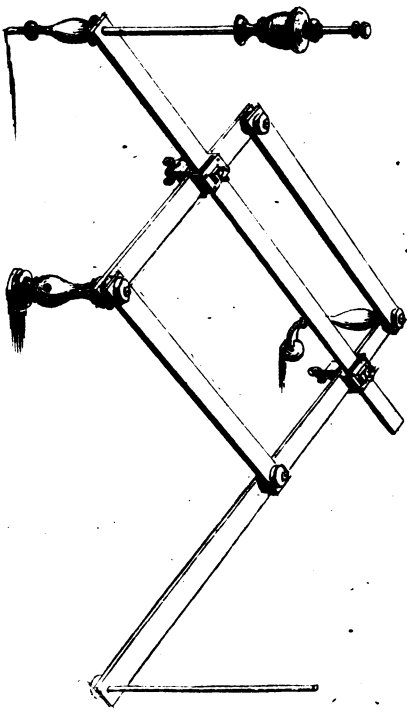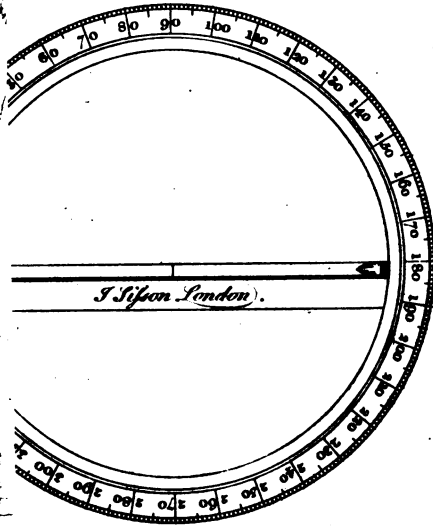J Sison London.

J Sison London.

Practical Surveyor,

OR, THE

Art of *Land-Measuring,*

Made EASY.

Shewing by plain and practical 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,

A New Method of Protracting Observations made
with the Meridian; and how to cast up the Con-
tent of any Plot of Land, by Reducing any Mul-
tangular Figure to one Triangle: Being more exact and
expeditious than heretofore used.

To which is added,

An APPENDIX,

Shewing how to Draw Buildings, &c. in Perspective,
from Observations made by the New Theodolite, its Use in
Levelling, in finding the exact Number of solid Feet,
contained in any Timber Trees before they are cut down,
by Inspection only; and also the Use of a new-invented
Spirit-Level. With several other Things never before made
Publick.

By *SAMUEL WYLD,* Gent.

LONDON:

Printed for J. HOOKE, at the *Flower-de-luce* against St.
Dunstan's Church in *Fleet-street*: And J. SISSON,
Mathematical Instrument-maker, the Corner of *Beaufort
Buildings* in the *Strand.* M.DCC.XXV.

(Price Three Shillings.)

THE

PREFACE

TO THE

READER.

N this fmall Tract you'll find the whole Art of Surveying Land Epitomized : The Rules and Methods here laid down in a plain and familiar Manner, being fuch as are fitteft for a Practifer's Ufe, without an unneceffary Mixture of ufelefs Curiofities and needlefs Repetitions. And altho' Brevity be chiefly intended, yet nothing is here omitted, but what might well enough be fpared in a Treatife that immediately relates to Practice.

A 2   I know

I know the common Objection will be raised by the Ignorant; that is, What needs any more Writing in this Kind, since so many Authors have, with great Ingenuity, bestowed no small Pains therein ; (to whose Labours and Industry I acknowledge this Tract not a little beholding.)   Now to this Objection, the old and common Answer must be returned, That *A Pigmy mounted on the Shoulders of a Giant, may see further than its Supporter.*   And Arts Mathematical can never be so fully learned, but that there will still be new Experiments left for the Trial of others that succeed.

Besides, here are inserted, not only the most useful and Practical Methods yet extant in any other Author, but also a great many new Improvements never before made publick, rendring the Business of Surveying Land more exact, easy and expeditious.

The Book is divided into Seven Chapters, and the Appendix into Three, and these into several Sections, for the more orderly Ranging the several Subjects under their proper Heads.

In the First and Second Chapters, is described the Manner of Measuring Land by the most useful Instruments, the Plain Table,

Theo-

Theodolite and Circumferentor; the firſt being proper for Gardens, or ſuch ſmall Pieces of Land about Buildings, the ſecond for larger Tracts of encloſed Land, and the third for Parks, Commons, &c.

In Handling this, I have not choſe the moſt Accurate Method I could think of, but rather the moſt Plain and Simple, as being moſt Agreeable to the Conception of a Stranger to the Art, to whom nothing can be too plain.

In the Third Chapter, is deſcribed a new Way of Protracting Obſervations made in the Field, by the Needle: As alſo how to Caſt up the Content of a Piece of Land, by Methods more facile and expeditious than heretofore uſed.

