do thus :

Having produced the Side *k i*, lay the Edge of a ſtrait Ruler from *i* to *g*, then take with a Pair of Compaſſes the Diſtance from *h* 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 traces out a Line parallel to it, and croſſes *k i* at *r*, and draw *r g* as before.

In the ſame Manner deal with the other Sides, uſing the Compaſſes, as here directed, inſtead of a parallel Ruler.

Or you may get a Plate of thin Braſs in Form of an Arch, near whoſe Ends let there be drilled ſmall Holes, thro' which ſtring it with a very fine Hair ; and then if an Hedge, as *g c*, *Fig.* 39. bends in and out in ſeveral Places, and thoſe Bends contain very ſmall Spaces, lay the Hair over it lengthways, ſo that the Quantities cut off from the Figure thereby may be equal to thoſe added to it, and with a 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 it may be obſerved, that in very ſmall Bends, you may judge by the Eye as near as you can come with the parallel Ruler.

But, if Hedges conſiſt of large Curvatures, chuſe out ſuch Points, and ſo many of them that Right-Lines drawn from Point to Point may vary the Area by ſuch Quantities only as may be rejected, and herein the Hair will be a ready Aſſiſtance.

SECT.

SECT. V.

The Manner of reducing hypothenuſal to horizontal Lines.

WHEN we meet with an Hill in Surveying a Piece of Land, we can only meaſure the hypothenuſal or ſlope Lines thereof, on the Superficies of the Hill, which are conſiderably longer than the baſe or level Lines on which the Hill is ſituated; as the Lines *a b*, *b c*, *Fig.* 40. are longer than *a o*, *o c*: Therefore when we plot this Hill (becauſe we cannot make a convex Superficies upon a Piece of plain Paper) we muſt reduce the hypothenuſal to horizontal Lines, that all the Lines in the Plot may be laid down alike *in plano*.

For the Lines of Level only muſt be expreſſed in a Plot, that every Field therein may lie in its true Situation; for if *a b*, and *b c*, were laid down on Paper as meaſured in the Field, they would reach to *d*, and not only thruſt the next Hedge out of its true Poſition, but alſo take up a great Space in the next Field, making that too little.

Note, Before hypothenuſal Lines can be reduced into horizontal, the Angle of Elevation or Depreſſion muſt be taken; and for this Purpoſe an Arch ſhould be fixed on the Index of the Inſtrument, ſo as to give the vertical Angles at the ſame Time the Index itſelf ſhews the horizontal ones on the Limb.

Let *Fig.* 40. repreſent an Hill; at the Foot of which the Theodolite is planted, which being ſet level in order to meaſure the Angle at *a*, elevate the Teleſcope to the Mark at *b* (which muſt be ſet the ſame Diſtance from the Ground as the Teleſcope is (and, when the Hair cuts the Mark at *b*, the Index ſhews the horizontal Angle on the Limb, and the vertical

vertical Arch the Angle of Elevation *b a o*, 25 *Deg.* 50 *Min.* both at the ſame Time; which note in the Field-Book one over-againſt the other.

The Inſtrument being removed from *a*, and planted level on the Top of the Hill at *b*, depreſs the Teleſcope to the Mark at *c*, and the ∠ of Depreſſion will be 21 *Deg.* 34 *Min.* The Length of *a b*, as meaſured up the Hill, by the Chain is 1200 Links, and *b c* 1416.

In order therefore to plot theſe Obſervations, firſt, draw the right Line *a d*, but do not ſet the Length 1200 Links thereon, becauſe the Angle of Elevation is noted in the Field-Book againſt the horizontal Angles, which ſhew that this Line is to be reduced to a Level; therefore lay the Center of the Protractor to *a*, the Diameter coincident with *a d*, and againſt 25 *Deg.* 50 *Min.* the Angle of Elevation, make a Mark, and through it draw the obſcure Line *a b*, ſetting thereon 1200 Links the Length of the Hypothenuſe, at the End of which make a Mark at *b*.

Having drawn the Angle of Elevation *b a o*, take a ſquare Protractor or any other Square that hath one right Angle and two ſtrait Edges, and apply one Edge thereof to the right Line *a d*, whilſt the other Edge cuts the Point *b* in the obſcure Line *a b*, and thereby let fall a Perpendicular from the Point *b*, which falls on the Line *a d* at *o*; ſo ſhall the Line *a o* be the true horizontal Line which muſt be laid down in the Plot.

In the ſame Manner reduce the Hypothenuſe *b c*, by firſt drawing the Angle of Depreſſion *d o e*, 21° 34′, ſetting the Length of the Hypothenuſe *b c* 14 Chains 16 Links on the obſcure Line *o e*, and where that Length 1416 Links reaches from *o*, make a Mark at *e*. Laſtly, from *e* let fall a Perpendicular on the Line *o d*, which falls at *c*; ſo ſhall the Line *o c* be the true horizontal Line.

Or elſe having noted the Quantity of the Angles of Elevation, and Length of the Hypothenuſe in the Field-Book, you may find the horizontal Line by the Help of the following Table.

A Table ſhewing how many Links to deduct from every Chain's Length in the Hypothenuſal-Line.

Deg.	Min.	Links	Deg.	Min.	Links	Deg.	Min	Links
4	3	¼	19	57	6	29	32	13
5	44	½	21	34	7	30	41	14
7	1	¾	23	4	8	31	47	15
8	6	1	24	39	9	32	52	16
11	29	2				33	54	17
			25	50	10			
14	4	3				34	55	18
16	16	4	27	8	11	35	54	19
18	12	5	28	21	12	36	52	20

Having the Angle of Elevation 25 *Deg.* 50 *Min.* and the Length of the Hypothenuſe *a b* 12 Chains given, thence to find the Length of the horizontal Line.

Look in the Table for 25 *Deg.* 50 *Min.* and againſt it you will find 10 Links, and ſo many muſt be deducted out of every Chain in the Length of the Hypothenuſe; then if 1 Chain or 100 Links require 10 Links to be deducted from thence, 12 Chains or 1200 Links require 120 Links to be deducted; therefore ſubtract 120 Links from 1200, the Remainder is 1080, the Length of the horizontal Line *a o*.

Again, the Angle of Depreſſion at *b* is 21 *Deg.* 34 *Min.* and the Length of the Hypothenuſe or ſlope Line *b c* 1416 Links, you will find in the Table againſt 21 *Deg.* 34 *Min.* 7 Links; then if 100 : 7 : : 1416 : 99; therefore ſubtract 99 Links out of

1416

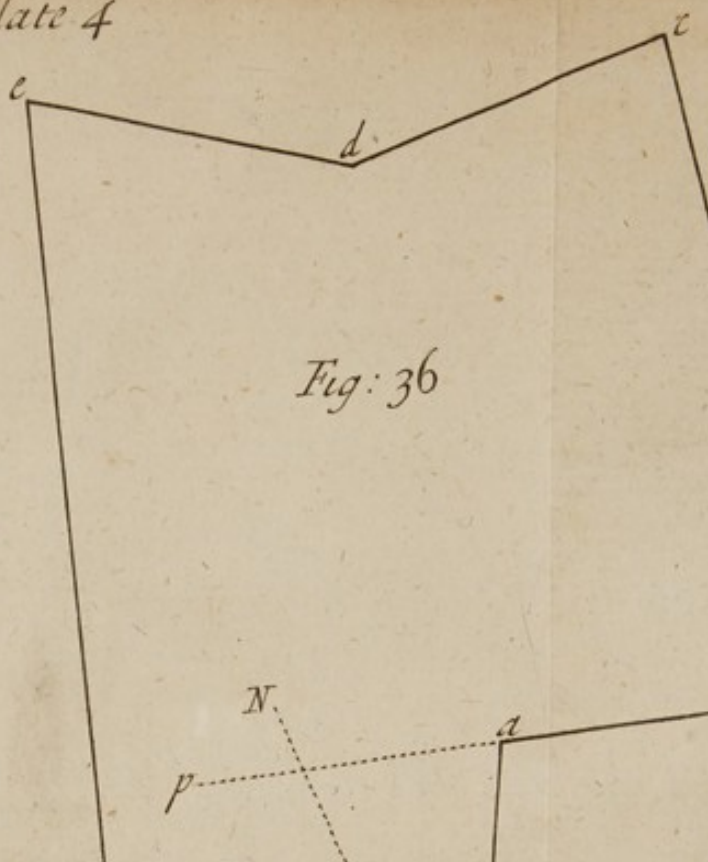


Fig: 36

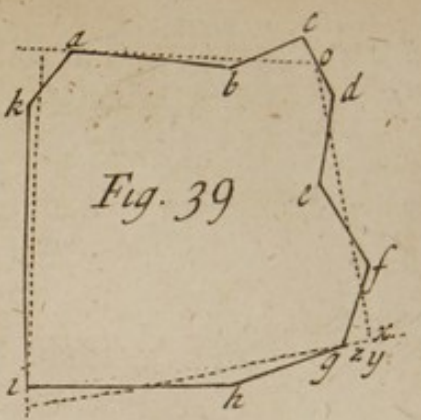


Fig. 39

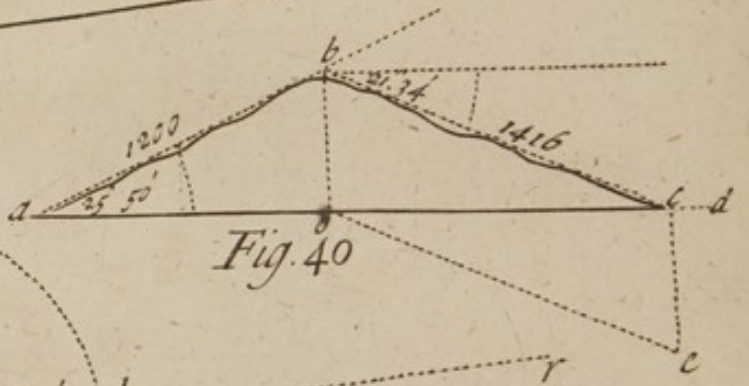
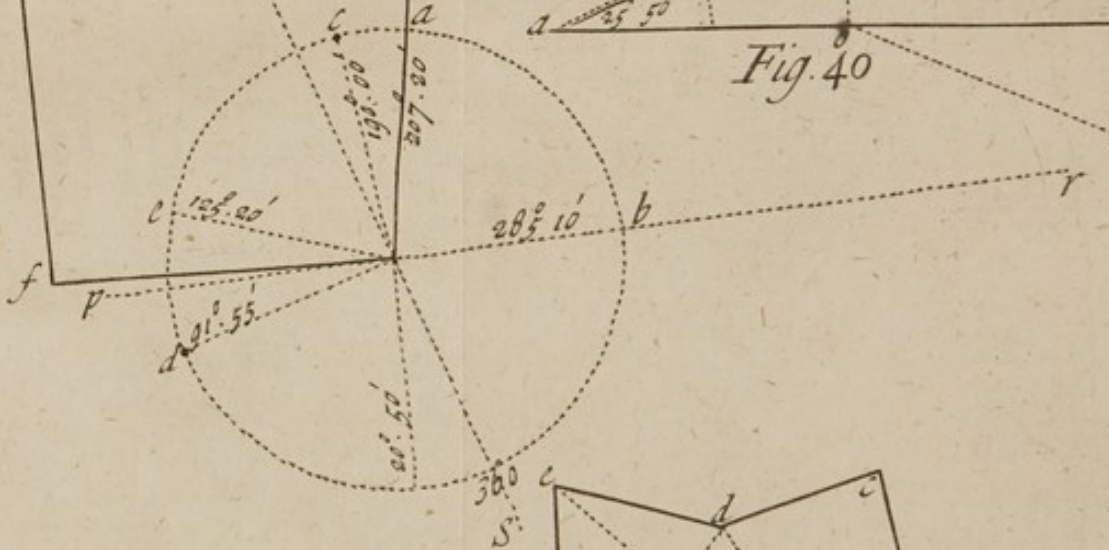


Fig. 40



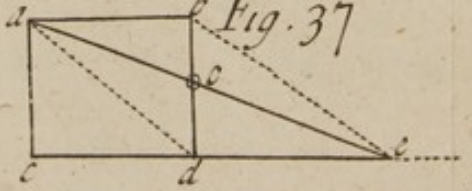


Fig. 37

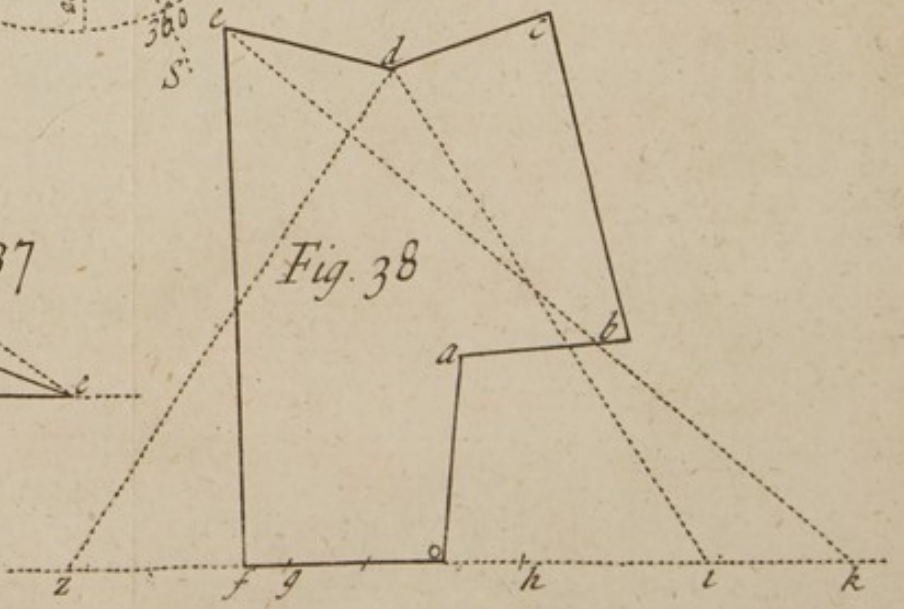


Fig. 38

1416 the Length of the ſlope Line, the Remainder is 1317 Links, the Length of the level Line *&c.* But if you cannot find the given Angle of Elevation in the Table, make uſe of that which approaches neareſt thereto; and *note*, Surveyors in Practice ſeldom take notice of a gradual Aſcent, if it does not make an Angle of 5 or 6 Degrees or thereabouts; the Difference between the ſlope and level Line being then inconſiderable, except in ſome extraordinary Caſe, and then 'tis ſafeſt to make uſe of the firſt Method here laid down, becauſe the Table is too ſhort: but if you have a correct Table of Sines and Logarithms, you may make uſe thereof.

If you are working with the Chain, and would find the horizontal Line of an Hill, you may carry a ſmall Quadrant in your Pocket, with which meaſure the Angle of Altitude, and note it in the Field-Book againſt the horizontal Angle obſerved at that Station (but let the Mark be ſet the ſame Diſtance from the Ground with your Eye when you obſerve the Angle of Altitude) and proceed to reduce the Line as aforeſaid.

Alſo you may obſerve an Angle of Altitude if you have only the Plain Table in the Field, by turning it down into the Notch of the Ball and Socket, making it ſtand perpendicular by applying the String and Plummet thereto, and then the Index and Sights ſcrewed to the Center of the Table may indifferently ſerve the Turn; but a Quadrant is better.

Remember to ſhade over that Part of your Plot where the Lines are thus reduced with the Repreſentation of Hills, leſt another Perſon ſhould meaſure them by the ſame Scale with the other Lines, and find them to differ.

If a Field hath the Bottom and Top Lines level, and both Sides riſing alike, it is to be accounted but

as a declining Level, and to be meaſured as a level Ground in regard of the Quantity of Superficies, through the Side Lines muſt be reduced, to make a regular Plot in reſpect of the adjacent Fields that are level: But if a Piece of Ground be level at one End, and both Sides, and an Hill riſing up along the Middle, or if there be ſeveral Hills in the Middle, the Superficies thereof will be more than in a Plain bounded by the ſame Limits.

Now Surveyors differ in their Opinion in reſpect of caſting up the Content of ſuch a Field; ſome argue on the Tenant's Behalf, that ſince all Vegetables ſtand in a perpendicular Direction on the Earth (that is, grow ſtrait upwards) as much will grow on the horizontal Line as on the Hypothenuſe, and therefore the Lines ought to be all reduced to a Level, and the Content to be deduced from the Plot ſo laid down.

Others ſay, that there ought to be Marks placed on the Top of the moſt remarkable Hills, and the Chain drawn over Hill and Dale, and the ſlope Lines laid on the Paper of the ſame Length as meaſured in the Field, and the true Content in Acres, *&c.* deduced from thence; although the Slopes be reduced afterwards, that the Field may be laid in its true Situation in reſpect of others adjacent in the fair Plot.

'Tis hard to determine which Way is to be practiſed in all Caſes; for, though by the laſt Method you will have the true Quantity of Superficies more nearly given, yet the Allowance in the firſt is often but reaſonable, if the Soil of the Hills is not ſo profitable as if the whole Field was ſituated on a Plain; but the Reader may uſe which he ſhall think moſt proper.

CHAP.

CHAP. V.

Shewing how to ſurvey and make a perfect Draught of ſeveral Pieces of Land lying together as a Manor, &c. *Alſo how to compare the Bearings and Angles one with another, at each Station, as obſerved by the Theodolite, in order to correct any Error that may ariſe in meaſuring the Angles in the Field, as well as protracting them on Paper.*

SECT. I.

HAVING in the former Chapters laid down the beſt and moſt practical Methods for meaſuring any Piece of Land by the moſt proper Inſtruments, I ſhall here ſubjoin the Manner of ſurveying ſeveral Parcels lying together; an Example of which may be taken from the ſmall Tenement or Farm, *Fig.* 41.

Firſt, I take a View of the Land, conſidering at which Part thereof it will be moſt convenient to begin, and proceed with the Work; and becauſe 'tis beſt working in a *Lane*, as often as an Opportunity

preſents ; therefore I ſet up the Theodolite at ⊙ 1 in *Charlton* Field.

Then I enter in the Field-Book the Title of the Survey, and in the middle Column ⊙ 1, and then ſend a Station-Staff forwards in the *Lane*, as far as I can ſee diſtinctly (the farther the better) as to ⊙ 2 (and when the Station-Lines are within the Field, I ſend the Staff to the next eminent Bend in the Hedge, or even to the farther End thereof, if the Line from the Inſtrument to the Staff be not at too great a Diſtance from the Hedge, ſo as to cauſe Off-ſets greater than a Chain, or a Chain and half, or thereabouts ; for Off-ſets taken too long are not ſo eaſily laid off at right Angles from the Station-Line :) I direct the Teleſcope to the Staff at ⊙ 2, and note the Degrees in the Box cut by the North End of the Needle, *viz.* 356 *Deg.* 10 *Min.* which I enter in the Field-Book, for the Bearing of this firſt Station-Line.