In the Fourth, the Uſe of the Theodolite is ſhewn in Surveying ſeveral Parcels of Land lying together; with the Form of the Field-Book, and Plan of the Work annexed; which ſhews, by Inſpection only, the ſeveral Stations and Station-Lines throughout the whole; from which the Obſervations are made in the Field.

The Fifth ſhews how to meaſure or plot any Piece of Land by the Chain only, with-

out the Help of any other Inftrument in the
Field but a fmall Crofs.

The Sixth fhews the Manner of Laying-
out, and Dividing Land, without inferting
the various Methods by which the fame might
be performed; but by fuch only as are the
moft eafy and fit for Practice.

The Seventh fhews how a County is
to be Surveyed; as alfo Roads and Rivers;
and how to make the Ground-Plott of a
City, &c. And becaufe thefe more feldom
come in Practice, I only touched gene-
rally on the Manner how they are to be
performed.

In the Appendix is defcribed the Ufe of a
new Spirit-Level, for Conveying Water to
any appointed Place: Shewing alfo, how the
Draught of a Building or other Objects, may
be drawn in Perfpective, from Obfervations
made with the Theodolite, by a Method
entirely new: As alfo how to find a true
Meridian-Line, &c. Thefe Problems, tho'
not immediately related to the Bufinefs of
Land-meafuring, will be found very ufeful
to a Practitioner in that Art, and may well
deferve the little Room that is allotted them
in this Book.

It

It may be expected, here fhould have been
inferted (as ufual in Books of Surveying)
more *Theorems, &c.* of Geometry; I confefs it
is neceffary a Surveyor fhould be well acquain-
ted therewith, as alfo with Trigonometry, as
the Ground-work of the reft. But then he
may as well read in the Commentators on
Euclid, the Demonftration of each Theorem
at large (beginning with the Principles of
the Art firft) as to fee 'em tranfcribed by
Piecemeal any where elfe. Since the Two
Theorems in the Firft Chapter, well under-
ftood and applied, will be fufficient for the
Performance of moft Problems relating to
Land-meafuring: And indeed, a Perfon who
is well acquainted with the Ufe of his In-
ftruments, will have little Occafion to have
Recourfe to Trigonometrical Calculations for
finding his Angles, and for cafting up the
Content of any Piece of Land after the Plott
thereof is made; the Directions in Sect. 4.
may be fufficient: But if any one thinks
otherwife, he may be farther informed from
the Works of our Trigonometrical Writers,
of which there are many good ones extant.

However, 'tis hop'd, the Country Farmer,
who underftands but fo much of Arithmetick,
as to add, fubtract, multiply and divide (with
a little Practice. the genuine Parent of Per-
fection) by thefe plain Directions, and with
<div align="center">A 4</div> good

good Inſtruments, will be enabled to find the Content of each Piece of Land in his own Occupation, (and thoſe who will not be at the Charge of Inſtruments, may make good Uſe of the Fifth Chapter,) and that this Knowledge is extremely neceſſary to the Countryman, none but the groſsly ignorant will deny, ſince thereby he may judge what Stock of Cattle each Field will be likely to feed, or what Quantity of Seed will be ſufficient for each Acre, or what Number of Workmen to reap or mow the ſame, &c. Which makes me admire, when I reflect, that this Science ſo beneficial to the Publick, as well as particular Perſons, ſhould be ſo much neglected, being ſo plain and obvious to every Capacity.

But I ſhall forbear any Panegyrical Expreſſions in Praiſe of the Art it ſelf, (tho' much might be ſaid on that Head) on Account of its Antiquity, Salubrity, Pleaſantneſs, and above all, its Uſefulneſs, *Ornari res ipſa negat contenta doceri.*

As for the Book it ſelf, tho' perhaps ſome ill-natur'd Artiſts may be offended therewith, becauſe ſeveral Things herein are diſcovered, (which they would have been as well pleaſed ſhould have been concealed) like Flowers gathered and placed in one Garland, and proſtituted to every one's View; yet if it
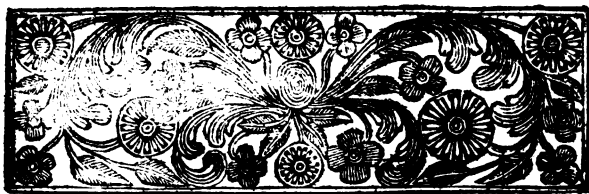
proves

proves any way ufeful to thofe for whom it
was defigned, I have my End in Publifhing it.
Rumpatur quifquis rumpitur invidiâ.

Indeed I hoped fome Perfon who had more
Hours of Leifure to fpare than my felf, might
have fpent fome of them in Compofing fome-
thing of this Nature, fince all the Books I
have yet feen are much deficient in many of
the moft neceffary Parts of the Bufinefs, or
elfe too voluminous for common Ufe ; but
could not hear of any fuch, till this was in
the Prefs, and feveral Sheets wrought off,
elfe I fhould gladly have refigned the Task :
But now that it is printed, e'en let it be
publifhed ; and at the Bookfeller's Requeft,
I have added thus much by Way of Preface,
which I fhall conclude with a Saying I have
fomewhere met with, *Va, mon Enfant, prend
ta Fortune.*

S. W.

THE

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ADVERTISEMENT.

BECAUSE the Practice of SURVEYING depends much on the *Inſtruments* uſed therein, which, being ill-contrived and adjuſted, cauſe unavoidable Errors : Therefore I thought fit to ſay, That all Sorts of Inſtruments for Surveying Land, are made with the greateſt Accuracy and neweſt Improvements,

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T H E

Practical Surveyor:

C H A P. I.

Shewing how to make a Plott of a Piece of Land by the Plain Table, and caſt up the Content thereof.

S E C T. I.

Geometrical Superficies or Sur-face, is produc'd or form'd by the Motion of a Line, as that is de-ſcrib'd by the Motion of a Point, for if *a b*, in *Fig.* 1. be equally mov'd upon the ſame Plane to *c d*, then will the Points at *a* and *b*, deſcribe the two Lines *a c*, and *b d*; and by ſo doing, they will generate the Superficies or Fi-gure *a b c d*, being the Quantity of two Dimen-ſions, *viz.* it hath Length and Breadth (but not Thickneſs,) conſequently the Bounds or Limits of a Superficies are Lines; ſo if the Line *a b*, doth contain in Length five Chains, and the Line *a c*

B   two

two Chains, and if their oppofite Sides and An-
gles be equal, the Quantity of Land thefe four
Lines enclofe, *viz.* (*a b, b d, d c,* and *c a,*) will be
an Acre.

Our prefent Bufinefs therefore, will be to com-
pute what Number of fuch Acres, or Parts of
an Acre, are contain'd in any Piece of Land,
(be it Arable, Meadow or Woodland) whofe Ex-
tent is limitted by certain Lines or Bounders.
Now an Acre of Land (by the Statute of 33. of
Ed. I.) is appointed to contain 160 fquare Perches
or Poles; it is no matter in what Form it lyes,
fo it contains 160 fquare Poles; and *Gunter's*
Chain (the beft for Practice) being therefore
made four Pole long, ten of thefe fquare Chains
make an Acre, (that is to fay) one Chain in Breadth,
and ten in Length, or two in Breadth, and five in
Length, *&c.* do contain 160 fquare Poles, as *per*
Statute. See the following Tables.

1 *Table of long Meafure.*

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

Length of an Acre	Breadth an Acre	Links	Pts. of a Link
Chains	Chains		
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

A Table

A Table of square Measure.

	Inch	Links	Feet	Yards	Poles	Chains	Acre
Inch	1						
Links	62726	1					
Feet	144	2.295	1				
Yards	1296	20.55	9	1			
Poles	39204	625	272.25	30.25	1		
Chains	627264	10000	4356	484	16	1	
Acre	6272640	100000	43560	4840	160	10	1

A Table, shewing how many Chains, Links, and Parts, are contain'd in any Number of Feet, from 1 to 10000.

Feet	Chain	Links	Pts.of Links	Feet	Chain	Links	Pts.of Links
1	0	1	5.15	200	3	03	030
2	0	3	030	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	7	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.

B 2

Let

Let Figure 2 be suppos'd to reprefent a Piece of Land, bounded with the four ftrait Lines *a b, b d, d c,* and *c a,* whofe Lengths are each ten Chain, then the Area or Superficies thereof will contain ten times ten fquare Chains, or ten Acres, (as *per Fig.*) each of the fmall Squares reprefenting one fquare Chain.

But before the Plan of any Piece of Land can be laid down (or protraƈted) on Paper, in order to make a Computation of the Area or Quantity of Superficies it contains, 'tis neceffary we fhould know the Length and Pofition of the feveral Lines that bound the fame.

And to find the Length and Pofition of Lines in the Field, we make ufe of Inftruments, *viz.*

To meafure the Length of Lines in the Field, we ufe *Gunter*'s Chain, containing in Length four Poles or 66 Feet, divided into 100 Parts or Links, each Link being 7 Inches, and $\frac{22}{100}$ of an Inch, and a Staff whofe Length is equal to $\frac{1}{10}$ part of the Chain; that is to fay, 10 Links, or 6 Foot 7 Inches $\frac{2}{10}$ of an Inch. For Roads the Wheel.