Then I ſet up a Staff in the Hole over which the Center of the Inſtrument was placed, to which Staff I direct one of my Aſſiſtants to apply the Ring at one End of the Chain, whilſt the other Aſſiſtant ſtretches it out in a right Line towards ⊙ 2 ; letting it lie on the Ground in that Direction, till the Occurrences in this Chain's Length are entered in the Field-Book, *viz.* I meaſure the Diſtances of the Chain from the Boundaries of each Field, which I enter in the Columns of Off-ſets ; that on the right Hand of the Chain in the right Hand Column, and that on the Left in the left Hand Column. If the Land is Part of that which I am about to ſurvey, I write in one of the outſide Columns by what Name it is called ; but if it belongs to a Stranger, I write the Name of the Owner thereof, and in all Caſes expreſs to which Land the Hedge belongs.

So, at the Length of 20 Links from ⊙ 1, I lay the Off-ſet Staff at right Angles with the Chain, and meaſure

measure the Distance from thence to the Corner of *Turfy-Lease*, which I find to be 15 Links; therefore in the middle Column representing the Station-Line I write 20, and against it in the right Hand Column of Off-sets I enter 15: Likewise when I come to 40 Links in the Chain-Line I am against the Corner of *Cow-pasture*; therefore I lay the Off-set Staff to the Chain, and measure the Distance from thence to the Corner of *Cow-pasture* 80 Links, which I enter in the left Hand Column of Off-set against 40 in the middle Column; denoting, that, at the Length of 40 Links from ⊙ 1, the Off-set 80 Links reached the Corner of *Cow-pasture* on the left Side of the Station-Line.

The Hedges on each Side the *Lane* running on very nearly strait from these Corners, I take no more Off-sets in this first Chain's Length, nor at the second: But when I have laid the Chain a third Time, and come against 80 Links, I there take an Off-set on the left Hand of the Chain-Line, because the Hedge varies its Direction, making a considerable Bend; for, though the Distance from the Chain to the Hedge continually varies from the Corner to this Place, yet I only take Off-sets at each End, omitting the intermediate Parts; since, when the Extreams of a right Line are given, that right Line is also given. But when the Hedge runs on with a continued, but irregular Curvature; then I take Off-sets at every Chain, or half Chain's Length, or oftener, as the Thing requires.

In this Manner I proceed with the Chain till I come to the Staff at ⊙ 2; observing, as I go along, the Bends in the Fences on each Side of the *Lane*; to every one of which I take an Off-set, and then write the Length of each on the right or left Side of the middle Column in the Field-Book, representing the Station-Line, according as they were laid off in the Field.

Note, the Mark ⊙ in the Field-Book denotes a Station; B a Bearing; ∠ an Angle; *cu.* the Cutting of an Hedge by the Chain; *a g* ſome remarkable Obj& on the fartheſt Side of the Hedge, as another Fence ſhooting up thereto; *ret.* Return to a former Station, *&c.*

Being come to ⊙ 2, I there plant the Inſtrument, and ſend the Station-Staff forwards in the *Lane* as far as I can ſee it, as to ⊙ 3; and then bring the Index to 360 on the Limb, and, turning the whole Inſtrument about, I direct the Teleſcope to the Staff left at ⊙ 1, and there fix the Inſtrument. Then having turned about the Index on the Limb, till through the Teleſcope I ſee the Staff at ⊙ 3, I find that the North End of the Needle points at 338 *Deg.* and the Index cuts on the Limb 161 *Deg.* 50 *Min.* therefore under 2, in the middle Column of the Field Book, I enter 338 *Deg.* and under that 161 *Deg.* 50 *Min.* denoting that at the ſecond Station the Bearing of the third from thence is 338 *Deg.* and the Angle which the Index cuts on the Limb is 161 *Deg.* 50 *Min.*

The Rule I obſerve in meaſuring each Angle is this:

Firſt, I bring the Index to 360, *and with that Part of the Limb towards me, I direct the Teleſcope to a Mark at the laſt Station, and there fix the Inſtrument; then I turn about the Index on the Limb till I ſee the Hair in the Teleſcope cut a Mark at the next Station before me; ſo ſhall the Needle ſhew the Bearing of the next Line, and the Index on the Limb ſhews the Quantity of the Angle at the preſent Station.*

The Angles and Bearings of the Lines are taken at once ſetting the Index, as eaſily and expeditiouſly as the Angle itſelf only; therefore inſert the Bearing of each Line in the Field-Book, as you ſee in the Form thereof; for then you may prove the

Truth

Truth of your Work in the Field at each Station, before you leave it, by one of the 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.*

Or, *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 at ⊙ 2, if to the present Bearing 338° 00′ you add 180°, the Sum is 518° 00′; from which Sum, if you subtract the last Bearing at ⊙ 1, 356° 10′, the Remainder is 161° 50′, equal to the present Angle.

Likewise, if to the Bearing at ⊙ 3, 1° 30′, you add 180 Degrees, the Sum is 181° 30′, which is less than 338° 00′, the Bearing of the last Station; therefore 181° 30′ must be increased by 360, and then the Sum is 541° 30′, from which if you subtract 338, the Bearing of the last Station, the Remainder will be 203° 30′, equal to the present Angle.

In like Manner may any other Angles be examined, and, if found erroneous, the Error may be corrected, before 'tis communicated to the following Part of the Work.

Therefore when you have noted the Bearing of the present Station, write it in one of the outside Columns of the Field-Book, and adding 180 thereto, subtract the Bearing at the last Station therefrom; and then, if the Angle thus calculated from the Bearings agrees with that which the Index cuts on the Limb, you may conclude the Angle is rightly

rightly obſerved, and therefore may be entered in the Field-Book.

But obſerve, tho' the Numbers thus compared will be very nearly alike, yet ſometimes they may differ ſome few Minutes, becauſe the Diviſions in the Box being ſo much ſmaller than thoſe on the Limb, the Degrees and Minutes cannot be eſtimated alike in both; but yet you will be ſure always to correct and avoid any groſs Error before you proceed with the following Work; and to this End the before-mentioned Rules are of excellent Uſe.

Theſe Directions I ſhall not repeat, though I make uſe of them throughout the whole Work, unleſs any thing new occurs in meaſuring of the other Lines and Angles, referring the Reader rather to the Field-Book and Plan of the Work, than tiring him with Repetitions.

Note, the chief, if not the ſole Uſe of taking the Bearings here by the Needle, is for the Sake of protracting from the Meridian: And becauſe the Needle is ſubject to err a little, therefore whenever the Bearings and the Angle, after they have been calculated one from the other, (according to the preceding Rules) are found to differ, if this Difference does not exceed a Degree or thereabouts, the Bearings muſt be corrected from the Angle; for in taking the ∠ there can be no ſenſible Error, if the Cautions given in Page 58 be duly obſerved. But if the above-mentioned Difference be conſiderable, and the Needle be not very faulty, you may conclude that ſome Miſtake hath been committed, which muſt be inquired into before you proceed any farther.

From ⊙ 2 I proceed with the Chain towards ⊙ 3; but, at twenty Links in the firſt Length from ⊙ 2, I am againſt the Hedge that parts *Home-cloſe* from *Turfy-Leaſe*; therefore I take an Off-ſet thereto perpendicular from the Chain-Line, and enter in

the

the Field-Book *ag* 17 Links, and this will hereafter be of Uſe in cloſing the Plot.

Being come to ⊙ 3, I there obſerve and prove the Bearing and Angle at that Station, and then proceed with the Chain towards ⊙ 4; but firſt, at ⊙ or the preſent Station, I meaſure an Off-ſet to the right 10 Links, and to the left 20 Links; at 41 in the Chain-Line, I am againſt the *Orchard-Hedge*; at 204, the *Orchard-Pales*; at 261, I am againſt the *Gate* that leads into the *Yard*, and alſo againſt another that goes into *Cow-Paſture*; therefore to each of theſe Remarks I meaſure an Off-ſet from the Chain-Line, and enter them into the Field-Book.

In going from ⊙ 4 to ⊙ 5, the Chain touches the Brow of the Ditch at 2 Chains 20 Links from the laſt Station; therefore againſt 220 in the Field-Book I write *o*, denoting that there was *o*, or no Diſtance from the Chain to the Ditch. By the Brow of the Ditch is meant the determined Diſtance of 5 Links from the Stem of the Hedge.

Being come to ⊙ 6, I ſend a Staff to the farther Side of the Field called the *Stockin*, and if I cannot ſee the Mark through the Hedge, I cauſe the Bows to be removed or held back till I can plainly ſee the Mark; but if that cannot be done, I make my Station a little on this Side, or elſe beyond ſuch a thick Place till I can plainly ſee the Mark, and draw the Chain through the Hedge in a ſtrait Line, and where it cuts the Hedge I write *cut*, as here it does at 10 Links; but, if the Fence is a Wall, I allow for the Thickneſs thereof, and always meaſure the neareſt Diſtance between Station and Station that can poſſibly be.

Being come to ⊙ 9 in the *Stockin*, I cauſe a Staff to be ſet up in the very Corner of the Field next the Lane where the Boundaries meet, to which I meaſure from ⊙ 9; ſo ſhall the End of this Line coincide with the Off-ſet which I took to this Corner from the Station-

Station-Line in the Lane, which will be a Proof that the Work is truly laid down, when I come to protract it.

If upon a Piece of Paper with the Pen only you make an Eye-draught of the *Lane*, and that Field which you have finiſhed, ſetting your Station-Lines with their Numbers, as you made them in the Field; you will plainly ſee your Work as you go along, and be able to diſtinguiſh which Boundaries of the preſent Field are already meaſured in the precedent, as well as be directed, with a great deal of Eaſe, how to proceed with your Work, when you come to protract it.

Having made all the neceſſary Obſervations round the *Stockin*, I return to ⊙ 9; and with 360 on the Limb towards me, I direct the Teleſcope to a Mark at the laſt Station before I came to this, *viz.* ⊙ 8, and fixing the Inſtrument there, I next direct the Teleſcope to ⊙ 10, and note the Angle and Bearing at that Station: Then I lay the Chain through the Hedge from ⊙ 9 towards ⊙ 10, and take an Off-ſet to the Fence where each Partition-Line joins it on the other Side; by the Help of which, together with the other Off-ſets on the further Side in the *Lane*, moſt of the inward Fences of the *Orchard*, *Garden*, *&c.* may be drawn.

From ⊙ 10 I cannot ſee into the very Corner next the *Lane*, therefore I take an Off-ſet thereto 20 Links from the Station-Line, and ſo are the Out-Lines of the *Garden*, *Yard*, &c. finiſhed.

Then I return to ⊙ 8 in the *Stockin*; and here it may be obſerved, that when I deſign to return to any Station, before I leave it, I cut up a Turf with a little Paddle, which I fix in one End of the Off-ſet-Staff, or make ſome ſuch Remark that I may be ſure readily to find the Place in which the Station-Staff before ſtood; and in the Field-Book to this Mark ⊙ I write *return*. Then planting the Inſtru-

ment

ment at ⊙ 1, I direct the Telescope to the Mark left at ⊙ 7.

Note, I make it a general Rule, to observe the Angle with that Line which was measured immediately before I come to the Station where I took the Angle the first Time: So here I observe the Angle made with ⊙ 7, ⊙ 8; and not with any other, as ⊙ 8, ⊙ 9; therefore according to this constant Rule I direct the Telescope back to ⊙ 7 in the *Stockin*, and, fixing the Instrument there, I next direct the Telescope to ⊙ 11 in *Home-Close*, and *note* the Angle, *&c.* as in the Field-Book.

After I have measured the Angle, *&c.* at ⊙ 11, and am going forwards towards ⊙ 12; at 76 Links of the Chain I perceive myself over-against the Fence that parts *Out-Wood* from *Crabtree-Close*: I therefore ask the Follower of the Chain, how many Arrows he hath in his Hand, he answers 4; therefore I enter in the middle Column of the Field-Book 476; and against that on the left I write 61, the Length of the Off-set; denoting, that at the Length of 4 Chains 76 Links from ⊙ 11, I laid off an Off-set to the left, 61 Links. Then I proceed to observe and enter in the Field-Book the rest of the Occurrences round *Home-Close*, closing it at the End of the Line from ⊙ 12, next the *Lane*.

Then I return to ⊙ 12, and proceed to ⊙ 13, closing *Turfy-Lease* at the Corner; to which I took the first Off-set from ⊙ 1, in *Charlton-Field*.

In the same Manner I proceed round *Crabtree-Close*, entering the several Occurrences as you find them in the Field-Book.

Being at ⊙ 17, I cause a Staff to be set up close to the Fence where the Hedges join one another near ⊙ 7; to which Staff I measure strait from ⊙ 17, closing *Out-Wood* at the Extremity of the Station-Line, which coincides with the Off-set laid off from ⊙ 7, in the *Stockin*.

Having

Having finiſhed all the Fields on this Side the *Lane*, I return to ⊙ 6; obſerving this general Rule, never to make a Tour greater than Neceſſity requires, but always to cloſe each Field as ſoon as poſſible: So inſtead of going up the *Lane* from ⊙ 2, if I had turned off into *Turfy-Leaſe*, and cloſed firſt *Turfy-Leaſe*, and then *Crabtree-Cloſe*, *&c.* the Work had been done as well.

Being at ⊙ 6, I cauſe a Staff to be ſet up in a convenient Place, on the farther Side of *Garrot-Field*, as at ⊙ 18, laying the Chain through the Hedge, from ⊙ 6, towards ⊙ 18; and becauſe the Hedge belongs to the next Field, I write Hedge to *Will. Green*, the Owner of the adjacent Land.

After I have obſerved the Angle at ⊙ 18, I direct the Teleſcope to a Staff ſet up by the *River* Side, and note the Degrees which the Index cuts on the Limb, *viz.* 131° 10′; and then meaſure from ⊙ 18, to that Staff, 300 Links, taking Off-ſets on each Side the Line to the Brink of the River, as you ſee in the Figure thereof; and this will be found very uſeful in all manner of Practice, where the Boundaries are very irregular, that as much Work may be performed at once ſetting down the Inſtrument as poſſible.

From ⊙ 18, I proceed with the Chain to ⊙ 19, and from thence I meaſure along the Hedge-Side that reaches from the *River* to the *Lane*; and when I come againſt the Hedge that parts *Magg-meadow* from *Cow-Paſture*, I write *a g* 50 Links, being ſo far diſtant from the Chain-Line; and becauſe the Hedge from this Place belonged to *Garrot-Field*, I entered it ſo in the Field-Book, but now it belongs to *Cow-Paſture*; therefore I write *Hedge* to *Cow-Paſture*.

Then returning to ⊙ 19, I direct the Teleſcope firſt to ⊙ 18, and then to ⊙ 20, and I find ⊙ 19 to be in a ſtrait Line with ⊙ 18 and ⊙ 20; therefore I enter in the Field-Book 180, or Station-Line continued;

tinued; then I proceed to obſerve and enter down the ſeveral Occurrences at ⊙ 20, ⊙ 21, and ⊙ 22, round *Mag-meadow*, and then return to ⊙ 21.

From ⊙ 21, I go to ⊙ 23 in *Cow-Paſture*, cloſing it on the Corner, near ⊙ 1 in *Charlton-Field*; and ſo is the whole finiſhed, as far as relates to the Field-work.

If there be ſeveral Pieces of Land belonging to the ſame Manor, *&c.* you are now ſurveying, that lie diſperſed in ſeveral Furlongs in common Fields adjacent to the ſame Manor; you may from one of your Stations on the Outſide of the Plot take the Bearings to each Piece, by cauſing a Mark to be ſet up thereon, and meaſuring the Diſtance from that Station to each Mark: So may each Piece be plotted in its true Form, and laid in the ſame Situation in the Plot as on the Land itſelf: And in your Table of References or Terrier, you may inſert the Name of the Furlong where each Piece lies, with the Name of other Perſons Land that lies round it, as a Direction to the Steward, or other Perſon, to find each Piece.

Obſervations

Observations and Dimensions of Land lying in the Parish of W——, *in the County of* L——, *Part of the Estate of* —— —— *31st of March*, 1724.

Remarks	*Off-sets*	*Station-Lines*	*Off-sets*	*Remarks*
		⊙ 1 *in Charlton-Field.*		
	B	356° 10′		
Corner of Cow-Pasture, Hedge to Pasture.		20	ag. 15	*Corner of Turfy Lease Hedge to Turfy Lease.*
	ag. 80	40		
	10	280		
		300	20	
	18	563		
		⊙ 2 *in the Lane.*		
338° 00′	B	338° 00′		
180° 00′	V	161 50		
518 00	10	0		
356 10		20	ag. 17	*Hedge to Home-close*
161 50		446		
		⊙ 3 *in the Lane.*		
	B	1° 30′		
	V	203 30		
	20	0	10	
1° 30′		41	ag. 10	*Orchard Hedge. Orchard Pales.*
180 00		204	ag. 15	*Gate into the Yard.*
181 30	*Gate into Cow-Pa-*	261	20	*Corner of Barn.*
360 00	*sture. Hedge to*	290	18	
541 30	*ditto.*			
338 00	20	388	ag. 24	*Calves Croft Hedge.*
203 30		435		

Gate

Remarks.	*Off-sets.*	*Station Lines.*	*Off-sets.*	*Remarks.*
		⊙ 4 *in the Lane.*		
	B	349° 30′		
	V	168 00		
	ag. 20	90		
	13	140		
		220	0	*On Stockin*
Gate into Garrot-Field.	16	500		*Hedge.*
Hedge to Field.		626		
		⊙ 5 *in the Lane.*		
	B	13° 50′		
	V	204 20		
	10	0	20	
		64	12	
	35	152		
	30	236	10	
		⊙ 6 *in the Lane.*		
	B	93° 30′		
	V	259 40		
Corner of Stockin	0	10 *int.*		
	Into Stockin.			
	6	270		
	3	500		
	40	750		
		⊙ 7 *in Stockin.*		
	B	193° 30′		
	V	280 00		
Hedge to Wood.	23	00		
	60	335		
	45	620		
	ag. 20	668		
		680		

Remarks.	Off-sets.	Station Lines.	Off-sets.	Remarks.
		⊙ 8 *in Stockin.*		
	B	229° 00′		
	A	219 20		
Hedge to Stockin	10	0		
	10	268		
		⊙ 9 *in Stockin.*		
	B	268° 30′		
	A	219 20		
Corner.	30	22		
Hedge to Stockin				
		300	20 *Close Stockin here.*	
Hedge to Lane, in Corner next to Calves Croft.				
		⊙ 9	*ret.*	
	B	192° 00′		
	A	143 00		
		20 *int.*		
		Into Home Close.		
		90	20 *Calves Croft Hedge.*	
		220	20 *Garden Pales.*	
		350	20 *Corner of Orchard Hedge.*	
		361		
		⊙ 10 *in Home Close.*		
	B	264° 40′		
	A	252 40		
		205 +	20 *on Orchard Hedge.*	
		250	30 *close here.*	
		255		
Out-lines of Orchard, Garden, &c.			*Close on Hedge next the Lane.*	

Remarks.