Inftruments us'd for taking the Pofition of Lines, are of two Kinds. With fome we take the Pofition of a Line by the Angle which it makes with the Meridian, ufing a Box and Needle, as the Circumferentor, *&c.* and this is ufually call'd the Bearing of the Line.

With others we take the Pofition by the Angle that the Line makes with any other given in Pofition; as with the Limb of the Theodolite, the Chain, *&c.*

But with fome we take the Angle it felf as with the Plain Table, *&c.*

All other Inftruments either differ from thefe only in Name, or are contain'd in them.

The

The Inftruments for Plotting, are a Scale and Compaffes, or rather a Scale decimally divided clofe to the Edge, and at every tenth Divifion, numbred 0, 1, 2, 3, *&c.* denoting Chains, and a Protractor always to be divided, numbred, and fitted to the Inftrument.

Of the ufe of thefe feveral Inftruments in their Order; and firft of the Plain Table; the Ufes thereof being as plain as the Name of the Inftrument denotes.

But becaufe we make ufe of the Chain in all manner of Bufinefs in the Field, it will be neceffary, in the firft place, to inform our felves in the manner how to manage it in meafuring the Length of Lines in the Field,

S E C T. II.

❧ *Directions for meafuring with the Chain.*

The Chain contains in Length 4 Pole or 66 Feet, divided into 100 Links, each Link being 7 $\frac{22}{100}$ Inches, as aforefaid, having a large Ring exactly in the middle of the Chain, and pretty large Pieces of Brafs of different Shapes at the end of each 10 Links, for the fpeedier counting of the odd Links; alfo you may tie a large red Rag at 50 Links, and others of a lighter Colour at 25, from each end of the Chain, efpecially when the Grafs is long.

Take care that they who carry the Chain deviate not from a ftrait Line, (that being the neareft Diftance that can be between any two Places,) for if the Lines be not exactly meafured, neither the Form nor Content of the Plott can be true. Provide a Staff juft fix Foot feven Inches and $\frac{1}{8}$ long, which divide into 10 equal Parts, fo will the Whole be the Length of 10 Links, and each Part the Length

               of

of one Link, and 10 times the Length of this Staff (which you may call the off-set Staff) the Length of the whole Chain; also provide 9 Arrows or small Sticks above a Foot long, which you may mark at the Tops with Bits of red Cloath, and at the Bottom you may put small Iron Ferrills and two strait Staves about 5 Foot each.

Before you measure with the Chain, 'tis necessary to examine its Length by the off-set Staff, stretching it on level Ground in such fort, as when you measure with it.

Being thus provided, let the Leader of the Chain take the nine Arrows in his Hand, and one of the 5 Foot Staves, and let the Follower, standing at the Station, direct him to place his Staff at the Chain's End, in a right Line with the Stations, and there to put down 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 Staves and the Station in one right Line, if they have directed right; but if not, the Leader must direct the Follower to place his Staff in the same right Line with the Station and the Leader's Staff, and so must each direct the other, till the two Staves and two Stations are in one right Line.

Let 'em 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 express'd by the Number of Arrows prick'd down, suppose 7; and the Leader holding the End of the Chain to the Station, the Fol-
                                                              lower

lower will see how many Links are contain'd
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 meaſur'd 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 laſt mea-
ſur'd Length is doubtful, and muſt be re-meaſur'd
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 is 10 Chains more, enter
20; alſo obſerve 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.

B 4

SECT.

S E C T. III.

Shewing how to make a Plott of one Field, or several Fields, upon the Paper on the Plain Table, by placing the Instrument at one or more Stations about the Middle, from whence the Angles may be seen.

Let *Fig.* 3. be suppos'd to reprefent two Fields or Enclofures, a Plott of which is defr'd, and firft of the Field, *a l m o b.*

Having put your Plain Table in order, and obferv'd the Needle to play well, put a Sheet of fair Paper thereon, and crufh down the Frame, fo that the Paper lyes fmooth ; then you may imagine the Paper on the Table to reprefent the Surface of the Land, and the Lines you fhall draw thereon, to be the Bounders of the refpective Fields or Enclofures in fome Proportion or other, and if you make the Proportion thus, A Line drawn on the Paper an Inch long, is equal to, or in proportion to, the Length of one Chain on the Land, and if 5 Chains in Length, and 2 in Breadth, do contain the Quantity of one Acre on the Land, then 5 Inches in Length, and 2 in Breadth, fhall alfo contain the Quantity of one Acre on the Paper, and takes up the fame Quantity of Space thereon, as an Acre does in the Field ; *vide Fig.* 1.

This being premis'd, we proceed to lay down the Lines that enclofe thefe two Fields of the fame Length and Pofition on the Paper, which fhall therefore include the fame Quantity of Superficies as thofe in the Field it felf in proportion, as 1 Inch to 1 Chain.