+ 210 touches Corner of Orchard

Remarks	Off-sets	Station Lines	Off-sets	Remarks
		⊙ 8 *ret.*		
	B	105° 00′		
	A	91 30		
		19 *int.*		
		into Home Close.		
Hedge to Wood.	*corner* 5	24		
	37	353		
	28	465		
		⊙ 11 *in Home Close.*		
	B	193° 30′		
	A	268 30		
	60	130		
Hedge to Home Close	*ag.* 61	476		
Corner	18	727		
		⊙ 12 *in Home Close.*		
	B	259° 00′		
	A	246 20		
	ag. 28	65		
	48	268		
		667	*Close here.*	

Close Home, Close on Hedge to Lane, next Turfy-Lease.

Remarks.	*Off-sets.*	*Station Lines.*	*Off-sets.*	*Remarks.*
		⊙ 12 *ret.*		
	B	189° 20′		
	V	176 00		
		20 *int.*		
		into Crab-tree Close.		
		60	55	*Corner Hedge to Turfy-lease.*
		612	12	*Corner.*
		618 *int.*		
		Into Charlton Field.		
		642		
		⊙ 13 *in Charlton Field.*		
	B	262 40		
	V	253 20		
		10	28	
		510	20	*Close here.*
		530 *reaches first Station.*		
Turfy-lease, Closes on Corner of Hedge next the Lane.				
		⊙ 13 *ret.*		
	B	103° 00′		
	V	94 00		
Touch on Hedge to to Crabtree-Close.	0	135		
	17	310		
		⊙ 14 *in Charlton Field.*		
	B	69 00		
	V	146 00		
	3	320		
	26	545		
		618		

Remarks.

Remarks	Off-sets	Station-Lines	Off-sets	Remarks
		⊙ 15 *in Charlton Field.*		
	B	5° 00′		
	A	116 00		
	15	60		
		166 *int.*		
		Into Charlton Common.		
	120	337		
Hedge to	16	563		
Crabtree Close		645		
		⊙ 16 *in Charlton Common.*		
	B	276° 35′		
	A	91 35		
		16 *int.*		
		Into Crabtree Close.		
		22	30	*Hedge to Wood.*
		710 *close here.*		
Close Crabtree-Close to Corner next Home-Close and Wood.				
		⊙ 16, *ret.*		
	B	10° 20′		
	A	185 20		
	22	222		
	60	386		
	69	434		
	50	611		
A Gate into	10	930		
the Wood.	32	1110		
	86	1268		
	142	1353		
		1553		

Remarks.	Off-sets.	Station Lines.	Off-sets.	Remarks.
		⊙ 17 *Charlton Field.*		
	B	264° 30′		
	V	74 10		
	128	225		
		318 *int.*		
		Into Clemenson's Land.		
	56	370		
	25	504		
	12	784		
		1240		
Outwood closes on Corner of Stockin, next to Clemenson's Field.				
		⊙ 6 *ret. into Lane.*		
	B	270° 50′		
	A	77 00		
		28 *int.*		
		33	10	*Hedge to W. Green.*
		288	40	
		560	10	
		932	98	*Corner to River.*
		⊙ 18 *in Garrot Field.*		
	B	186° 00′		
	A	95 10		
	V	131 10		*Angle to a Bend in the River, from* ⊙ 18
		26	75	
	56	175	82	
	25	248	53	
		300		
		225	⊙ *Touch the River's Brink.*	
		422	145	
		536	110	
		620	116	

Remarks.

Remarks.	Off-sets.	Station Lines.	Off-sets.	Remarks.
		⊙ 19 *in Garrot Field.*		
	B	96° 30′		
	A	90 30		
		0	8	*Hedge to Garrot Field continued to River.*
		180	0	
		390	34	
		558	50	*ag. Hedge to Cow-Pasture.*
		890	76	
		1024	50	*close here.*
Close Garrot-Field on Hedge next to Lane.				
		⊙ 19 *ret.*		
	B	186° 00′		
	A	180 00		
		8 *int.*		
	Into Mag-Meadow.			
		57	126	
		143	120	
		280	42	
		348	21	
		572	97	
		665	46	
		780	8	*A Bridge.*
		900	0	
		1004	15	
		1045		

Remarks.	Off-sets.	Station Lines.	Off-sets.	Remarks.
		⊙ 20 *in Magg-Meadow.*		
	B	151° 00′		
	A	145 40		
		78	40	
		154	82	
		280	75	
		395	30	*Corner to River.*
		⊙ 21 *in Magg-Meadow.*		
	B	54° 30′		
	A	83 35		
		00	28	*Hedge to Magg Meadow.*
		100 64	64	
		245 78	78	
		380 59	59	
		452 27	27	
		⊙ 22 *in Magg-Meadow.*		
	B	358° 00′		
	A	123 20		
		00	28	
		147	53	*A Gate.*
		378	28	
		600	6	
		790	30	
		890	60	
		1010	137	*Close here.*
		1032		

Magg-Meadow closes on the Corner of the Hedge next Garrot-Field.

Remarks.

Remarks.	*Off sets*	*Station Lines.*	*Off-sets.*	*Remarks.*
		⊙ 21 *ret.*		
	B	143° 35′		
	A	172 25		
		22 *int.*		
		Into Cow-pasture		
		93	6	
		244	60	*Corner to River.*
		⊙ 23 *in Cow-pasture.*		
	B	90° 50′		
	A	129 05		
		205	55	*Hedge to Cow-pasture.*
		245	60	
		302	62	
		428	24	
		560	20	
		680	38	
		755	58	
		842	45	*Close here.*
		936		
Cow-pasture closes on Corner next Charlton-Field.				

SECT.

SECT. II.

The Manner of Protracting the Observations contained in the preceding Field-Book.

THE Protractor for this Purpose is best made a whole Circle, and marked on the Limb where the Numbers begin with *N.* or a *Flower-de-luce*; for then may that Part of the Prrotractor be kept always one Way as the Instrument in the Field; and therefore you will be less liable to Mistake, than if you use a Semicircle, which must be laid upwards or downwards, as the Degrees of the Bearing are more or less than 180: The Diameter of this Protractor may be laid parallel to the Meridians, by the Help of equal Divisions graved on the inner Edge thereof; or by the Degrees on the outward Edge.

Being provided with a Sheet of strong Cartridge-Paper, or (if that is not large enough) a Skin of Parchment; or which I reckon better (especially for the fair Plot) if one Sheet of Paper be not big enough, to have several Sheets pasted on Cloth or Canvas well stretched and dried in a Frame before you use it; and this you may have of any Size, as the Largeness of the Work to be laid down requires.

Or a Practitioner may have Sheets of large Paper printed from a Copper-Plate, with fine Meridian Lines drawn thereon at exact Distances; and these will be very neat and true, and will save much Trouble in drawing Meridian Lines by a Parallel Ruler, or otherwise.

If you have not a Parallel Ruler, you may draw Lines parallel to one another, by setting one Foot of a Pair of Compasses at or near the End of your given right Line, and with the other describe the Arch of a Circle; do the same at the other End of the Line,

and

and through the utmoſt Convex of theſe two Arches you may draw a Line parallel to the firſt.

Or if you bend the Paper double, ſo that the two Ends coincide, and prick Holes through them both; then the Paper being opened, Lines drawn through the correſpondent Points will be parallel one to the other.

Having drawn parallel right Lines at convenient Diſtances throughout the Paper marked with N. S. repreſenting Meridian, or North and South Lines; I chuſe out ſome Place in one of theſe Lines to repreſent the firſt Station, as at ⊙ 1, *Fig.* 41, and lay the Center of the Protractor on the Point ⊙ 1, the Diameter being parallel to the Meridian Line, and the Beginning of the Degrees of the Protractor towards N. or upwards: And becauſe the Bearing of the firſt Station-Line is 356°, 10′, I make a Mark with my Protracting Pin againſt that Number, cloſe to the Limb of the Protractor; to which Mark I draw an obſcure Line from ⊙ 1, repreſenting the Chain Line from ⊙ 1 to ⊙ 2.

Then the Field-Book being open before me, I lay the Edge of my Plotting-Scale to this obſcure Line ⊙ 1 and ⊙ 2; and becauſe I find in the Field-Book that the Off-ſets from this Line were laid off at 20, 40, 280, 300, and 563; therefore making the Beginning of the Numbers on the Plotting-Scale to coincide with ⊙ 1, I make a Prick againſt each of theſe Numbers cloſe to the Edge of the ſaid Scale; then turning the Scale perpendicular to the Line, I apply it ſucceſſively to thoſe ſeveral Points, and there prick off the Length of the ſeveral Off-ſets on the reſpective Sides of the obſcure Line; ſo againſt the firſt Mark in the obſcure Line, I prick off 15 Links to the Right, which gives the Corner of *Turfy-Leaſe*: Alſo againſt the ſecond Prick in the obſcure Line, I prick off 80 Links to the Left, which gives the Corner of *Cow-Paſture*; at 280, or the third

third Mark in the obſcure Line, I prick off 10 to the Left; at 300, 20 to the Right; and at the End of the Line 563 I prick off 18 Links to the Left; laſtly, I draw Lines with Ink from Point to Point on the Outſides of this obſcure Line, thereby conſtituting the Boundaries of the *Lane* ſo far.

At the firſt and ſecond Diſtances, I was againſt the Corners of *Turfy-Leaſe* and *Cow-Paſture*; therefore, with a Black-Lead Pencil I draw two ſhort Lines, cutting the *Lane*, to denote that the *South* Fences come up to the *Lane* at thoſe Corners, and will hereafter be of Uſe in cloſing theſe Plots.

Having thus finiſhed my firſt Length, I produce the obſcure Line, if Occaſion requires, both Ways, till it is as long each Way as the Radius of the Protractor; then I place the Center of the Protractor on the Point ⊙ 2, and turn it about thereon, keeping the Beginning of the Degrees towards ⊙ 1, the laſt Station, till the Diameter coincides with the Station-Lines ⊙ 1, ⊙ 2; then cloſe to the Edge of the Protractor, right againſt 161° 50′ the Degrees of the preſent Angle, I make a Mark with my Protracting-Pin; and to that Mark from ⊙ 2 draw an obſcure Line, repreſenting the Station-Line, from ⊙ 2 to ⊙ 3.

And that I may be ſure the Line ⊙ 2, ⊙ 3, is drawn in its true Poſition, I turn about the Protractor, the Center ſtill coinciding with ⊙ 2, till the Diameter be parallel with the Meridians; the Beginning of the Numbers of the Protractor being towards N. on the Meridian Line, and then will the Line ⊙ 2, ⊙ 3, before drawn, meet the Limb of the Protractor againſt 338° 00′, the Bearing of the Line ⊙ 2, ⊙ 3, which proves the Line ⊙ 2, ⊙ 3, to be truly laid down.

And thus may the Plot be laid down by the Angles, and examined by the Bearings.

The

The conſtant Rule I obſerve in drawing the Angle is this : To 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 ; and to keep the Beginning of the Numbers on the Protractor towards the laſt Station. And, in order to prove that each Angle is truly laid down, I turn about the Center of the Protractor on the Point, repreſenting the preſent Station, till the Diameter be parallel to the Meridians, with the Beginning of the Numbers towards N. on the Meridian Line ; then will the Line laſt drawn, cut the Number expreſſing its Bearing on the Limb of the Protractor, if that Line be drawn in its true Poſition.

But there will be no Need of this double Trouble in protracting, if the Bearings be carefully examined, and corrected from the Angles, according to the Directions given in the laſt Section ; it will be beſt then to lay down the Angles on the Plot from the Bearings in the Field-Book, without at all regarding the Angle obſerved by the Limb of the Theodolite.

In like Manner, I lay down the Angles taken at the 3d, 4th, 5th, 6th, 7th, 8th, and 9th Stations ; and alſo the correſponding Lengths and Occurrences : I continue the Boundaries to the ſeveral Off-ſets as I go along, drawing a ſhort Line acroſs them with a Black-Lead Pencil, where the Remarks *a g*, *&c.* are noted in the Field-Book, and I break off the Fences where there are Gates : So at the laſt Length, from ⊙ 9, when I have drawn that Line in its true Poſition, and made it of its juſt Length, as noted in the Field-Book, I find its Extremity to coincide with that Point in the Fence, to which I laid off an Off-ſet from 388 in the Station-Line ⊙ 3, ⊙ 4, in the *Lane*, which proves that the Angles and Lengths incloſing the *Stockin* are truly laid down.

But

But if the Extremity of the laſt Line does not coincide with the Extremity of the laſt Off-ſet laid off from the Station-Line ⊙ 3, ⊙ 4, both denoting the North-Weſt Corner of the *Stockin*, the Lines and Angles, deſigned to incloſe the ſame *Stockin*, are not truly laid down, and therefore muſt be corrected before I proceed.

Next, I lay the Protractor ⊙ 9, and, having laid down the Angles ⊙ 8, ⊙ 9, ⊙ 10, I prick off the ſeveral Off-ſets, marking them as the Field-Book directs, where the Lines of Partition within come up to the Hedge.

Having drawn the Chain-Link from ⊙ 10, and ſet off the laſt Off-ſet therefrom 20 Links, I find the Extremity of that Off-ſet to coincide with the Mark I drew croſs the Fence at the 2d Off-ſet from ⊙ 3, which proves the Work to be truly laid down.

The Out-Lines round the *Orchard*, *Garden*, *Yard*, *&c.* being drawn, the external Angles about the Buildings may be meaſured with a Bevel; or elſe with the Chain only (as directed in the Uſe of the Chain;) which, together with the Remarks on the Outſides, will be an eaſy Direction for drawing the ſeveral Boundaries within thoſe Lines.

Having finiſhed the Ground-Plot about the Buildings, I find the next Station in my Field-Book, marked ⊙ 8. *ret.* therefore I return to ⊙ 8, in my Draught, and lay down that Angle by the Line immediately preceding that Station, *viz.* ⊙ 7, ⊙ 8, and proceed to ⊙ 11, laying down the ſeveral Occurrences as noted in the Field-Book.

The Rules I obſerve in theſe Caſes are to number with Black-Lead all the Stations I have already laid down in my Draught, and to expreſs thoſe Numbers ſucceſſively one after another, in a Piece of Waſte Paper.

If the Number of the preſent Station doth not immediately ſucceed that of the laſt, but is greater by an Unit than any of the Numbers in the waſte Paper; then I lay down the Angle of the preſent Station with the Line I meaſured immediately before I came to it, and number it as in the Field-Book.

But, if the Number of the preſent Station is greater than any in the waſte Paper by more than an Unit, there hath been ſome Omiſſion in the waſte Paper, which muſt be rectified.

If I come to a Station, whoſe Number is already entered in the waſte Paper, then I return to that Station in my Draught, and there lay down that Angle with that Line meaſured immediately before I came to this Station the firſt Time.

Thus, obſerving theſe Directions, may the Plot be laid down without any Burden at all to the Memory; and, if it was ſurveyed by one Man, it may be plotted by another, provided the Perſon who ſurveyed it, obſerved theſe Rules, and any Method of keeping a Field-Book, that lays a Burden on the Memory, is imperfect, and not fit for Practice.

The remaining Part of the Work is reſerved for the Exerciſe of the Reader: The Plan thereof was here laid down by a Scale of $\frac{1}{4}$ of an Inch: I ſometimes lay down the Plot of each Field by a Scale of half an Inch or larger, if the Plot will lie on one Sheet of Paper, and caſt up the Content of each ſeperately by that Scale; and, for this Purpoſe, the Sheets, with Meridians ready printed thereon, are very ſerviceable. Afterwards I lay down the whole Plan together by a Scale of a Quarter of an Inch or leſs, entering the Content of each Field, as caſt up by the large Scale in the Middle thereof.

SECT.

SECT. III.

Observations on measuring Land in Common-Fields.

WHEN ploughed Lands in Common-Fields are measured by the Chain, 'tis usual to measure the Length down the Ridge of the Land, and to take the Breadth at the Top of the Land, about the Middle, and at the Bottom; and adding these three Numbers together to take the third Part of the Sum for the mean Breadth: but 'tis not advisable to take the Breadth very near the Lands Ends, because the Turning of the Plough generally makes it considerably narrower or wider; and, if in measuring down the Land you find the Breadth is not nearly equal, 'tis best to measure cross the Land oftener, as at every 3 or 4 Chains Length, and, adding the several Breadths together, divide that Sum by the Number of Breadths, for the equated Breadth: And, for this Practice, half the four Pole Chain is most convenient, remembring either to set them down as whole Chains, or to make them so, when you cast up the Content.

The several Furlongs, in common arable Fields, may be accounted as so many particular Inclosures, and measured after the same Manner, by setting up Marks at the Extremities of the Furlong, and measuring the Angles by the Theodolite, as before directed; and, as you pass along the Station-Lines, you may from thence take Off-sets to each Man's particular Lands; and, against that Off-set, write the Name of the Owner or Tenant: And when you plot that Furlong, you may, by those Directions in your Field-Book (if you will take the Pains, which is not a little) express each particular Land in your Draught

Draught, with its Buttings and Boundings (but the Buttings and Boundings of Land in Common-Fields is neceſſarily expreſſed in all Caſes): An Example of this is needleſs, only it may be added, that, in the Survey of a large Common-Field, 'tis ſafer to divide it into Parcels, as ſeparate Fields, keeping good Marks at the Stations, than to venture the Cloſing of the Plot, by going round it all at once, and dividing it into Parcels afterwards.

SECT IV.

Of Reducing Plots.

THE Plot of a Manor or Lordſhip conſiſting of ſeveral hundred Acres lying together, being laid down by a Scale of a Quarter of an Inch or leſs, may yet be larger than is deſired, and therefore muſt be reduced into a leſſer Compaſs. Now for the Performance of this Work there are ſeveral Inſtruments, as a long Scale made with a Center-hole at one third Part thereof; ſo that two third Parts may be numbered one Way with equal Parts from the Center hole to the End; and the other third Part numbered the other Way with the ſame Number of equal Parts, though leſs according to what Proportion you pleaſe: But to paſs by this, and ſeveral others, I ſhall only give an Inſtance of the *Parallelogram*, which is commonly made of ſix wooden Rulers joined together, and ſupported by Braſs Feet, with Holes in the Rulers for ſetting the Inſtrument to certain Proportions.

But ſometimes theſe Inſtruments are made of Braſs, and ſo as they may be ſet to any given Proportion whatever, by the Help of ſliding Centers, that are moved along certain Lines calculated for that Purpoſe, and divided on the Sides of the Parallelogram; ſo that a Plot may be reduced

with the utmoſt Exactneſs according to any given Ratio, in reſpect of the former, either in Proportion, as the Length of the Sides of the foul Plot ſhall be to the fair one, or elſe as the Area of the one to the Area of the other. By this Inſtrument Curves are as well reduced as Right-Lines, which by any other Inſtrument is exceeding difficult, if not impoſſible to be done.