But if we make half, or a quarter of an Inch, or half a quarter (by which the following

Di-

Dimensions were laid down) on the Paper, to represent one Chain, it is the same in effect, only the Plott thereby is made lesser; also the Inches, &c. on the Paper, are capable of being subdivided, as the Chain is into Links.

First, place the Table somewhere about the middle of the Field, from whence, if possible, you can see all the Angles, as at ☉, and make an 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, and having set the Instrument steady on the Ground, turn the Table about till the Needle hangs over the Flower de Luce in the Box, (or if 'tis more convenient, turn the Length of the Table to the Length of the Plott, that it may, if possible, lye 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 ☉, (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 a Line from the Point ☉ towards the Angle *a*, with the Point of the Compasses, without regarding the Length, so it be 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

Now see whether the Needle continues to hang over the same Point in the Box as when you first 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 mov'd out of its first Position, which is carefully to be obferv'd.

In the next place we proceed to make the Lines ⊙*a*, ⊙*l*, *&c.* of their just Length, and to that end apply the Ring at one end of the Chain to the Hole under the Table, and let the Chain be ftretch'd at length towards one of the Angles as at *a*, and when I have meafured up thereto, (obferving the Directions before laid down for meafuring with the Chain,) I find the Length of the Line ⊙*a*, to contain 3 Chains 60 Links, or 360 Links, which note in a Bit of Paper.

Having found the Length of the Line ⊙*a* on the Ground, I proceed to make that on the Paper of the fame Length, to correfpond therewith in Proportion, as an Inch to a Chain, or any other Proportion as shall be moft convenient.

Therefore having provided a Scale and Compaffes, becaufe the Length of the Line I am about to take off, is 360, or 3 Chains 60 Links: I fet one Foot of the Compaffes in the Line of Inches, *&c.* at 3, and extend the other to 60 in the diagonal Divifions; thereby taking off 360 Links, then the Compaffes remaining at this Extent, I fet one Foot in the Point ⊙ on the Paper, and let the other fall in the Line ⊙ *a*, where I make a vifible Mark or Prick with the Compaſs Point, in order to find it again prefently.

Note, each whole Inch, ½ Inch, *&c.* on the Scale, reprefents one Chain, and the Links, or hundredth Parts of the Chain, are taken off from one whole Inch, ½ Inch, *&c.* divided alfo into 100 Parts,

by

by diagonal Lines drawn crofs the Scale; for each 10*th* of that Divifion reprefents 10 Links, and is divided into other ten Parts, by the croffing of the diagonal Lines. Any Inftrument-maker that fells this Scale, will prefently fhew the Ufes of thefe Lines, or the Sight thereof will be a fufficient Information; only it may be obferv'd, that thefe Scales are beft made of Brafs, and the Joints of the Compaffes are chiefly to be obferv'd, which fhould have an equal eafy Motion without leaping, and that the Points be well temper'd, and clofe in a Point exactly.

Obferving the Directions before laid down, I firft meafure with the Chain the Length of the feveral Lines ⊙ *l*, ⊙ *m*, ⊙ *o*, and ⊙ *b*, and then transfer the Length of each Line on the Ground to its Reprefentative on the Paper, making vifible Marks where the end of each Line falls, as at *a*, *l*, *m*, *o*, *b*.

And here it may be obferv'd, that I generally meafure one Line from the Inftrument to an Angle, and the next from the Angle to the Inftrument, till all are finifh'd, and note the Length of each Line as I meafure it in a Piece of wafte Paper, and never truft to my Memory; then obferving which Line I began with, I fet on its true Length on the Paper on the Table, and the reft of the Lines in their order.

Laftly; I join the Points *a*, *l*, *m*, *o*, *b*, with Ink Lines, becaufe they fhould not rub off, (and for this purpofe a drawing Pen is requifite,) as the Lines *a l*, *l m*, *m o*, *o b* and *b a*, which conftitute the Bounders of the Field *a l m o b*.

It may be a young Beginner will take fome Pleafure to meafure crofs fome part of the Plott on the Paper, as the Diftance from *a* to *o*, or from *a* to *b*, with his Scale and Compaffes, and afterwards meafuring the fame Diftance on the Ground with the Chain, he will find them both exactly to agree, if the Plott be truly laid down.   Ha-

Having finish'd this Field, I cause a Staff to be set up with a Paper thereon in the next, in a convenient Place, from whence I can view all the Angles; but if such a Station can't be found, I 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 Plott of the next Field can't be truly laid down in respect of the last) I 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, I 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 plac'd, 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 strait Line, and set on the Distance *δ*21, (by the Help of the Scale and Compasses) from ⊙ 1 to ⊙ 2.

Now I 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 as it lyes 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, and then screw the Table fast that it stir not out of this Position, till I have finish'd the Observations in this Field, (but observe to turn that Part of the Table mark'd with ⊙ 1, towards its Representative in the last Field.)