The Parallelogram being fixed upon a very ſmooth and even Table, and the foul Plot and fair Paper faſtened thereon, one over-againſt the other; ſet the Parallelogram to what Proportion you would have your reduced Plot be of, in reſpect of the former, then bring the Point of the Tracer to one of the outmoſt Angles of the foul Plot, and put in the Point which is to draw in its Place, letting it reſt on the fair Paper: Then move the Tracer with a gentle, equal Motion over all the Lines of the foul Plot; ſo ſhall the Motion thereof occaſion the Drawing-Point to draw upon the clean Paper or Parchment the true and exact Figure of the former Plot, tho' of another Bigneſs, according to what Proportion you ſet your Inſtrument; which will better appear by ſeeing the Inſtrument once uſed, than Words can poſſibly explain.

When you have gone round the Lines that incloſe one Field, you may take out the Drawing-Point and bring the Tracer to any other Point on the foul Plot; then put the Drawing-Point in its Place again, and proceed on with your Work.

Note, This Inſtrument is uſeful, not only for this Purpoſe, but alſo for Copying any ſmall Print, *&c.* in Miniature.; but for reducing great Plots of Land, it ſhould be made of a larger Size than is commonly uſed for other Purpoſes.

Schol. The Parallelogram is a pretty contrived Inſtrument; but whether for the Purpoſe of a Surveyor, the *Proportional Compaſſes* will not do as well

well or better, must be left to the Decision of those who have experienced both. The Compasses consist of two Legs of equal Length, having a steel Point at each End; the Center which joins the Legs together is moveable up and down the Middle, by which Contrivance the Instrument may be set in any given Proportion. When the Center is exactly in the Middle, the Distance betwixt the Points at each End will be the same, whatever Extent they are opened to; if the Center be moved a little higher up, the Extent betwixt the upper Points will be less than that betwixt the lower ones, and that always in the same Proportion whilst the Center remains in the same Place. There are usually Divisions cut upon one of the Legs for setting the Center according to any given Proportion; but lest these Divisions be faulty, you may correct them thus: Let the Proportion assigned be as 2 to 1; having set the Center to the Number 2, open the Legs, and by the widest End take some Number off a Scale of equal Parts, suppose the Scale 20; then if the other End will reach to the same Number upon the Scale 40, the Center is rightly placed, otherwise it must be moved a little as you see occasion.

To reduce Plots by this Instrument.

For Example, Let it be required to reduce a Plot to a Scale of half the Bigness. 1. Draw parallel and equidistant Right-Lines along the Plot to be reduced; this Distance may be $1\frac{1}{2}$ Inch or 2 Inches; cross these again at Right-Angles with other Lines drawn exactly at the same Distance; then will the whole Plot be reduced into Squares all of equal Bigness. After the same Manner reduce the Paper or Parchment on which your new Plot is to be drawn into Squares, whose Sides are exactly half the Length of the former. Then the proportional Compasses being set in the same Proportion with the Sides of

the Squares on the two Plots, you will be able readily and expeditiously with a little Practice to reduce one Plot into the other.

SECT. V.

Directions for Beautifying and Adorning of Plots.

HAving reduced the Plan of the Lordship, Manor, *&c.* to the intended Bigness, 'tis necessary to draw imaginary Lines, both vertical and horizontal, denoted by Letters at the Top and Bottom, and also on the Sides; to be referred to by the Table of References, for the ready finding of any Field or Parcel of Land therein contained; such as you will find in the new Maps of *London*, *&c.*

The *North* Part of the Plot is always supposed to be placed upwards, and the *East* to be on the right Hand.

The Representation of Hedges ought to be laid down on the same Side of the Fences that they are in the Land, and to be broke off where there are to be Representations of Gates

The Out-borders of the Plot, at least such as border next to the Demesnes, ought to be filled with the adjacent Hedges, and the Tenants or Owners Names of the Grounds.

If you describe all Rivers, Highways, Windmills, large single Trees, Gates, Stiles, *&c.* that fall within your Plot, it will add to the Beauty thereof.

The Ground-Plot of Buildings ought in all Cases to be expressed by the same Scale that the rest of the Plot was laid down by, and to be taken Notice of in the Table of References; but never go about to draw the Representation of an House or Barn in the midst

midſt of the Plot, ſo big as will cover an Acre or two of Land.

But if you would expreſs a Gentleman's Seat, or Manor-houſe, 'tis beſt done in ſome Corner of the Draught, or in a Plan by itſelf, annexed to that of the Eſtate to which it belongs. And the Houſe muſt be drawn in Perſpective (as you will be ſhewed hereafter) and if the Gardens, Walks and Avenues to the Houſe are expreſſed, it muſt be in the ſame Manner; and where there are Trees, they muſt be ſhadowed on the light Side.

If you will take the Pains, you may, in one of the upper Corners of the Plan, draw the Manſion-Houſe, *&c.* in the other the Lord's Coat of Arms, with Mantle, Helm, Creſt, and Supporters, or in a Compartment, blazoning the Coat in its true Colours: In one of the Corners at the Bottom, you may deſcribe a Circle, with the 32 Points of the Mariners Compaſs, according to the Situation of the Ground, with a *Flower-de-luce* at the *North* Part thereof, always allowing for the Variation of the Needle: And, in the other Corner, make a Scale equal to that by which the Plot was laid down, adorning it with Compaſſes, Squares, Ovals, *&c.*

Having wrote the Name and Content of each Cloſe about the Middle thereof, you may, about the Bounds of each Field or Incloſure, with a ſmall Pencil, and ſome tranſparent Colour, neatly go over the black Lines; ſo ſhall you have a tranſparent Stroke or Margin on either Side of your black Lines, which, being ſhadowed, will add a great Luſtre and Beauty to the Plot.

If you would have your Fields all coloured, it will not be amiſs to pounce over the Paper or Parchment with ſome Staniſh Grain and burnt Allom, and a double Quantity of Roſin, finely ſearced and lightly pumiſed, to preſerve the Paper from being piereed through with the Colours; or wet it over

with Allom-Water, which will add to the Luſtre of the Colours.

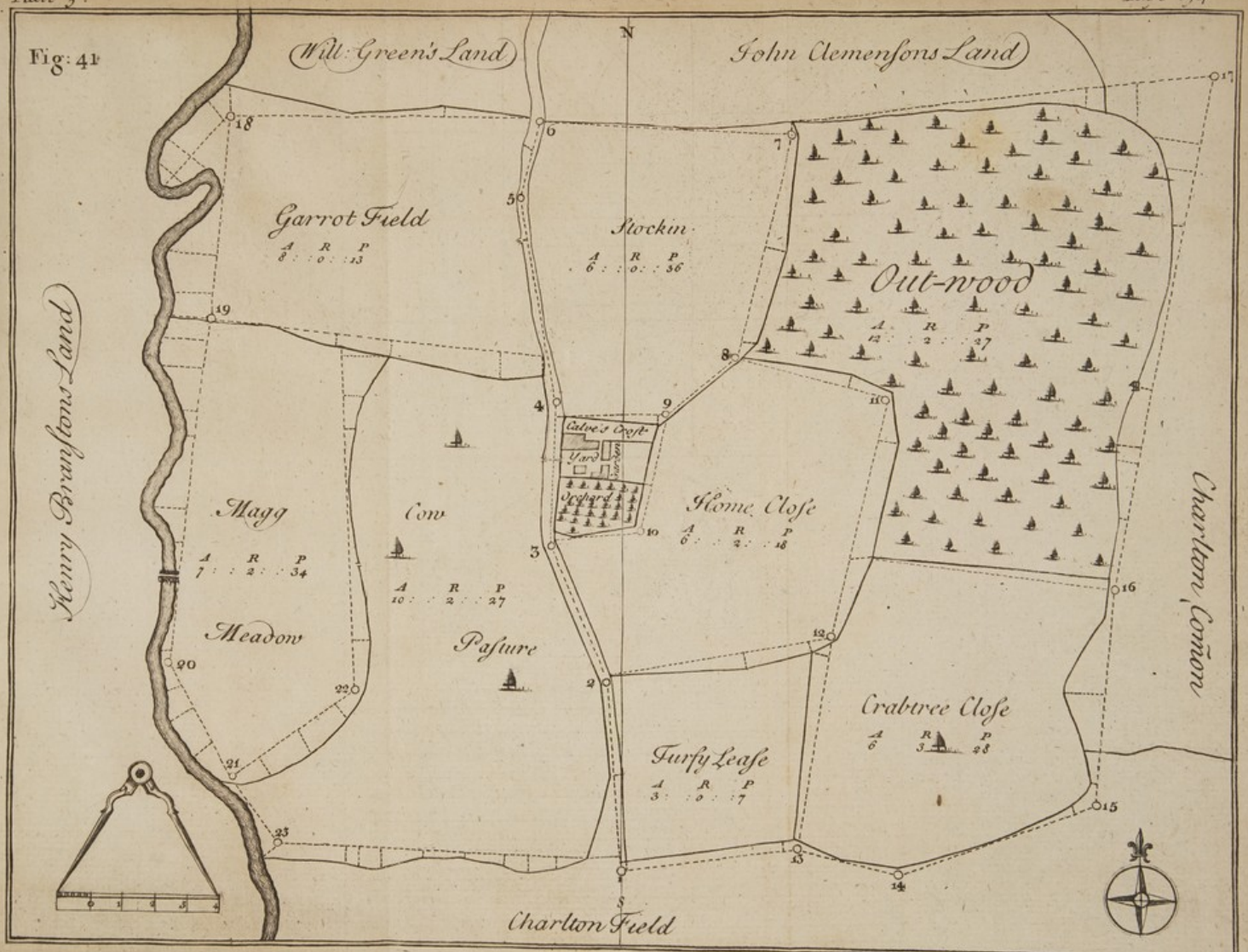
Then lay on the Colours in Manner following, being firſt ground, and bound with Gum-Water very thin and bodileſs: *Arable* for Corn, you may waſh with pale Straw-Colour, made of King's Yellow and White; for *Meadows*, take Pink and Verdigris in a light Green; *Paſture*, in a deep Green of Pink, Azure and Smalts; *Fenns*, a deep Green; as alſo *Heaths* of Yellow and Indico; *Trees*, a ſadder Green, of White and Verdigris; for *Mud-Walls* and *Ways*, mix White and Ruſt of Iron, or with brown Oker of *Spain*; for *White Stone*, take Umber and White; *Water* or *Glaſs* may be ſhewn with Indico and Azure or *Indian* Ink; for *Seas*, a greeniſh Sky-Colour, of Indico, Azure, Smalts, White and Verdigris.

Having waſhed your Pencil very clean, take a ſmall Quantity of the Colour, and on the Inſide of the Bounding-Line draw the Colour along, of an equal Breadth, as near as you can, broader or narrower as the Field is in Bigneſs; and, having gone round the Field in this Manner, ſwill the Pencil in fair Water, and ſtrike along the Inſide of the coloured Line, bringing it down more towards the Middle of the Field; and this will ſoften your Colour, and make it ſhew as if it loſt itſelf by Degrees to the very Colour of the Paper: Laſtly, with a Pen take ſome of that Colour which ſhadoweth the Colour you laid on the Field, and go over the black-lead Line only; ſo ſhall your Field be finiſhed.

In this Manner, you may make 100 Fields in one Plot, of divers Colours, obſerving, as near as you can, not to colour two Fields adjoining to one another of the ſame Colour; and therefore it will be convenient to underſtand what Colours beſt ſet off one another; and as near as you can, lay the Inclo-

ſures

Fig: 41


Will: Green's Land
John Clemensons Land
Henry Bramsons Land
Charlton Common
Charlton Field
N
S
Garrot Field
A 8 : R 0 : P 13
Stockin
A 6 : R 0 : P 36
Out-wood
A 12 : R 2 : P 27
Calve's Croft
Yard
Garden
Orchard
Home Close
A 6 : R 2 : P 18
Magg
A 7 : R 2 : P 34
Cow
A 10 : R 2 : P 27
Meadow
Pasture
Furfy Leafe
A 3 : R 0 : P 7
Crabtree Close
A 6 R 3 P 28
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

ſures adjoining to one another, of two ſuch Colours, that one Shadow may ſerve both.

This Colouring and Adorning of Plots is rather the Painter's Work than the Surveyor's; yet if he has Time to ſpare, and Patience to finiſh the Work, it may prove a pretty Diverſion. But for the general Practice, I would recommend the Uſe of *Indian* Ink, which, ground very fine upon a ſmooth Tile, and the Hedges or Bounders of each Field ſhadowed therewith, will look very neat, and make the Plot reſemble one done from a Copper-Plate, if rightly managed.

The Water-Colours before-mentioned you may have in Shells ready prepared (being much readier than to trouble yourſelf with grinding, *&c.*) as alſo the *Indian* Ink, Pencils, *&c.* at any of the Colour-Shops.

CHAP. VI.

The Manner of laying out or dividing Land.

SECT. I.

Of Laying-out Lands.

PROBLEM I.

IF any Quantity of Acres be given, to be laid out in a ſquare Figure, annex to the Number of Acres given 5 Cyphers, which will turn the Acres into ſquare Links; then from the Number thus increaſed, extract the ſquare Root, which ſhall be the Side of the propoſed Square.

So, if you would cut out of a Corn-Field one ſquare Acre, add to 1 five Cyphers, and then it will be 100000, the Root of which is 3 Chains 16 Links, and ſomething more for the Side of that Acre.

Problem. 2. If you would lay out a given Quantity of Acres in a Parallelogram, whereof one Side is given—Firſt, turn the Acres into ſquare Links, by adding 5 Cyphers; and divide that Number thus increaſed by the given Side, the Quotient will be the other Side: As if 100 Acres were to be laid out in a Parallelogram, one Side whereof ſhall be 20 Chains; therefore to the 100 Acres add 5 Cyphers, which

Sum

Sum divide by 20 Chains, the Length of the given Side, the Quotient will be 50 Chains for the Length of the other Side.

Problem 3. If you would lay out a Parallelogram that ſhall be 4, 5, 6, *&c.* times longer than it is broad: Firſt, turn the given Quantity of Acres into Links, as before, which Sum divide by the Number given, for the Proportion between the Length and Breadth, as 4, 5, 6, *&c.* the Root of the Quotient will ſhew the ſhorteſt Side of ſuch a Parallelogram: As if it was required to lay out 100 Acres in a Parallelogram that ſhall be 5 Times as long as broad; firſt, to the 100 Acres add 5 Cyphers, and it makes 10000000; which Sum divide by 5, the Quotient is 2000000, the neareſt Root of which is 14 Chains 14 Links, and that ſhall be the ſhorteſt Side of ſuch a Parallelogram; and, by a multiplying that 14 Chains 14 Links, by 5, ſhews the longeſt Side thereof to be 70 Chains 70 Links.

Problem 4. If you would make a Triangle that ſhall contain any Number of Acres, being confined to a certain Baſe: Firſt, double the given Number of Acres, to which annex 5 Cyphers, and divide that Sum by the Baſe; the Quotient will be the Length of the Perpendicular: As if the Baſe given be 40 Chains, upon which you are to make a Triangle that ſhall contain 100 Acres; firſt, double the Number of Acres, and, annexing 5 Cyphers thereto, divide it by 40 Chains, the limited Baſe; ſo ſhall the Quotient be 50 Chains, for the Height of the Perpendicular, which ſet on any Part of the Baſe; then you may, from the Extremities of the Baſe, draw the other two Sides, which ſhall form the Triangle required.

So if, when you are laying out a new Piece of Land of any given Content, although you meet in your Way with 100 Lines and Angles, yet you may, by making a Triangle to the firſt Station you began at, cut off any Quantity required.

SECT.

SECT. II.

Of Dividing Lands.

EXAMPLE I.

SUppoſe it was required to divide *Fig.* 42. whoſe Content is 10 *A.* 3 *R.* 22 *P.* into 2 equal Parts, by a Line drawn parallel to *a b.*

Firſt, the Acres, Roods, and Poles muſt be reduced into ſquare Links, which may be done thus:

If the Roods are $\left\{\begin{matrix}1\\2\\3\end{matrix}\right\}$ add $\left\{\begin{matrix}40\\80\\120\end{matrix}\right\}$ to the Poles,

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 if the Quotient

Figures are but $\left\{\begin{matrix}4\\3\end{matrix}\right\}$ write $\left\{\begin{matrix}1\text{ Cypher}\\2\text{ Cyphers}\end{matrix}\right\}$

after the Acres, and then the Quotient Figures; ſo will you have the ſquare Links required.

Therefore 10 *A.* 3 *R.* 22 *P.* reduced into ſquare Links, will ſtand thus:

$$\left\{\begin{array}{r} 22 \\ 120 \\ \hline 16)142.0000(88750 \\ \text{Square Links}—1088750 \end{array}\right\}$$

Having reduced the Acres, *&c.* into ſquare Links, they make 1088750, the Half of which is 544375; next draw a Line by Gueſs parallel to *a b*, as the Line *c d*, and then caſt up the Content of the Figure *a d c b*, which ſuppoſe 494375 ſquare Links; this is leſs than 544375 by 50000 ſquare Links, which ſhews that the Partition-Line muſt be ſet forwarder from *b a.*

Now, in order to know how much *c d* muſt be ſet forwarder, I divide the Exceſs 50000 ſquare Links

by

by the Length of the Line *c d*, 953 Links, and it quotes 52 Links; therefore from *c* I ſet off 52 Links, and draw the Line *f e* parallel to *b a*, and it will be ſufficiently near the Partition-Line.

This is performed by the ſecond Problem of the laſt Section; but, if thoſe Parts of the Boundaries *c f d e* be not nearly parallel, then 'tis beſt to draw a Triangle to *c d*, inſtead of the Parallelogram *c f d e*.

But if *c d* had cut off the Quantity *a d c b*, greater than that required, then the Partition-Line had been more towards *a b*, whoſe Diſtance might be found as before.

Example 2. Suppoſe it was required to cut off from *Fig.* 43. ſix Acres towards *g f*, by a Line drawn from a given Point in the Boundary *g a*, at *a*.

Firſt, reduce the given Quantity, 6 Acres, into ſquare Links, and they will be 600000; and then draw the Line *a b*, by Gueſs, from the given Point *a*, and caſt up the Content of *g a b f*, which amounts to 431680 ſquare Links, which is too little.

Next draw the Line *a e*, from the Point *a*, forming the Triangle *a b e*, whoſe Content is 235600, which added to the Part *g a b f*, amounts to 667280, which is more than the given Quantity 600000, by 67280 ſquare Links; therefore the Partition-Line paſſes between *e* and *b*.

Now divide the Exceſs 67280, by 380, half the Length of the Perpendicular *a c*, in Links; the Quotient is 77 Links, which ſet off from *o* towards *b*, and draw *a d*, which is the true Line of Partition.

Example 3. Suppoſe *Fig.* 44. was to be divided equally among three Tenants, in ſuch a Manner that the dividing Lines may paſs through the Pond *o*, in the Middle of the Field, ſo that each Tenant may have the Benefit of the Water.

Firſt, Reduce the whole Figure into ſquare Links, and it will be found to contain 1477410; then each

Tenant

Tenant must have one third Part thereof, *viz.* 492470 square Links.

From *o* to any two Angles, as *a* and *b*, draw the Lines *o a*, *o b*, forming the Triangle *a o b*; which being cast up, amounts to 291984 square Links, which is too little.

To the next Angle *f*, draw *o f*, forming the Triangle *a o f*, which being cast up, amounts to 231000 square Links, which, added to the Triangle *a o b*, gives 522984, which exceeds the Quantity required by 30514 square Links.

Divide the Excess 30514 by 347, half the Length of the Perpendicular *o g*, and lay the Quotient 87, from *f* to *h*, and so shall *h o b a* be one third Part of *a b c d e f*.

Next draw the Line *o e* to the next Angle *e*, and cast up the Content of *o e f*, amounting to 256410 square Links; to which add the Triangle *h o f* 30514 square Links, the Sum is 286924, which is too little.

Therefore draw *o d* to the next Angle *d*, and cast up the Content of *o e d*, 265500 square Links, to which add *h o e f* 286924, their Sum is 552424 square Links; which is more than the third Part of *a b c d e f*, by 59954 square Links.

Divide the Excess 59954 by 295, half the Length of the Perpendicular *o i*, and lay the Quotient 203 Links from *d* to *k*, and draw *o k*; so shall *Fig.* 44. be divided into 3 equal Parts, by the Trapezias *b a h o*, *h f e i k o*, and *k d c b o*, as was required; and the Pond *o*, laid out to each Tenant apart.

These three Examples express all the Variety that most commonly happens in Practice; for either the Partition-Line is required to be parallel to some other Line assigned; or to pass through some given Point in the Fence; or to pass through a Point assigned in the Land.

If

If a Piece of Common was to be divided amongſt ſeveral Tenants, in Proportion to the Rent which each pays for his Farm: The Numbers being reduced to the loweſt Denomination (except you expreſs the Parts of Acres and Pounds by Decimals, which is better) the Rule is:

As the Sum total of all the Tenants Rent is to the whole Number of Acres in the Piece of Land contained; ſo is each particular Tenant's Rent to the Number of Acres to be laid out for his Part. This is very plain, and needs no Example.

So if a Piece of Common was to be incloſed, and divided amongſt ſeveral Tenants, according to the Number of Beaſt-Gates which each Tenant hath in the Common, it is to be performed by the ſame Rule.

There is no Need of Direction how to make the Lines on the Land in the ſame Poſition as on the Paper-Plot, by carrying the Chain in a ſtrait Line from Point to Point, on the Land itſelf, as divided on the Paper: Only take Notice, that the larger the Scale is, by which the Plot is laid down on the Paper, the exacter will the odd Links of each Line be eſtimated by the Scale, in order to transfer thoſe Lines to the Land.

But if you are to divide a Wood, or very hilly Ground, ſo that you cannot ſee the Marks from Side to Side, do thus:

Be ſure to keep good Marks at every Station, as you meaſure round it, that you may find the Hole at each, in which the Staff ſtood; then having plotted the Wood, and divided it on the Paper-Plot, in ſuch Manner as deſired; plant the Center of the Theodolite directly over that Point in the Station-Line on the Land where the dividing Line cuts it on the Paper-Plot, and bring the Index to 360; or ſet it in the ſame Poſition as it was at the forward Station when you meaſured that Angle, turning about

the Inſtrument, till the Hair in the Teleſcope cuts the laſt Mark; ſo that the Teleſcope be ſet exactly in the Direction of the preſent Station-Line, where the dividing Line cuts, and there ſcrew the Inſtrument faſt: Then meaſure, with your Protractor on the Paper-Plot, the Angle which the dividing Line makes with the preſent Station-Line; and turn about the Index on the Limb to the ſame Angle, ſo ſhall the Teleſcope be ſet in the Direction of the dividing Line; then, by looking through the Teleſcope, you may cauſe Staffs to be ſet up in the ſame Direction: And thus proceed in a ſtrait Line, till you are far enough in the Wood, or quite through, if it be divided by one Line; but, if by two Lines, you muſt continue them till they meet one another, as in the Paper-Plot.

The ſame Thing may be performed by the plain Table, or the Chain only; but thoſe Inſtruments are not ſo convenient to meaſure a Wood, or hilly Ground, as the Theodolite.

SECT. III.

How to reduce Cuſtomary into Statute Meaſure.

IF you would change Cuſtomary into Statute Meaſure, *& è contra*, the Rule is: *As the Square of one Sort of Meaſure is to the Square of the other*; ſo *is the Area of the one to the Area of the other.*

In ſome Parts of *England*, they account 18, in ſome 20, 22, *&c.* Feet to a Pole or Perch, and 160 ſuch Perches to make an Acre, which is called *cuſtomary Meaſure*; whereas our true Meaſure of Land, by Act of Parliament, is but 160 Perches to an Acre, accounting 16 Feet and an half to the Perch.

So

So if a Field measured by a Perch of 18 Feet, accounting 160 such Perches to the Acre, contains 100 Acres; how many Acres shall the same Field contain by the Statute Perch of $16\frac{1}{2}$ Feet? Say, As the Square of $16\frac{1}{2}$ Feet, (*viz.*) 272.25, is to 100 Acres, so is the Square of 18 Feet (*viz.* 324) to 119 $\frac{8}{1000}$ of *a Statute Acre.* See the Operation at large.

16.5	
16.5	18
	18
825	
990	144
165	18

272.25 : 100 :: 324 :

272.25)32400.00(119.008 Acres.
51750
245250
0225

CHAP.

CHAP. VII.

General Observations on the Method of Surveying and Plotting of Roads, Rivers, &c. *With short Hints how to make the Draught of a County, or Ground-Plot of a City,* &c.

IN this ſeventh Chapter I have added general Directions for Meaſuring of *Roads*, &c. omitting particular Forms of Charts, which would take up more Room than can be ſpared in this ſmall Tract; and indeed, if the ſeveral Varieties that occur in theſe large and ſpacious Works were inſerted, it would ſwell to a large Volume: But ſince the Surveyor's Judgment in contriving and carrying on his Work muſt be his beſt Guide; theſe few Obſervations may ſerve as Memorandums of the moſt neceſſary Things in Practice; which, together with other Rules before laid down in this Tract, may perhaps be a ſufficient Inſtruction for the Performance of any Thing of this Nature.

SECT.

SECT. I.

General Directions for making a Draught of the Roads lying through any Country, &c.

INſtruments fitteſt for this Purpoſe, are, 1. The *Theodolite* as before deſcribed; the Angles which each Station-Line on the Road makes with the Meridian, being obſerved by the Limb in the ſame Manner, as before ſhewed, and the Bearings of the ſeveral Remarks from thence by the Needle. 2. The *Wheel*, or *Way-wiſper* to meaſure the Length of the Lines, by driving the Wheel on the Road before you; ſo ſhall the Hands on the upper Part of the Inſtrument ſhew how many *Miles*, *Furlongs*, and *Poles*, you go at one Time from any Station. 3. The *Protractor*, as before deſcribed: A neat *diagonal Scale* of Braſs, and a good *Pair* of *Compaſſes*. Or, you may have a *Beam Compaſs*, with ſuch a Scale on the Beam as ſhall be agreeable to the Largeneſs of your Plot; and thereby you may lay down the Length of your Lines very expeditiouſly, by ſetting one Foot of the Compaſſes at one End of the Line, and moving the Socket on the Beam to one of the equal Diviſions near the other End of the Line you are about to lay down, repreſenting Chains or Furlongs; and then you may bring the Point of the Compaſs which ſtands perpendicular on the Paper to the Parts of that equal Diviſion, repreſenting Links or Poles by the Help of a ſmall Screw; there being Diviſions on the Edge of the Socket ſliding cloſe on the Beam according to *Nonus*'s Projection; ſo that the Links of a Chain or Poles of a Furlong are eſtimated in the ſame Manner as the Minutes of a Degree on the Limb of the Theodolite. In theſe large Plans, where the Diſtances of Places are determined by the Interſection of Right Lines from your Sta-

tions, thoſe ſtationary Diſtances ought to be laid down as accurately as may be; for, where a Mile is laid down in the Compaſs of an Inch, a Prick of the Compaſſes is conſiderable.

In order therefore to make a Draught of the principal Roads that lie through any County, *&c.* Firſt, begin at ſome noted Market-Town, or rather at the County-Town, placing the Theodolite at ſome remarkable Church, *&c.* then having a Field-Book with large Margins to enter the Remarks, and the middle Column repreſenting the Station-Lines divided into three Parts, at the Head of which write *M.* for Miles, *F.* for Furlongs, and *P.* for Poles.

When you begin your Journey, at the Top of the Field-Book write the Name of the Place where you begin your Work, and make ⊙ 1 in the Field-Book to repreſent the firſt Station: Send ſome Perſon forwards on the Road, with a white Flag in his Hand, as far as you can ſee; and then by ſome known Sign cauſe him to ſtand; then bring the Index to 360 on the Limb, and turn the Inſtrument into the Direction of the Meridian, and there fix it; then direct the Teleſcope to the Perſon on the Road, and note the Degrees cut on the Limb for the Bearing of the firſt Station-Line.

Put the Hands to the Beginnings of the Numbers on the Plate, and bring the Wheel to the Station; then cauſe one to drive it from the Place where your Inſtrument ſtood, towards the Man on the Road, till you ſee ſome remarkable Object on either Side thereof; there let him ſtop and direct the Teleſcope to that Object, and note the Degrees which the Needle points to in the Box, and at what Diſtance the Inſtrument is planted from the laſt Station, together with the Name of the Object to which the Teleſcope was directed.

Having entered this in the Field-Book, go on with the Wheel till you ſee ſomething elſe remarkable on either

either Side of the Road; there ſtop and take a Bearing; and in this Manner proceed till you come up to the Man at the ſecond Station, obſerving as you go along on the Road from Station to Station: *Firſt*, what *By-Lanes* or *Roads* you meet with in your Way, whether they be to the right Hand or to the Left, and to what Places they go; how they incline, whether forwards or backwards, or whether they be at right Angles with the Road you are meaſuring, and note it down in the Field-Book with two Lines thus = on the right or left Side of the Station-Line: That is, if the Road or Lane be on the right Hand, then place it on the right Hand; but if the Road be on the left Hand, then place it on the Left: If the Road doth incline forwards, then mark it on either Side of the Lane or Road thus ⊬: If the Road or Lane incline backwards, then mark it thus ⊰: If it be at right Angles with the Road you meaſure, then mark it down thus ⫤: If another Road croſſes that you are upon, note it thus ⫩: Likewiſe ſet down at what Diſtance from your Stations the Lanes or Roads turn out from the Road you meaſure, *viz.* at ſo many Furlongs, *&c.* a Road to the Right or Left of ſuch a Place.

Likewiſe, when you paſs over any *Bridge*, note it in the Field-Book, with the Diſtance from the laſt Station; as alſo the Name of the Water that runs under it, and from whence it hath its Riſe, and where it empties itſelf: The ſame muſt be obſerved when you paſs over any *Ford* or *Rill*.

Note down alſo, when you aſcend an *Hill*, and when you come to the Top thereof, and when you deſcend the ſame, and come to the Bottom thereof.

When you paſs through any *Town* or *Village*, note at how many Miles, Furlongs, and Poles, you enter the ſame; and at how many Miles, *&c.* you leave it, and whether the Houſes be cloſe, or ſcattering, or on the right or left Side of the Road, or

on both Sides of it; alſo write down the right Name thereof; and, if a *Market-Town*, take Notice on what Day the *Fairs* or *Market* are kept, and by what Officers the Town is governed.

Note down alſo the *Mills* that are on the Road, whether *Water-mills*, or *Wind-mills*, and the Diſtance from your laſt Station. If there be any *Lone Churches* on the Road, note them down by their Names, and whether they be Towers or Spires, with their Diſtance from your laſt Station.

In your meaſuring along the Road, if you ſee any *Churches*, *Manſion-Houſes*, *Beacons*, *Wind-mills*, *Towns*, *Villages*, or any other Thing remarkable, you muſt take a Bearing to each, noting down in your Field-book the Name of the Place, and how it does bear, and at what Diſtance from your laſt Station you took this Bearing.

Then in your meaſuring forwards, at as great a Diſtance as you can, take another Bearing to thoſe Places you took laſt, provided you may but ſee them, and note the Names of the Places, and how they bear, and at what Diſtance from your laſt Station, as before.

Obſerving theſe Directions, proceed with your Work on the Road as far as you can go the firſt Day, entering the ſeveral Obſervations in as plain and fair a Manner as poſſible in the Field-book; and then it may be convenient to protract that Day's Obſervations, before you go any further.

Therefore, on the Paper or Parchment, on which you draw the foul Draught, let there be ruled Meridian-Lines all over, exactly parallel to one another; and chuſing a proper Place in one of the Lines, to repreſent the firſt Station, draw an occult Line from thence, making ſuch an Angle with the Meridian, as you obſerved the firſt Station-Line to do, when you directed the Teleſcope to the Man ſtanding in the Middle of the Road.

When

When you have drawn the Station-Line in its true Poſition, ſet thereon the ſeveral Diſtances from the laſt Station very exactly, at which you made any Remarks, as you find them noted in the Field-book; and make a ſmall Prick at each, in the Station-Line: Then having made the Station-Line of its juſt Length, proceed to lay down the ſeveral Objects you obſerved on each Side the Road, in their true Situation; as ſuppoſe a Steeple that ſtands at a Diſtance from the Road, *viz.* a Mile or two; lay the Center of your Protractor on the Place at which you took the Bearing, (*Ex. gr.* ſo many Poles, *&c.* Diſtance from ſuch a Station, ſuch a Steeple did bear from you 207° 40′) and againſt the Degrees of Bearing make a Mark, and draw a Line at Length.

Then at the ſecond Place in the Station-Line, where you obſerved this ſame Steeple to bear from you, lay the Center of your Protractor, and againſt the Degrees of Bearing make a Mark, and likewiſe draw a Line at Length; and, where this laſt Line of Bearing interſects the firſt Line of Bearing, there place the Steeple, with the Body of the Church to the Eaſt Side thereof.

All *Wind-mills*, eminent Houſes, or other Remarks that are diſtant from the Road, you muſt protract, in the ſame Manner as you did the Church, by the Bearings, and likewiſe write down the Name of each; and, if you protract a *Village* that ſtands at a Diſtance from the Road, you muſt ſignify by Writing the ſame, that it is a Village; but, that you may know Market-towns from Villages, write the Name of the Market-town in a different kind of Letter; and if you protract a Village that is in the Road, with Houſes ſcattering, you muſt place your Houſes ſcattering on the right or left Hand of the Road, as you noted them in the Field-book.

You muſt protract the Road all along with two Lines parallel one to the other. If your Road hath Hedges on both Sides, then draw your Lines black; but if your Road be an open Way, then draw it with pricked Lines; you may alſo inſert the Quality of the Ground, whether it be a *Common*, *Moor*, or *arable* Land.

If the Road paſs through a *Wood*, then make little Trees on both Sides the Road, to ſignify the ſame ſo far as the Wood goes.

If the Road paſſes over an *Hill*, you muſt, at the Beginning where the Hill aſcends, ſhadow very deep, and, as the Hill more and more aſcends, you muſt ſhadow it lighter, till you come to the Top thereof: But if the Hill makes an Angle of above 5 or 6 Degrees, or thereabouts, and the Height be above a Furlong, you muſt find the horizontal Line of that Hill, and protract that; otherwiſe a great Error may enſue.

If there be a Village or Town on the Side of the Hill, you muſt ſhadow it likewiſe, ſo that the Houſes may be ſeen. If the Remarks that are at a Diſtance from the Road ſtand on a Hill, make an Hill to repreſent the ſame.

If your Road paſs by or through a *Park*, *Foreſt*, or *Chace*, write down on your Road protracted, where you entered the ſame, and where you left it, writing the Name thereof among the Trees.

If your Road paſs over a *Ford*, draw the River quite croſs the Road, to ſignify there is no Bridge, and write the Name of the Ford; but if there be a Bridge, then draw the River on both Sides of the Road, till it touch the parallel Lines; and write the Name both of the Bridge and of the River; likewiſe write on that Side of the Road that the Stream runs from you, at what Place the River empties itſelf; and on the other Side of the Road

Road write from whence the Water or River hath its Riſe, if you can learn that of the Inhabitants.

All *Rills* you may ſignify by drawing a Line croſs the Road; and *Brooks* may be ſignified by drawing two Lines croſs the Road, and *Rivers* by more Lines, together with the Names; for all Rivers have Names, but Rills and Brooks often have none.

It will likewiſe be neceſſary, that you take Notice of the Quality of the Way, whether it be ſtony, clayey or boggy, and write it down on the Road that you have protracted: And by this Means you will have your Road very full of Remarks, and it will ſhew very neat and handſome.

SECT II.

Containing general Directions for making the Plot of a River or Brook, by the beforementioned Inſtruments.

FIRST, when you come to the Mouth of the River, cauſe a Man to go and ſtand at the next Bend thereof; then plant your Theodolite at the Mouth of the River, letting your Needle hang directly over the Meridian-line in the Box; there fix the Inſtrument faſt, and direct your Teleſcope to the Man that ſtands at the next Bending of the River, and note down the Angle in your Field-book, as you did in the Road.

Then cauſe the Man that drives the Wheel to meaſure between your firſt Station, and the Man at the next Bending; and note that down alſo in your Field-book, under Miles, Furlongs, and Poles.

Then bring your Inſtrument to the Man at the firſt Bending of the River, and cauſe that Man to go forwards, till he finds another Bending; there let

him ſtand; and, placing your Inſtrument where the Man laſt ſtood, let your Needle (as before) hang directly over the Meridian-line, and there make your Inſtrument faſt; then direct the Teleſcope to the Man that ſtands at the next Bending of the River, and note down the Angle in your Field-book, as you did in the former: And in this manner you muſt proceed all along the River, to the Head thereof.

In order to take the Breadth of the River, it will be convenient to ſend ſomebody on purpoſe croſs the River, in a Boat, (unleſs a Bridge or Ferry be near) and let him ſet up a Staff by the Brink of the River, on the further Side, to which Staff take a Bearing, from the Place of your Standing, which call the firſt Station; alſo let another Staff be ſet up on the ſame Side where you ſtand, and call that the ſecond Station, to which take a Bearing alſo. Now meaſure, in as ſtrait a Line as poſſible, the neareſt Diſtance between the 1ſt and 2d Stations, and that Diſtance note in the Field-book with the Bearings.