<div align="right">When</div>

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 truly, 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 observe; because the removing the Table from one Station to another is the greatest Difficulty in this Way of Surveying.

Having caus'd 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 ☉, 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 lk, ki, ih, and hg, with ink Lines, and they constitute 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 plac'd in its true Position at ☉ 3 in this Field; and direct the Sights to the Angles f, e, d, and c, and when the several Distances from ☉ 3, to f, e, d and c, are set on the Paper, join the Points gf, fe, ed, dc, and cb, with ink Lines, so is the true Plott 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 Pro-
portion

portion, as the Scale you made ufe of is to the Chain.

But obferve that if the Hedge *b c*, had been fo thick, that from ☉ 3, you could not have feen the Angle *d*, or other Obftruction had hinder'd your Sight or Meafuring thereto, you muft have remov'd the Table to another Station; but when you can (as commonly you may) by holding afide the Boughs or otherwife, fee the Mark, and by drawing the Chain through the Hedge, meafure the Line from ☉ 3, to the Angle *d*, 'tis a better way than to remove the Table, for the fewer Stations you make, the better, and the Work will be more truly laid down, which remember.

It would be only repeating the fame thing over again, to give Directions how to furvey a Field from a Station taken in any Angle thereof, from whence the reft may be feen; 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 muft have been directed from thence to the reft of the Angles *l, m, o, b*, and the Lines meafured on the Ground, from *a* to *l, m, o* and *b*, whofe Length laid down on the Paper from *a*, would give the fame Points *l, m, o, b*, as if the Station had been in the Middle of the Field, and when the Bounders are drawn, they will be in the fame Pofition as before.

If you would draw a Meridian, or a North and South Line through the Plott, turn the Table about, till the Needle hangs over the Flower-de-luce in the Card, and laying the Index on fome of the equal Divifions on the fides of the Frame, draw a Line clofe by the Edge, which fhall be a meridian Line; and if you crofs this Line by another at Right Angles, that fhall fhew the Eaft and Weft Points.

S E C T. IV.

S E C T. IV.

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

The next thing that lies before us is the Manner of Calculating the Quantum of the Superficies enclosed by the Lines on the Paper, as they represent the Bounders in the Field; that is to say, how many Acres, and Parts of an Acre are contain'd therein.

In order thereto, these several Things may be premised : First, That every Magnitude is mensurable by some Magnitude of the same Kind ; as, a Line by a Lineal Foot, &c. a Superficies by a Square Foot, &c. and a Solid by a Solid Foot, &c. The Superficial Measure may be conceived, by imagining *Fig.* 2. to be a Field, as now divided into 100 Squares, every Square being one Chain, having a Chain for its Side : Now if the Field be just one Chain broad, the Number of Square Chains will be equal to the Number of Lineal Chains in the Length of the Field : But if the Field be 2, 3, 4, &c. Chains broad, the Number of Square Chains will be twice, thrice, or four times so many square Chains ; so this Field being 10 Chains long, and 10 Chains broad, the Number of square Chains in it are, 100, *viz.* 10 multiply'd by 10, gives 100; or if it had been 40 Chains long, and 5 broad, the Number of square Chains would be 200.

2. That the Mensuration of all superficial Figures, as Land, &c. depends on the exact Measuring of certain regular Figures, as the Parallelogram, Triangle, &c. so that if any Plot of Land be not one of these Figures, it must be reduc'd into

<div align="right">some</div>

some or one of these Forms before it can be
measured.

3. A Parallelogram is a quadrilateral Figure, each
of whose oppofite Sides are parallel, and the
Diagonal divides the fame into two equal Parts,
as the Parallelogram *a b c d, Fig.* 5. the oppofite
Sides and oppofite Angles of which are equal
between themfelves, and the Diameter or Diago-
nal *a c* bifects the Parallelogram.

4. A Right-lin'd Triangle, is a Figure compre-
hended within three ftrait Lines.

We need not here take notice whether a Tri-
angle be Right or Oblique-angled, or by what
Name diftinguifh'd, whether an Ifofceles, Scale-
num, &c. becaufe they are all meafured by one
and the fame Rule.

5. A Trapezia is an irregular four-fided Figure,
comprehended under 4 unequal Sides and An-
gles.

To this we fhall add thefe two ufeful Theorems
following.

Theorem 1.

That Parallelograms conftituted upon the fame
Bafe, and between the fame Parallels, are equal,
Euclid. lib. 1. *Prop.* 35.

Let *a b c d, e b c f,* be Parallelograms confti-
tuted upon the fame Bafe *b c,* and between the
fame Parallels, *a f,* and *b c,* then the Parallelo-
gram *a b c d,* is equal to the Parallelogram
e b c f.