Plant the Theodolite at the ſecond Station, and take a Bearing to the ſame Mark on the further Side of the River, and note that Bearing alſo in the Field-book.

When you protract theſe Obſervations, lay the Center of the Protractor to ⊙ 1, and turn it about till the Diameter be parallel to the Meridians on the Paper; then againſt the Degrees of Bearing from ⊙ 1, to the Mark on the further Side of the River, and alſo to ⊙ 2, cloſe to the Limb of the Protractor make two Marks, through which, from ⊙ 1, draw two Lines at Length.

Set off the Diſtance between the two Stations on the 2d Line, and make it ⊙ 2, to which Mark lay the Protractor as before, and againſt the Degrees of Bearing obſerved at this 2d ⊙, to the Mark on the further Side of the River make a Mark, through which draw a Line at Length; then will this Line

interſect

interſect the firſt Line drawn at your firſt Station, and the Point of Interſection will ſhew the Breadth of the River.

In the ſame Manner are the Diſtances of the Churches, *&c.* from your Stations on the Road determined.

If there be a Ferry over the River, you muſt draw the River to its true Breadth, and make a pricked Line croſs the River to repreſent the Paſſage of the Ferry-Boat; and note on the Side of the River the Name of the Ferry.

In meaſuring on by the River, obſerve what *Bridges* you paſs by, and at what Diſtance from your laſt Station; alſo whether they be of Wood or Stone, and by what Name they are called; alſo take Notice of all *Corn-Mills*, *Paper-Mills*, &c. and note them in the Field-Book, in the Column of Remarks, with their Diſtance from the Mouth of the River, and your laſt Station.

Likewiſe take Notice of all the *Sluices* (if there be never ſo many) that are on the River, and of all the *Locks* and *Flood-gates* as you paſs along, with their Names, if they have any; alſo if there be any *Cut* or *Canal* from the River that you are meaſuring, note where it goes out of the River, and where it comes in again, and for what End it was ſo cut: Alſo where any *Brook* or *River* enters into that you are meaſuring, note down the Place, and the Name of the River that comes in; and alſo take an Account of thoſe Places of the River that are *fordable*, and note them down in your Field-Book: And in all theſe Caſes expreſs the Diſtance of each Remark from your laſt Station, as alſo their Diſtance from the Mouth of the River.

You muſt alſo note in your Field-Book all the *Towns* this River runs through, or by, with the Towns Names, and the Diſtance from your laſt Station and the Mouth of the River.

You

You must also take an Account of all the *Churches* that are on each Side the River within your View, by taking a Bearing to them at two several Places, as you did on the Road; and note them down in the Field-Book, with the Distance of the Place from your last Station, where you took the Bearing to the Steeple both Times; by this Means you will come to know how far each Church is distant from the River: The same you must do by all the *Windmills*, *Great Houses*, &c. noting their Names and Places of Situation in the Column of Remarks in the Field-Book.

When you have thus measured your main River, begin to measure the several *Branches* thereof; for there are but few Rivers but have smaller Rivers running into them, and all those small Rivers ought to be done with the same Exactness as the great ones.

Note, Every Bending of all the Rivers that are navigable must be taken exactly; but for other small Creeks there is no great Need; for you will find such small Brooks to have a Bend at every two or three Poles, nay sometimes less, therefore they are to be taken thus:

Take your Sights as far as you can conveniently, till you find the Brook to have a considerable Bending; and, if your Scale will permit, you may take Off-sets to represent the small Turnings and Windings thereof, as in *Fig.* 41: But, in measuring a small Brook, if your Scale is to be a Mile or two in an Inch, then these small Turnings and Windings cannot be described in the Map.

The Manner of protracting these Observations is the same with the Roads, except the Off-sets from the Station-Line to the Brink of the River, and its Breadth, which are particularly to be regarded.

SECT.

SECT. III.

General Directions for making a Map of a County, &c.

FIRST, from the County-Town, or other Market-Town, where you began your Work, lay down the principal *Roads* throughout the *County*, and protract them truly, as you observed them in your Survey, inserting the *Towns*, *Villages*, *great Houses*, *Cross-Ways*, &c. according to their true Situation, taken at two Stations, as you went on the Road; so will you (if Care be taken) have the true horizontal Distance of all those Places within Sight of the Roads, from the Road itself, or from one another.

Secondly, Lay down the *chief* Rivers that run through the County; so will you have the Situation of several more Towns, and other Remarks, as observed in your Survey of that River; and, when the main Rivers are done, all the Branches must be protracted with the like Exactness; for the main Rivers and Branches being exactly done, will be a great Ornament to a County Map.

Thirdly, If the County borders upon the Sea, first protract the *Sea-Coast* exactly; and then take a Survey of and plot all *Rocks*, *Sands*, or other Obstacles that lie at the Entrance of any River, Harbour, Bay or Road, upon the Coast of that County, by going out in a Boat to such Sands or Rocks that make the Entrance difficult; and, at every considerable Bend of the Sands, take, with a Sea-Compass, the Bearing thereof, to two known Marks upon the Shore: And, having so gone round all the Sands and Rocks, you may, upon the Plot before taken of the Coast, draw Lines, which shall intersect each other

other at every conſiderable Point of the Sands; whereby you may give good Directions either for the laying of *Buoys*, or making Marks upon the Shore, for the Direction of Shipping; and the beſt Time to do this, is at low Water, in Spring Tides.

Fourthly, Having truly protracted the principal Roads, Rivers, *&c.* with the ſeveral Remarks obſerved from thence, you'll find moſt of the remarkable Places in the County laid down: But, in order to compleat the Work, look upon ſome old Map of the County, and contrive three or four Market-Towns, or other Towns, to meaſure thro', that you have not yet laid down, and from thence to other Towns or Villages; and ſo do till you have meaſured moſt or all the Roads that lead from Market-Town to Market-Town, taking all the Remarks you can as you go along; and if you find any Thing remarkable in the old Map, that you have not yet taken Notice of, you may go and ſurvey it. And thus, by Degrees, you may ſo finiſh a County, that you need not ſo much as leave out one Gentleman's Houſe; for ſcarce will any Thing remarkable eſcape coming into your View, either from the Roads, Rivers, or Sea-Coaſt.

Fifthly, When you are in a Town, place your Inſtrument, if you can, upon the Steeple, and from thence take the horizontal Angles to the moſt remarkable Objects within your View; take the Bearings of theſe a ſecond Time from ſome other eminent Place, and meaſure the Diſtance between theſe two Stations. *Note*, All Churches are to be laid down according to their horizontal Diſtance one from the other: Therefore, if the Road between them be over Hills of a conſiderable Height, the hypothenuſal Lines on the Road muſt be reduced to horizontal.

Sixthly,

Sixthly, All Parks and Foreſts muſt be truly laid down in the Map, as to their true Bounds and Situation; and alſo all remarkable Lakes of Water: You are likewiſe to deſcribe the Quality of the County, whether it be hilly or woody, placing the Hills and Woods in their true Situations.

Laſtly, Take the true Latitude in three or four Places in the County; which put down on the Edge of your Map accordingly.

SECT. IV.

General Directions for taking the Ground-Plot of a City or other Town.

THE Performance of this Work is very laborious, and you muſt be careful to keep the Field-Book in a plain and regular Manner, otherwiſe the Multitude of Obſervations and Off-ſets will be apt to breed Confuſion; but if Care be taken therein, you'll find the Work not very hard to be done: One that underſtands the fifth Chapter will make no Difficulty of this Section, for the ſeveral Streets, Lanes, *&c.* in a City are ſurveyed and protracted in the ſame Manner as the Lane, *Fig.* 41. The ſeveral Off-ſets to the Houſes, Churches, *&c.* all along the Sides of the Street being taken from the main Station-Line, running through the Middle thereof, in ſuch Sort as the Off-ſets are taken from the Station-Line to the Hedges, Gates, *&c.* on the Sides of the Lane.

The Inſtruments for this Purpoſe, are, 1. The *Theodolite* as before deſcribed, to meaſure the ſeveral Angles made by your Station-Lines, as they incline out of one Street into another; and in this Caſe work with the Limb only, but never truſt to the Needle; for (beſides the Danger of its being attracted) you will

will find it neceſſary to lay down every Line by ſome other, given in Poſition in the Plot itſelf, rather than by the Bearings from the Meridian.

2. The *Chain*; and becauſe the Ground-plot of the Houſes, Pavements, *&c.* is generally laid out by Foot-meaſure; therefore let every Link thereof be a Foot long, and fifty of theſe Links will make the Chain of a ſufficient Length, diſtinguiſhed at every ten Links by Marks, as *Gunter*'s Chain is: But, if the Content of any Part of the Plot be deſired in Acres, you may reduce the Feet in any Line to Links; and for this Purpoſe the Table in *Chap.* II. will be a ready Aſſiſtant.

3. The *Off-ſet-Staff*, divided alſo into Feet, five o fwhich may make it of a convenient Length, becauſe you will have Occaſion to meaſure many Paſſages, Alleys, *&c.* that are not wider; alſo at one End of the Staff you may have a Piece of about three Feet joined, like the Square of a Drawing-board; and this will be a Direction to meaſure the Off-ſets from the Chain at Right-Angles.

4. The *Scale* (or a Beam-Compaſs) according to the Bigneſs of the Plot; the *Protractor*, the *Drawing-Pen*, &c.

Firſt, in one of the principal Streets, as at ⊙ 1, in the Lane, *Fig.* 41. ſet up a Station-Staff, and ſend another forwards in the Street as far as you can ſee; then lay the Chain on the Ground exactly in the ſame Direction with the two Stations; and with the Offſet-Staff, both to the Right and Left at Right-Angles from the Chain, meaſure the Off-ſets as in the Lane, taking Notice at how many Links from the laſt Station each is laid off; and when any of thoſe Off-ſets reach any remarkable Houſe, *&c.* or the Corner of a Street, Alley, or Court, enter ſuch a Remark againſt the reſpective Off-ſet, in one of

of the outside Columns of the Field-Book: And in this Manner proceed to the second Station.

Set up the Theodolite at the second Station, and bring the Index to 360 on the Limb, turning the whole Instrument about till you see through the Telescope the Staff at ⊙ 1; there fix the Instrument, and then turn about the Index, directing the Telescope to another Staff sent forwards in the Street, to the further End thereof, if you can see so far; and note in the Field-Book the Angle which the Index cuts on the Limb with the utmost Exactness: Then proceed with the Chain towards the next Station as before.

Having in this Manner gone through several of the principal high Streets, that lead through one Part of the Town, it will be convenient, as you pass along, as often as you come against any cross Street, to take a Sight down it, and note the Place or Mark to which the Telescope is directed, and also at how many Links Distance from the last Station the Instrument is planted, when you thus look into a cross Street: Note both these Places in your Field-Book, or Eye-draught, with this Mark ⊙; so that you may be sure to find the Place exactly, when you begin to take your cross Streets.

It will be convenient not only to enter your Observation in the Field-Book, but also to form a Sketch or Eye-Draught of the Work, as you go along, making Lines to imitate the same; and draw the cross Streets, Alleys, *&c.* thereon, in such Manner (as near as you can guess) as you see those cross Streets to bear from the Place of your Standing in the high Streets, and write the Name of each Street between the Lines representing the same; and this will be useful when you come to protract.

Note, Before you begin your Work, it will be necessary to walk about the Town, and chuse four or five principal Streets that lead out of one into

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another, incloſing between them ſeveral By-Lanes, Alleys, *&c.* And contrive your firſt Station in ſuch a Manner, that when you come round theſe four or five Streets, the laſt Station-Line may cloſe exactly on the firſt Station-Point; and obſerve, that the fewer Angles you make in going round theſe Streets before you cloſe, the better.

This is no more than ſurveying a Field; the main Difficulty will be to find your Stations when you come to ſurvey the croſs Streets, By-Lanes, Thoroughfares, *&c.* between the eminent Streets that you firſt went round; but you may help yourſelf herein, if you lay one End of the Chain at ſome Door, or other remarkable Place on the right Side of the Street; and draw it in a ſtrait Line through the Station-Point to ſome Remark on the other Side of the Street; taking Notice at how many Links from the Right, the Chain cut the Station: You may alſo much help yourſelf herein by your Eye-Draught.

When the Station-Line leads you into a Square, you may plant the Theodolite in the Middle thereof, and from that one Station direct the Teleſcope to the Corners (very often there are but four, and the Sides all ſtrait) and meaſure the Diſtances from that Station to the Corners, as in *Chap* II. *Sect.* 4. But if you would take Notice of particular Houſes therein, or if the Sides are very irregular, then go round it: But Lanes and Alleys are laid down by Off-ſets only, from the Station-Line through the Middle.

Having thus finiſhed one Part of the Town or City, you may proceed to another till the Whole be finiſhed; but this is a Work that will take up a great deal of Time.

The Manner of protracting this Work is the ſame as in the preceding Chapters, therefore particular Directions are needleſs; but 'tis beſt to protract ſo much as you ſurvey in one Day, before you proceed with

with more; and, for this Purpoſe, a Skin of fine ſoft Parchment is better than Paper, unleſs the Paper be very fine, and paſted on Cloth or Canvas. The Ground-Plots of Churches muſt be very exactly taken, and laid down in the ſame Manner on the Draught, and ſhadowed very deep; the ſame muſt be obſerved of Houſes.

Alſo, if you uſe a Protractor that will lay down Minutes, your Work will be more likely to cloſe; for you cannot be too curious in obſerving and laying down the Angles, eſpecially thoſe in the principal Streets.

APPENDIX

TO THE

Practical SURVEYOR.

CHAP. I.

Of LEVELLING.

SECT. I.

Of the Spirit-Level and Station-Staffs.

THE Inſtrument, commonly uſed for *Levelling of Land*, conſiſts of a *Braſs Teleſcope* of about two Feet long, in the Focus of which is fixed an horizontal Hair, to cut the Object in Time of Obſervation: Upon the Teleſcope is fixed with two Screws a ſmall *Braſs Tube*, within which is a *Glaſs Tube* containing ſome *Spirits*. This Tube is hermetically ſealed at each End, to prevent the Spirits running out; and the Braſs Tube is filed away on the upper Side, ſo that the Glaſs Tube, and the *Bubble of Air* moving in it from End to End, may be ſeen. This *Bubble* is the Direction for ſetting the Inſtrument, and is occaſioned by the Glaſs not being quite filled with Spirits. The Bore of the Tube and the Length of the Bubble ſhould be bigger, according to the Degree of Accuracy that is required; for the bigger theſe are, the Friction will be leſs,

and the Motion more ſenſible. Some will move ſenſibly to 5 or 6 *Seconds*; but, for the Purpoſe of levelling Ground, they ſhould not be made to move ſo quick; for, in that Caſe, the Inſtrument would be ſcarce manageable.

The Teleſcope ſhould be fixed upon a *Braſs Bar* of a convenient Strength, and of near the whole Length of the Teleſcope: At the farther End of this Bar there ſhould be a ſhort *Axis*, upon which the Teleſcope may have a ſmall Motion up and down; and at the hither End there ſhould be a *Hair Screw*, by which the Teleſcope may be gently raiſed or depreſſed, till the Bubble reſts exactly in the Middle of (or at ſome particular Mark in) the Glaſs Tube, which is the Situation it muſt be always in at the Time of Obſervation. Under the Middle of the Braſs Bar ſhould be fixed a *Socket*, by which the whole Inſtrument may be readily fixed to the *three-legged Staff*, belonging to the Theodolite. Inſtruments for levelling ſhould be ſo contrived, that the Agreement of the Hair in the Teleſcope, and the Bubble in the Glaſs Tube, might be eaſily examined, and (if need be) adjuſted at every Obſervation: But, as they are not uſually ſo made, the common Way of rectifying them will be ſhewed in the next Section.

Of the Station-Staffs.

Provide two *Station-Staffs*, each 10 Feet long, that may ſlide one by the Side of the other to 5 Feet, for eaſier Carriage; let them be divided into 1000 equal Parts, and numbered at every 10th Diviſion, 10, 20, 30, 40, *&c.* to 100, and from 100, 110, 120, *&c.* to 200, and ſo on till you come to 1000; but every centeſimal Diviſion, as 100, 200, 300, to 1000, ought to be expreſſed in large Figures, that the Diviſions may be more eaſily counted; and

you

you may have another Piece 5 Feet long, divided alſo into 500 Parts, to be added to the former, when there ſhall be Occaſion.

Upon theſe Staffs are two *Vanes*, made to ſlide up and down, which will alſo ſtand againſt any Diviſion on the Staff, by the Help of Springs. Theſe Vanes may be made about 3 or 4 Inches wide, and about 10 Inches long; let the Faces of them be divided into 3 equal Spaces, by two Lines drawn lengthways; let the two extreme Spaces be painted white, and let the middle Space be divided alſo into 3 ſmaller equal Spaces, and let that in the Middle be painted white, the other 2 black, which will render them fit for all Diſtances.

Being thus provided with a good *Spirit-Level*, *two Sation-Staffs*, a *Chain*, and *two Aſſiſtants*, you may proceed to your Work; but firſt it will be neceſſary to make a Trial whether or no your Level be well adjuſted.

SECT. II.

How to adjuſt the Spirit-Level.

CHUSE ſome Field or Meadow that is nearly level, and ſet down the Inſtrument about the Middle thereof, and make an Hole in the Ground, under the Center of the Inſtrument; from which meaſure out, in a right Line, ſome convenient Length, as 20 Chains, and there leave one of your Aſſiſtants with his Station-Staff; then return to the Inſtrument, and meaſure out the ſame Number of Chains, *viz.* 20, the other Way, by the Direction of the Inſtrument, and laſt Station-Staff, as near in a Right Line as you can gueſs, and there leave your other Aſſiſtant with his Station-Staff; ſo will the Inſtrument and two Station-Staffs be in the ſame ſtrait Line.

Then return to the Inſtrument, and turn the Teleſcope about to your firſt Aſſiſtant, and move the Teleſcope by the Hair Screw, till the Bubble reſts exactly in the Middle of the Spirit-Tube; then obſerve where the Hair in the Teleſcope cuts the Staff, and direct your Aſſiſtant to move the Vane up or down, till the Hair cuts the Middle thereof, ſo that you may ſee as much of the Vane above the Hair as below it, and there give him a Sign to fix it; then direct the Teleſcope towards your ſecond Aſſiſtant, and proceed in the ſame Manner; ſo are the Vanes on each Staff placed horizontally, or in a Level one with the other.

Remove the Inſtrument to that Aſſiſtant which is neareſt the Sun, if it ſhines, that you may have the Advantage of its Rays upon the other Aſſiſtant's Vane, and there ſet down the Inſtrument as near the Staff as you can; then having ſet the Inſtrument horizontal, ſo that the Bubble reſts in the Middle of the Tube; obſerve what Diviſion on the Staff is then cut by the Hair in the Teleſcope, above or below the Middle of the Vane; for ſo many Diviſions muſt the other Aſſiſtant's Vane be raſed or depreſſed, which direct him to do accordingly.

But, becauſe the Inſtrument is 40 Chains diſtant from the Station-Staff, you muſt make an Allowance for the Earth's Curvature, which by the following Table you will find to be $16\frac{6}{10}$ Parts, therefore let the Vane on the Staff be raiſed $16\frac{6}{5}$ Parts.

Thus, 16.6 of a foot
× 12
1992 wch call 2 inches

A TABLE *of the* Earth's Curvature, *calculated to the Thouſandth Part of a Foot, at the End of every Chain, from* 1 *Chain to* 40.

Chains	Dec. Feet	Chains	D. Feet.	Chains	D. Feet.	Chains	D. Feet.
1	.000	11	.013	21	.046	31	.099
2	.000	12	.015	22	.050	32	.106
3	.001	13	.017	23	.035	33	.113
4	.002	14	.020	24	.060	34	.120
5	.003	15	.023	25	.065	35	.127
6	.004	16	.026	26	.070	36	.134
7	.005	17	.030	27	.075	37	.141
8	.007	18	.033	28	.081	38	.149
9	.008	19	.037	29	.087	39	.157
10	.010	20	.041	30	.093	40	.166

Now direct the Teleſcope to the Vane thus raiſed, and if the Hair cuts the Middle thereof, while the Bubble reſts in the Middle of the Tube, the Inſtrument is right; but if not, you muſt raiſe or depreſs the Teleſcope till the Hair cuts the Middle of the Vane; and then by the Help of the Screws that fix the Spirit-Tube to the Teleſcope, move the Bubble till it reſts in the Middle of the ſaid Tube: So is the *Level* adjuſted.

SECT. III.

Rules to be obſerved in Levelling, in order to find the different Height of any two Places; being uſeful for conveying Water, cutting Sluices, making Soughs, &c.

SUppoſe it was required to know whether Water may be conveyed in Pipes or Trenches, from a Spring-Head to any aſſigned Place.

1. At the Head of the Spring ſet up one of your Station-Staffs as nearly perpendicular as you can, and leave with one (whom you may call your firſt Aſſiſtant) proper Directions for raiſing or depreſſing the Vane on his Staff, according to certain Signs which you (ſtanding at your Inſtrument) ſhall give him: Alſo let him be provided with Pen, Ink, and Paper, to note down very carefully the Diviſion on the Staff which the Vane ſhall cut, when you make a Sign that it ſtands in its right Poſition.

2. Carry your Inſtrument towards the aſſigned Place you are going to, as far as you can ſee, ſo that through the Teleſcope you may but ſee any Part of the Staff left behind, when the Inſtrument is ſet horizontal; and from that Place ſend your ſecond Aſſiſtant forwards, with his Station Staff, with the ſame Inſtructions as you gave your firſt Aſſiſtant.

3. Set the Inſtrument horizontal, and direct the Teleſcope to your firſt Aſſiſtant's Staff; then bring the Bubble exactly to the Middle of the Tube, and, when it reſts there, give a Sign for your Aſſiſtant to note the Parts of the Staff where the Vane reſts.

4. Turn about the Teleſcope to your ſecond Aſſiſtant's Staff, and by the adjuſting Screw, as before, ſet the Bubble exact: Then direct your ſecond Aſſiſtant to move the Vane higher or lower till you ſee the Hair in the Teleſcope cut the Middle of the Vane, (but in long Diſtances the Hair will almoſt cover the Vane; however, let it be in ſuch Manner that as much may be above the Hair as below it, as near as you can gueſs) and then give him a Sign to note the Diviſion on the Staff; and always let your Aſſiſtants note the Diviſion cut by the upper Edge of the Vane.

5. Let your firſt Aſſiſtant bring his Station-Staff from the Spring-Head, and give it to the ſecond Aſſiſtant, and let your ſecond Aſſiſtant carry it forwards

wards towards the aſſigned Place you are going to, and at a convenient Place erect it perpendicular; whilſt your firſt Aſſiſtant tarries at the Staff where your ſecond Aſſiſtant ſtood before.

6. Place your Inſtrument between your two Aſſiſtants, ſomewhere about the Middle, if you can; and firſt direct the Teleſcope to your firſt Aſſiſtant's Staff, and when the Teleſcope is levelled to one of the Diviſions on the Staff, let him note that Diviſion in an orderly Manner under the firſt Obſervation; and let your ſecond Aſſiſtant do the ſame: And in this Manner proceed over Hill and Dale, as ſtrait forward as the Way will permit, to the appointed Place (by only repeating theſe Directions) tho' it be 20 Miles diſtant from the Spring-Head; but in your whole Paſſage let this conſtant Rule be obſerved, otherwiſe great Errors will enſue, (*viz.*) That your firſt Aſſiſtant muſt at every Station ſtand between the Spring-Head and your Inſtrument, and your ſecond Aſſiſtant muſt always ſtand between the Inſtrument and the appointed Place to which the Water is to be conveyed.

Being come to the appointed Place, let both your Aſſiſtants give in their Notes, which ought to ſtand in Manner and Form following.

Firſt Aſſiſtant's Notes.		*Second Aſſiſtant's Notes.*	
Stations.	*Parts.*	*Stations.*	*Parts.*
⊙ 1	1019	⊙ 1	330
⊙ 2	512	⊙ 2	540
⊙ 3	737	⊙ 3	1337
⊙ 4	40	⊙ 4	742
⊙ 5	1495	⊙ 5	30
⊙ 6	1475	⊙ 6	32
⊙ 7	1430	⊙ 7	30
⊙ 8	1149	⊙ 8	227
Sum.	7857	*Sum.*	3268

Theſe

These Notes were collected from Observations made at several Stations between the Ground at the North-Gate at *Hanover-Square*, and the Surface of the Square-Pond by the *New-River Head*, near *Islington*. The first Assistant's Notes, when added together, amount to 7857; the second Assistant's 3268; the Difference 45,86 Parts, that is almost 46 Feet; and so much is the Pond higher than the Ground of that Part of the Square where the first Station-Staff was planted.

The following Observations were repeated in the Afternoon of the same Day, at quite different Stations, from the Pond before-mentioned to the said North-Gate of *Hanover-Square*; and then the two Assistant's Notes stood in the following Manner:

First Assistant's Notes.		*Second Assistant's Notes.*	
Stations.	*Parts*	*Stations.*	*Parts.*
⊙ 1	290	⊙ 1	1278
⊙ 2	36	⊙ 2	1515
⊙ 3	77	⊙ 3	1395
⊙ 4	68	⊙ 4	1500
⊙ 5	58	⊙ 5	74
⊙ 6	1243	⊙ 6	38
⊙ 7	998	⊙ 7	468
⊙ 8	437	⊙ 8	774
⊙ 9	206	⊙ 9	1066
Sum.	3513	*Sum.*	8108

These Notes, as observed in the Afternoon, being added together, and the lesser subtracted out of the greater, the Difference is 45,95 Parts, which very nearly agrees with the former Observations; being but $\frac{5}{100}$ of a Foot Difference, which is inconsiderable.

Note, If from the first Assistant's Staff you measure any Number of Chains towards the Place you are

are going to, ſuppoſe 10, and there ſet down the Inſtrument, and then meaſure ten Chains forwarder, and there place the other Station-Staff; you will have no Occaſion to make any Allowance for the Curvature of the Earth, becauſe, the Inſtrument being planted in the Middle of the Diſtance between the Station-Staffs, the Errors mutually deſtroy each other.

But this Meaſuring of the Diſtances with the Chain, or otherwiſe, is very tedious, and indeed impracticable in many Caſes, unleſs you make a Multitude of Stations: So if the Way between the two determined Places, whoſe different Height you would know, lies over Hills and Dales, as *Fig.* 45, you muſt in that Caſe make four or five Stations (otherwiſe you will not be able to ſee any Part of the Staff, when the Inſtrument is ſet horizontal) which might as well be done at one Station (as in the foregoing Obſervations) in the following Manner.

SECT. IV.

How to make Allowance for the Curvature of the Earth, when the Station-Staffs are planted at unequal Diſtances from the Inſtrument.

SUppoſe the Inſtrument was planted on the Eminence between the two Valleys A and B. *Fig.* 45. the firſt Aſſiſtant with his Station-Staff, ſtanding at C, and the ſecond at D; and it is required to know the different Height of the Hills C and D.

Firſt ſet the Inſtrument horizontal; and then direct the Teleſcope to the firſt Aſſiſtant's Staff at C, and by the adjuſting Screw ſet the Bubble exact, obſerving where the Hair cuts the Staff; then

by

by Signs cauſe your Aſſiſtant to move the Vane higher or lower till the Hair cuts the Middle thereof; and then give him a Sign to note the Diviſion cut by the upper Edge of the Vane, which ſuppoſe 104 Parts from the Ground, and you will find the Diſtance from the Inſtrument to the Staff at C to be about ten Chains *.

Then direct the Teleſcope to D, and, proceeding in the ſame Manner as before, you will find that the Hair cuts 849 Parts from the Ground: The Diſtance to D is about 35 Chains.

Next look into the Table of Curvature, and, againſt 10 Chains, you will find one Part to be deducted from the Curvature of the Earth at that Diſtance, ſo will the firſt Aſſiſtant's Note be made 103 Parts.

Alſo againſt 35 Chains, you will find $12\frac{7}{10}$, which being deducted out of 849, there will remain $836\frac{3}{10}$ Parts, which muſt be noted by the ſecond Aſſiſtant.

Now if 103, as noted by the firſt Aſſiſtant, be ſubtracted from $836\frac{3}{10}$, as noted by the ſecond, the Remainder will be $733\frac{3}{10}$; and ſo much the Hill C is higher than the Hill D: But, if you have not the Table of Curvature at hand, then you may find the Allowance that is to be made at any Diſtance, by this Rule.

Multiply the Square of the Diſtance in Chains by 31, and divide the Product by 300000.

In this Manner, making an Allowance for the Curvature of the Earth, you may ſend a Station-Staff forwards half a Mile, or farther, from the Inſtrument; and take a Sight over ſeveral Valleys at once, the horizontal Diſtance in this Caſe being only regardable.

Note, When Water is to be brought to any appointed Place, there muſt be an Allowance of $4\frac{1}{2}$

* Note, The Diſtance is here ſuppoſed to be found by the Theodolite, or ſome other Inſtrument fitted for this Purpoſe.

Inches

Inches for every Mile, more than the ſtrait Level, for the Current of the Water; but if the Spring-Head be much higher than the appointed Place, ſo that the Water will have too violent a Current, the Pipes may be laid one up and another down; and, inſtead of being laid in a ſtrait Line, the Water may be brought in a crooked or winding Way.

CHAP.

CHAP. II.

Shewing the Uſe of the Theodolite, *in drawing Buildings*, &c. *in Perſpective.*

WHEN a *Building* is to be drawn upon a *Perſpective Plane* (or *Picture*) the *Repreſentation* of the ſeveral Objects ought to be delineated thereon according to their Dimenſions and different Situations, in ſuch Manner that the ſaid Repreſentations may produce the ſame Effects on our Eyes as the Objects whereof they are the Pictures.

But without mathematical Rules this Repreſentation cannot well be found; for when Objects are drawn by only viewing or looking at them, their true Repreſentations will often be miſſed; whereas by the following Method they may always be obtained.

For all Objects appear ſuch as the viſual Angle under which they are ſeen; which Angle is taken at the Eye, where the Lines meet that compriſe the Object; that is to ſay, an Object ſeen in a great Angle will appear great; and another ſeen in a little Angle will appear little; which is the principal Thing to be obſerved in Perſpective.

So the Windows 6, 7, 8, *Fig.* 46, muſt be drawn on the Perſpective Plane of different Dimenſions (altho' on the Building one of them is really as big

as

as the other) according to the Angle which the Rays from their Extremities make with the Eye at *z*.

Objects of equal Bigneſs appear greater or leſs, according to their Diſtance from the Beholder's Eye; ſo the Windows 6 and 8 are really one as big as another on the Geometrical Plane; but the Window 6, at the End of the Building, being nearer the Eye at *z*, than the Window 8 on the Front, it muſt be made ſo much larger on the Perſpective Plane, as the Window 6 is nearer than that marked with 8.

Therefore, if the Angles, under which Objects appear, be given; thoſe Objects may be drawn on the Perſpective Plane (or Paper) according to their Dimenſions and different Situations, in the ſame Form as they appear to the Beholder at any Diſtance.

The Figures on the Geometrical Plane (or Building) are compoſed either of ſtrait Lines, or Curves: Now, to find the Repreſentation of a ſtrait Line, its Extremes need only be ſought: And, to find the Appearance of a Curve, we need only to find the Place of ſeveral Points therein. And hence it follows, that the whole Buſineſs of Perſpective conſiſts in finding only the Place of a Point.

But theſe Points cannot be determined, unleſs by the Interſection of Right Lines. And the Reaſon of theſe Sections is, That one Line can determine nothing: Therefore it is neceſſary, that there be two of them, which divide themſelves, (forming an Angle) for to have the Place of a Point, as will be ſeen in the following Example.

The Inſtrument referred to in this Chapter, is ſuppoſed to take horizontal and vertical Angles, both at the ſame Time; and the Method here laid down may ſerve for an Amuſement, and to ſhew what Theory alone may do: But I fancy thoſe who are already acquainted with the Rules of Perſpective, would hardly be prevailed upon to make uſe of a Theodolite for this Purpoſe; and for thoſe who are not, they had better make uſe of a *Camera Obſcura*.

SECT.

SECT. I.

Let Fig. 46 repreſent a Building as viewed from Z, being the Place from which the Proſpect is deſired to be taken.

THE Inſtrument being planted at *z*, and the Staffs made to ſtand firm on the Ground, I ſet the Inſtrument exactly level; and with the Index at 360, and the Quadrant at 0 Degrees, I direct the Teleſcope to ſome Part of the Building, as to *o*, by turning about the whole Inſtrument, and there ſcrew it faſt, that it ſtir not out of this Poſition, till the ſeveral Obſervations be finiſhed.

The Inſtrument being ſet level, the Index, when turned round on the Limb, carries the Teleſcope in a Line parallel to the Horizon, as *x*, *y*: And the Quadrant, elevated or depreſſed, moves always in a Circle vertical thereto, as *w*, *z*.

Now with one Hand move the Index on the Limb, and with the other elevate or depreſs the Teleſcope as there ſhall be Occaſion, till you ſee the croſs Hairs therein cut any Point on the Building; and then note down, on a Piece of Paper, the Degrees and Minutes which the Index cuts on the Limb in one Column, and call thoſe the horizontal Angles: Likewiſe note the Degrees and Minutes cut by the Quadrant in another Column, and call thoſe the vertical Angles.

So the Teleſcope being directed to the Point *a*, the Index then cuts 7° 25′, and the Quadrant 19° 30′; and thoſe Obſervations, when protracted, will give the Point *a*.

Likewiſe I make Obſervation of the Point *b*; and then depreſs the Teleſcope to the Bottom of the Building at *c*, and the Index then cuts the ſame Angle

gle on the Limb as at *b*, and the Quadrant 8° 30′: But this Angle of Depreſſion muſt be marked with A, or ſome ſuch Mark to diſtinguiſh it from the Angles of Elevation, that, in protracting that Point, it may be known to be under the Horizon, or the Line *x y*.

When the Inſtrument is planted at a conſiderable Diſtance from the Building, the Ground there may be higher or lower than any Part of the Building: And then all the Points will be above or under the Horizon; and in ſuch Caſe there will be no Occaſion for this Diſtinction,

In the ſame Manner I make Obſervation of ſo many Points on the right Side of the Houſe as is convenient; but, when the Teleſcope is directed to the Point *m* on the left Side, the Index cuts 340° 40′.

Now this Number 340° 40′ muſt not be noted for the horizontal Angle, but its Complement to 360 (*viz.*) 19° 20′, by ſubtracting 340° 40′, out of 360; but, if the Degrees be numbered by ſmall Figures from 360, the contrary Way, as 10, 20, 30, *&c.* to 60, or further, as may conveniently be done, the Numbers will increaſe from 360, both to the Right and Left; and then the Index will always cut the Number denoting the horizontal Angle, in the ſame Manner as the Quadrant.

Having obſerved the Point *m*, the Index remaining at the ſame Angle on the Limb, I depreſs the Teleſcope to the Points, 4, 3, 2, 1, and note the Degrees, *&c*, cut by the Quadrant; which, when protracted, will give the Breadth of the Faces and their Diſtance one from another.

Next I obſerve the Points of the Window *e i u*, in the left Wing of the Building; and, becauſe theſe Remarks are on the left Side of the Building, therefore I note them by ſuch Names as I call the ſeveral Points I look at (inſtead of the Letters *a*, *b*, *&c.*) on the left Side of the Column of Obſervations,

viz. contrary to that Part of the Limb where the Index cuts (which remember) for when the Index is turned from 360, on the Limb towards the right Hand, the Teleſcope moves towards the left: And theſe Remarks, thus noted, muſt be protracted on the left Side of the vertical Line *w z*, *Fig.* 46.

In making theſe Obſervations, 1. *Set the Inſtrument level in that Place from which the Proſpect is deſired to be made; and, with the Index at* 360, *direct the Teleſcope to ſome remarkable Place about the Middle of the Building, and there fix the Inſtrument.*

2. *The Remarks on the right Side of the Building enter in the Column of Obſervations on the right Hand*; and è contra.

3. *If there be Angles both of Elevation and Depreſſion, mark the Angles of Depreſſion with* Λ.

The Obſervations of moſt of the Points, that need to be taken of *Fig.* 46. in order to protract or draw the ſame in Perſpective, are inſerted in the following Table: And obſerve, that, if the Building be regular, there will need but few Points to be given; for, where you have the Height and Breadth of one Window given, with its Diſtance from the next, the whole Row may thereby be drawn, being all of the ſame Dimenſions; but Objects more irregular muſt be drawn by obſerving ſo many Points therein, as ſhall be neceſſary: But Practice in this Caſe is the beſt Guide.

SECT.

SECT. II.

The Manner of Protracting these Observations, in order to find the Points of the Building. Fig. 46.

	Horizon. Angles.	*Vertical Angles.*	
	7° : 25′	19° : 30′	*a*
	11 : 39	16 : 30	*b*
	14 : 30	8 : 30	*c* Λ
	19 : 20	26 : 50	*d*
	19 : 20	13 : 30	*e* Λ
	38 : 00	26 : 50	*f*
	38 : 00	13 : 30	*g* Λ
4	19 : 20	26 : 50	
		25 : 30	
3	——	18 : 40	
2	——	9 : 35	
Λ : 1	— —	1 : 00	
i	18 : 30	19 : 00	
e	18 : 30	22 : 40	
u	16 : 50	17 : 50	

FIRST draw a right Line *xy*, Fig. 46. for the horizontal Line; and at right Angles therewith draw another Line *w z*, which represents the vertical Line.