For becaufe *a b.c d* is a Parallelogram, *a d*
is equal to *b c,* and for the fame Reafon *e f*
is equal to *b c,* wherefore *a d* fhall be equal
to *e f,* but *d e* is common, therefore *a e* is
equal to *d f,* but *a b* is equal to *d c,* wherefore
e a, a b, the two Sides of the Triangle *a b e*
are equal to the two Sides *f d, d c,* each to each,
                                                and

and the Angle *f d c*, equal to the Angle *e a b*, the outward one to the inward one, therefore the Base *e b* is equal to the Base *f c*, and the Triangle *e a b*, to the Triangle *f d c*.

If the common Triangle *d g e* be taken from both, there will remain the Trapezia *a b g d*, equal to the Trapezia *f c g e*, and if the Triangle *g b c*, which is common, be added, the Parallelogram *a b c d*, will be equal to the Parallelogram *e b c f*, which was to be demonstrated. *Vide Fig.* 4.

Theorem 2.

If a Parallelogram and a Triangle have the same Base, and are between the same Parallels, the Parallelogram will be double to the Triangle, *Euclid. Lib.* 1. *Prop.* 41.

Let the Parallelogram *a b c d, Fig.* 5. and the Triangle *e b c*, have the same Base, and between the same Parallels *b c*, *a e*, then the Parallelogram *a b c d*, is double the Triangle *e b c*.

For join *a c*, then the Triangle *a b c* is equal to the Triangle *e b c*, for they are both constituted upon the same Base *b c*, and between the same Parallels *b c*, *a e*, but the Parallelogram *a b c d*, is double the Triangle *a b c*, since the Diameter *a c* bisects it, wherefore likewise it shall be double to the Triangle *e b c*, which was to be demonstrated. *Vide Fig.* 5.

By the last *Theorem*, a Parallelogram having the same Base with a Triangle, and lying between the same Parallels, is double to the Triangle; therefore if the Base of a Triangle be of the same Length with one side of a Parallelogram, and the Perpendicular of the same Height, as the other side of the Parallelogram, those Triangles are equal but to half that Parallelogram. *Vide Fig.* 6.

C   If

If a Weight (as a Bullet) was suspended at *e, Fig.* 6. and from thence let fall on the oppo-site Line *b d,* it wou'd describe the Perpendicular Line *e f,* then a Perpendicular is the near-est Distance, or shortest Line that can possibly be drawn from any Angle to its opposite Side.

And here it may be convenient to insert the Manner of raising or letting fall a Line perpendicular to another.

Let a Perpendicular be raised on the Line *d e,* from the Point *c, Fig.* 7. Open the Compasses to a convenient Distance, and mark out the two Points *a* and *b,* then opening them something wider, you may by setting one Foot in *a* and *b,* severally describe the two Arches cutting one another at the Point *f,* from which draw the Perpendicular *f c,* to *c,* also the Line *f c,* continued, will cross the Line *d e,* at Right Angles.

Let a Perpendicular be raised from the End of the Line *a b,* at *b, Fig.* 8. Open the Compasses to an ordinary Extent, and setting one Foot in the Point *b,* let the other fall at Adventure, as at ⊙, then without altering the Extent of the Compasses, set one Foot in the Point ⊙, and with the other, cross the Line *a b,* at *d,* and describe the obscure Arch *d d,* then lay the Ruler to *d* and ⊙, and draw the obscure Line *d* ⊙ *e,* through the Arch. Lastly, apply the Ruler to the Point of Intersection at *f,* and to the Point at the End of the Line *a b,* and draw the Perpendicular *c b.*

Let a Perpendicular be let fall from the Point *c,* upon the Line *a b :* Set one Foot of the Compasses in the given Point *c,* and with the other, describe such an Arch of a Circle, as will cross the given Line *a b,* in two Points, *viz. d, f,* then bisect the Distance between the

two

two Points *d* and *f*, as at *e*, and draw the Perpendicular *c e*.

This is no more but the First Problem reversed: Also a Perpendicular may be let fall nigh the End of a Line by the Second.

Note, Those Problems touching Perpendiculars, aim at no greater Matter, than may be performed in a mechanical Way, by the help of a small Square, exactly made as a Square Protractor, or for want thereof, a Scale in a Case of Instruments, that hath a Right Angle, and true Sides, or the Square therein, in the Form of a Carpenter's, *&c.* for if you apply one Leg of such a Square to any Line, so as the Angle of the Square may touch the End of the said Line, or any other Point where the Perpendicular is to be raised, you may by the other Leg, draw the Perpendicular. In like manner may you let fall a Perpendicular from a Point assigned, by applying one Leg of the Square to the Line, so as the other may touch at the same Line the assigned Point, whence you may draw the Perpendicular by that Leg that touches the Point.