Set off the Points of Distance from *o*; (*viz.*) from that Point where *xy*, and *w z*, intersect one another: And, according to what Bigness you would have the Plan of the Building be, make the Distance bigger or less. If you would have the Draught large, make the Distance large: *Et è contra.* There-

fore ſet one Foot of the Compaſſes at *o*, and with the ſame Extent mark the Points of Diſtance *x*, *y*, *z*.

The horizontal Angles muſt be drawn from the Point *z*, to the horizontal Line *x y*; and the vertical Angles from the Points *x*, or *y* (according as the Remarks are noted on the right or left Side of the Columns) to the vertical Line *w z*.

The Index muſt be at 360, and the Quadrant at *o*, when the Croſs hairs in the Teleſcope cut the Point *o* on the Building: Therefore the Point *o* ſhall be the firſt Point of Sight on the perſpective Plan.

By the Table of Obſervation I find, that the Index cut 7° 27′ on the Limb, and the Quadrant 19° 30′, when the Teleſcope was directed to the Point *a*: Therefore lay the Center of the Protractor to *z*; and, becauſe the Letter *a* is noted on the right Side of the Columns, lay the Limb on the right Side of the Line *w z*, the Diameter being coincident therewith; and, againſt 7° 25′, make a Mark cloſe by the Limb of the Protractor.

Lay the Edge of a ſtrait Ruler to the Point of Diſtance *z*, and to that Point 7° 25′; and where the Edge cuts the horizontal Line make a Mark.

Lay the Center of the Protractor to the Point of Diſtance *y*, (becauſe *a* is noted on the right Side of the Columns) the Diameter coincident with the Line *x y*; and, againſt 19° 30′ on the Limb, make a Mark.

Lay a ſtrait Ruler to that Mark, and the Point of Diſtance *y*; and where the Edge cuts the vertical Line *w z*, make a Mark at *r*.

Laſtly, lay a parallel Ruler to the horizontal Line *x y*, and move it parallel thereto, till the Edge cuts the Point *r* in the vertical Line, and with the Compaſs Point draw the obſcure Line *r* 5.

Then lay the parallel Ruler to the vertical Line *w z*, and move it parallel thereto till the Edge cuts the

the Point *t*, in the horizontal Line *x y*, and by the ſame Edge draw an obſcure Line *t* 9; ſo ſhall the Interſection of theſe two Parallels determine the Place of the Point *a*, which was ſought.

In the ſame Manner may the Point *b*, or any other Point be found: And then theſe Points, joined with right Lines, ſhall repreſent the Lines on the Building, and bear an exact Proportion thereto, according to the Rules of Perſpective.

The Point *c* is found in the ſame Manner as *a*, only, becauſe the horizontal Angle is the ſame with the Point *b*, you have no more to do but continue a ſtrait Line from *b*, through the Point *x* in the horizontal Line, parallel to *w z*; and then lay the Center of the Protractor to *y*, with the Limb downwards; becauſe *c* is marked with ∧ (*i. e.*) under the Horizon; and draw the vertical Angle 8° 30′, to 8 in the vertical Line; ſo ſhall a Line drawn parallel to *x y*, from the Point 8, cut the obſcure Line *b c*, at *c*, the Point ſought.

The Points *h*, *k*, *l*, *m*, *n*, *p*, *q*, on the left Side of the Building, *Fig.* 46. have the ſame Angles with *a*, *b*, *c*, *d*, *e*, *f*, *g*, on the Right, and therefore protracted in the ſame Manner; excepting this Difference, that becauſe the Points *h*, *k*, *l*, *&c.* are on the left Side of the Building, therefore the ſame Points muſt be found on the left Side of the vertical Line *w z*, and the Protractor laid to the Point of Diſtance *x*; but the horizontal Angles are all laid off from the ſame Point of Diſtance *z*.

Obſerve, that, in protracting theſe Points, it is convenient, that the Numbers on the Semicircular Protractor ſhould be made to increaſe from the Diameter both Ways, that the Numbers may be counted thereon, both to the Right and Left: And then, in protracting any Point on a Building, 1. Draw the

horizontal Angle from the Point of Diſtance *z*, to the horizontal Line *x y*, as to *t*. 2. Draw the vertical Angle to the vertical Line *w z*, as to *r*. 3. Draw Lines parallel to *w z*, and *x y*, through the Points *t* and *r*; ſo ſhall the Interſection of the two Parallels give the Point ſought.

But theſe Points are found with much greater Expedition, if the Paper on which you draw the Plan of the Building, be faſtened to a *Drawing-Board*, and the Angles laid down by the *Sector* in the following Manner:

For Example: Suppoſe the Point *a*, *Fig.* 46. was ſought.

Firſt, Draw two Lines by the Side of the *Tee*, croſſing one another at right Angles, as *x y*, and *w z*. *Fig.* 46.

Take between the Points of the Compaſſes the Diſtance *z o*, and let the *Sector* be opened to the ſame Extent, by ſetting one Foot of the Compaſſes at the End of the *Tangent-Line* at 45, on one Side of the Sector, and let the other fall at the other End of the *Tangent-Line*, at 45, on the other Side of the Sector.

The Sector remaining at this Extent, ſet one Foot of the Compaſſes in the Tangent-Line on one Side of the Sector at 7° 25′ the horizontal Angle, as in the Table; and let the other fall at 7° 25′ on the other Side; this Diſtance ſet from the Point of Sight *o*, in the horizontal Line *x y*, to *t*.

In the ſame Manner take off from the Sector the vertical Angle 19° 30′, which ſet on the vertical Line *w z*, from *o* to *r*.

Laſtly, lay the *Tee* to the Drawing-Board, parallel to *w z*, ſo that the Edge cut through the Point *t*, and draw the obſcure Line *t* 9.

Lay the *Tee* to the other Side of the Drawing-Board parallel to *x y*: And, the Edge cutting thro' the Point *r*, draw the obſcure Line *r* 5; ſo ſhall the

Inter-

Plate 6

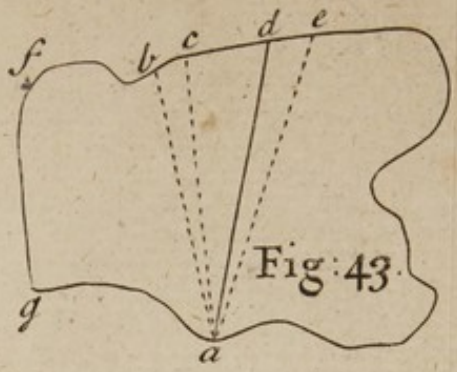

Fig: 43

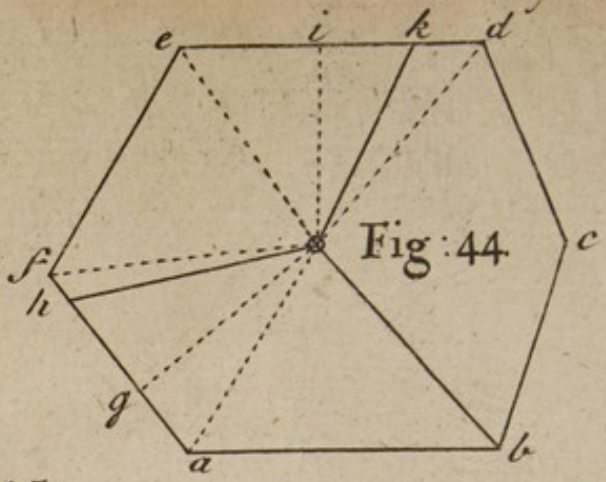

Fig: 44

Fig: 45

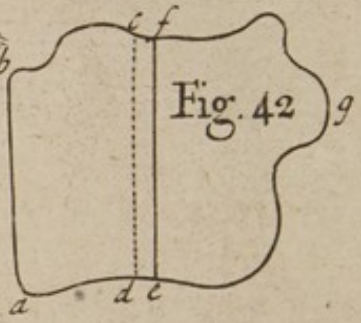

Fig. 42

Fig: 46

Interſection of theſe two Lines *t* 9, and *r* 5, give the Point *a*, which was ſought.

In the ſame Manner may any other Point be found in as little Time as it could be obſerved by the Theodolite; but if you have not a Drawing-Board, nor parallel Ruler, you may put the Paper on the Plain Table, and, by the Edge of the Index laid on the equal Diviſions, draw the Parallels; but a Drawing-Board is better.

Having found the Points *m* and *k*, both denoting the upper Part of the Facies, if you lay a Ruler to theſe two Points, and continue a ſtraight Line till it cuts the horizontal Line *x y*, as at *f*, that ſhall be the accidental Point (or, as the Draughts-Men ſometimes call it, the vaniſhing Point) which being found, you may from thence draw Right-Lines to any other Points on the Draught which were viewed obliquely from *z* (and therefore the Figures on that Part of the Building muſt be made inclined on the Draught) and thereby find the Abridgment of all the Lines parallel to the Horizon on the building or geometrical Plan (which is ſuppoſed parallel to the perſpective Plan or Picture.)

So when you have pro racted the vertical Angles of 4, 3, 2, 1, and thereby found thoſe Points; you may lay a Ruler to each of them, and the accidental Point *f*, and thereby draw the Facies on the Wings of the Building according to their Breadth and Diſtance from one another on the perſpective Plan or Draught.

In like Manner having found the Points *e*, *i*, and *u* of the firſt Window, you may from *e* and *i* draw Lines to the accidental Point *f*, which will give the Bottoms and Tops of all that Row: And then you have nothing to do but find their Breadth and Diſtance; and by theſe Directions draw all the Windows on that Wing of the Building.

If a Statue, Coat of Arms, or other Object was placed at *o*, and it was desired to place the same (or another) a good deal higher, as at *r*; but so, that the Object when placed at *r* should appear full as big as when at *o*, being viewed from *z*.

Observe with the Theodolite the Angles under which the Object appears at *o*; as, if it was a Statue, observe the Height from the Feet to the Head, *&c.* and note the Angles with proper Remarks on a Piece of Paper; and then by directing the Telescope to *r*, and setting the Quadrant and Index to the same Angles, you may give Directions how to make the Object at *r* of such Dimensions as, being viewed from *z*, it will appear of the same Magnitude (or natural Height) with that at *o*; *& vice versa.*

The same may be done, if Objects are desired to be placed at a Distance, to appear of the same Size as those that are nearer; with several other Problems to be performed by this Instrument, which the Ingenious will find out in the Use thereof: But I have already exceeded what I intended on this Head, and shall only add two or three Astronomical Problems, which the Surveyor perhaps may find useful in Practice.

CHAP.

CHAP. III.

PROBLEM I.

How to find a True Meridian-Line by Observing with the Theodolite.

THE beſt Time to make the Obſervations is in a clear Day, about 3 or 4 Hours before and after Noon.

In the Morning, having ſet the Inſtrument exactly level, move the Index horizontally, and the Quadrant vertically, till through the Teleſcope you ſee the croſs Hairs in the Center of the Sun: Then obſerve what Degrees and Minutes are cut by the Index, ſuppoſe 3° 25′; which note in a Piece of Paper, as alſo the Angle of Elevation cut by the Quadrant.

About ſo many Hours after Noon, obſerve that the Quadrant be ſet exactly to the ſame Angle of Elevation as in the Morning; and then move the Index on the Limb till you ſee the croſs Hairs cut the Center of the Sun, as in the Morning; and note the Degrees and Minutes which the Index then cuts on the Limb, ſuppoſe 64° 37′.

But *note*, 'Tis convenient in the Morning to make 3 or 4 Obſervations 5 or 6 Minutes from one another; becauſe in the Afternoon you muſt wait till the Sun falls into the ſame Altitude as it had when you made the Obſervation in the Morning, (the Quadrant remaining at the ſame Angle at both) and, if it ſhould happen to be obſcured by Clouds at that Inſtant, your

your Labour will be loſt for that Day, having made but one Obſervation in the Morning.

Now, if from 64° 37′, the Evening Obſervation on the Limb, you ſubtract 3° 25′, the Morning Obſervation, the Remainder will be 61° 12′, the Half of which is 30° 36′; to this half Sum 30° 36′, add the Morning Obſervation 3° 25′, and the Sum will be 34° 1′.

Laſtly, the Inſtrument remaining in the ſame Poſition, bring the Index on the Limb to 34° 1′, and the Quadrant and Teleſcope will be exactly in the Plane of the Meridian: But, if the Obſervation on the Limb in the Morning exceed that in the Afternoon, you muſt add to the Afternoon Obſervation 360, and work in like Manner; and, if the Remainder ſhould exceed 360, you muſt ſubtract 360 therefrom.

Now obſerve what Point (on ſome firm Wall of a Building) is cut by the croſs Hairs in the Teleſcope, there cauſe a good Mark to be fixed, or cauſe a Pillar with a Mark thereon to be ſet up by the Direction of the Teleſcope: Alſo take Notice, If you could place the Mark a quarter or half a Mile diſtant from the Inſtrument, it is better than if it was nearer. And, in making theſe Obſervations, you ought to be very exact; becauſe, when a Meridian-Line is once well fixed, it is very uſeful for divers Purpoſes.

Obſervé, When the Sun is near the Tropics, the Meridian-Line may be found well enough by obſerving as aforeſaid: But, when it is near the Equinox, there will be ſome Variation; becauſe the Sun's Declination is greater or leſs at different Times in the ſame Day, and conſequently, when in equal Altitudes, has different Azimuths. Therefore the Meridian-Line may be more truly found by the *Pole-Star*.

The

The following Table ſhews the Time from Noon, when the Pole Star *makes the greateſt Angle from the Meridian-Line towards the Eaſt, for any Time in the Year.*

January.			*February.*			*March.*			*April.*		
D.	H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.
1	23	16	5	20	52	5	19	8	2	17	27
8	22	51	12	20	26	12	18	43	9	17	0
15	22	17	19	19	59	19	18	17	16	16	35
22	21	48	26	19	33	26	17	52	23	16	7
29	21	20							30	15	40
May.			*June.*			*July.*			*Auguſt.*		
7	15	13	4	13	19	2	11	23	6	9	6
14	14	45	11	12	49	9	10	55	13	8	40
21	14	16	18	12	20	16	10	26	20	8	14
28	13	48	25	11	52	23	9	59	27	7	50
						30	9	33			
September.			*October.*			*November.*			*December.*		
3	7	23	1	5	42	5	3	26	3	1	26
10	6	58	8	5	16	12	2	57	10	0	54
17	6	32	15	4	50	19	2	27	17	0	24
24	6	8	22	4	22	26	1	57	24	23	53
			29	3	54				31	23	23

And, to find the Time that the Pole-Star will make the greateſt Angle to the Weſt of the Meridian, add 11 Hours 58 Minutes on the Time found in the Table. Alſo *note*, The Star comes to the ſame Place about 4 Minutes ſooner every 24 Hours than it did the Day before.

The

The following Table shews the greatest Angle which the Pole-Star *makes with the Meridian in any of these Latitudes*, viz.

Latitude.		*Angles.*	
Deg.	*Min.*	*Deg.*	*Min.*
49	00	3	53
49	30	3	55
50	00	3	57
50	30	4	00
51	00	4	03
51	32	4	06
52	00	4	09
52	30	4	12
53	00	4	15
53	30	4	18
54	00	4	21
54	30	4	24
55	00	4	27
55	30	4	30
56	00	4	34

The Time that the Pole-Star comes to the East or West of the Meridian, and the greatest Angle which it makes therewith, being found by the preceding Table: Set the Theodolite horizontal, and bring the Index to 360 on the Limb; then turn the whole Instrument about, and elevate or depress the Telescope, till you see the Pole-Star in the Intersection of the Hairs therein, and there screw the Instrument fast: Then (if the Observation was made in the Latitude of *London*, 51° 32′) move the Index on the Limb 4° 6′, (as by the Table) towards the right Hand or Left, according as the Star is Westward or Eastward: And the Telescope will be set exactly in the Plane of the Meridian.

PRO-

PROBLEM 2.

How to find the Latitude of any Place by the Theodolite.

THE Inſtrument being ſet level, bring the Quadrant and Teleſcope into the Plane of the Meridian, and let the Index remain at the ſame Angle on the Limb; then elevate or depreſs the Teleſcope towards the Sun, at ſuch Time as you think it is near the Meridian, until you ſee the croſs Hairs in the Center thereof, dividing it as it were into four equal Quarters; and obſerve exactly what Degrees and Minutes are then cut on the Quadrant, ſuppoſe 42° 15′, which note for the Sun's Meridian Altitude.

By an Ephemerides, you may find the Sun's Declination for the ſame Day, ſuppoſe 3° 47′, which if it be North Declination, ſubtract it from 42° 15′, the Meridian Altitude, and the Remainder will be 38° 28, the *Co-Latitude*.

But, if the Sun hath South Declination, add it to the Meridian Altitude, and the Sum will be the Co-Latitude; which, ſubtracted from 90°, gives the *Latitude of the Place*.

PROBLEM 3.

How to find when the Sun or any of the Stars are upon the Meridian.

HAving the Co-Latitude of the Place, by the laſt Problem, and the Declination of the Sun given; add the Declination, if North, to the Co-Latitude; but, if South, ſubtract it, and the

the Remainder will be the Sun's Meridian Altitude for the Day, as aforeſaid, which ſuppoſe to be 42° 15′.

Set the Quadrant to 42° 15, and the Teleſcope will be elevated to the Meridian Altitude of the Sun; then note the Inſtant of Time by a Watch or Pendulum-Clock, when through the Teleſcope (remaining at the ſame Angle) you ſee the croſs Hairs cut the Center of the Sun; for at that Time is the Sun upon the Meridian.

And, if you proceed in like Manner the next Day, you will have the exact Limits of the natural Day, which muſt exceed or want ſo many Seconds of 24 Hours, by your Clock or Watch, as appears by the Equation-Table for the Day, if your Clock or Watch goes right.

In the ſame Manner you may obſerve when any Star comes to the Meridian; and, if the ſame Star comes to the Meridian 3 Minutes, 56 Seconds and a half, ſooner the ſecond Night than it did the firſt, your Pendulum-Clock or Watch keeps true Time, *& è contra.* Alſo if you ſubtract 3 Minutes, 56 Seconds and a half, for each Night after that on which you made the firſt Obſervation, you will have the true Time of that Star's coming to the Meridian for each Night following.

And thus may a Pendulum-Clock or Watch be adjuſted to the mean Motion of the Sun.

PROBLEM

PROBLEM 4.

How the Azimuth and Altitude of any of the fixed Stars are found by the Theodolite.

THE Inſtrument being ſet level, and exactly in the Plane of the Meridian, and there fixed, if you direct the Teleſcope to any Star, its Azimuth is ſhewn by the Index on the Limb, and the Altitude by the Quadrant, both at the ſame Time.

FINIS.

J. Wakefield's Book