If the Angle of the Square, be a little Blunt by Wearing, you must allow for it when you apply it to the Point in a Line, and when you are drawing a Perpendicular, you must stop before you reach the given Line, and then by applying the Leg of your Square, to that Part of the Perpendicular already drawn, so as that Part of the Leg may pass clearly over the Line, you may draw the Perpendicular as exactly, as if the Angle had been true. The like Course is to be taken, when a Line is to be crossed by another drawn quite through it at Right Angles.

6. Every Figure enclosed with 3 Right-lines is a Triangle, and in the Mensuration thereof, only the Length of the Base, and Height of the Perpendicular

dicular

dicular is confiderable, and any of the Lines may
be made the Bafe, though commonly the longeft
is, and a Line let fall from the oppofite Angle
upon, or made to touch the Bafe in the neareft
Point, is the Perpendicular, and you are not con-
fin'd to any Angle, but may let fall the Perpen-
dicular from what Angle you pleafe, taking the
Line on which it falls for the Bafe.

7. The Area or Content of the two Primitive
Right-Lin'd Figures, the Square or Parallelo-
gram and Triangle is found by multiplying the
Length of the Square or Parallelogram by its
Breadth, and the Bafe of the Triangle by half
the Perpendicular, or the whole Perpendicular
by half the Bafe, or the whole Bafe by the whole
Perpendicular, then the half of that laft Product,
is the Content of the Triangle.

And here it may be worth obferving,
that the Multiplier in any of the Multipli-
cations made ufe of in cafting up any Menfurati-
on, is an abftract Nnmber, as well as in all other
Multiplications whatfoever, which may prevent
the falfe Confequences ufually drawn from multi-
plying Feet, *&c.* by Feet, (*viz.*) that of multi-
plying by a contract Number (as half a Crown
by half a Crown) which is contrary to the Na-
ture of Multiplication, whofe Operations are on-
ly compendious Additions, either of the Multi-
plicands, or fome Part of it continually to its felf
or its Part.

8. The Parallelogram or Square, being the origi-
nal Figure from which are deduced all Compu-
tations, that relate to the cafting up the Con-
tent of a Superficies, a Line drawn from any
Angle therein to its oppofite Angle, may be di-
vided into two Triangles (which dividing Line is
called the Diagonal, as aforefaid) both of
which Triangles taken together, are equal to
                                    the

the Square or Parallelogram, and one of them e-
qual to half of it, and any manner of Figure that
hath four Sides, whether equal or parallel, or nei-
ther, let it be called a Trapezia-Rhombus, *&c.*
is capable of being divided and cast up in the same
manner.

9. Then any irregular Figure, let it consist of ne-
ver so many Sides, may be divided by such Diago-
nals into a Number of Triangles, *&c.* which se-
parately cast up and added together, their Sum
is the Content of the whole Figure.

10. And almost all Fields to be met with in Sur-
veying, being bounded with a Number of unequal
Lines, we first take the Plott thereof by some In-
strument, and lay it down on Paper, and by draw-
ing Diagonal Lines through it, reduce it into
Triangles, *&c.* *Vide* Fig. 10.

11. And these Triangles or Squares, being measur-
ed by the Chain of 100 Links, when cast up,
their Content is given in the lowest Denomina-
tion, (*viz.*) square Links, as in Figure 10:
10 Chains multiplied by 10 Chains, gives 100 square
Chains ; or, which is all one, 1000 Links by 1000
Links, gives 1.000000 square Links in the lowest
Denomination, only making the Links to possess
two Places of Figures after the Chains, as 6 Chains
54 Links must be written 654, without any Point
of Separation between them, and 10 Chains must
be written 10.00.

12. In one square Chain, there are 10000 square
Links, and 100000 square Links in an Acre;
the Chain therefore is divided into 100 Parts or
Lengths (such as a Link is made to be) on pur-
pose, that all Operations may be made in a de-
cuple Manner, and to save the trouble of Division:
For as the Acre is limitted by Statute, this Num-
ber 100000 is the Divisor in the lowest Denomi-
nation (*viz.*) Links. So if a Field contains

C 3   1654321

1654321 square Links, we need not to find the Number of Acres therein divide it by 100000, the square Links in one Acre; but according to the old Rule, when a Divisor confifted of 1 and Cyphers, cut off from the Right-hand, fo many Places of Figures of the Dividend, as the Divifor hath Cyphers, accounting them the Remainder; fo fhall the reft on the left Side be the Quotient; fo the five laft Figures cut off from the Right, there are 16 Acres for the Quotient, the remainder Parts of an Acre. Then by the known Rules in Decimal Arithmetick (*viz.*) multiplying Decimal Fractions by known Parts in the next inferior Denomination, gives thofe known Parts in Integers; due regard being had to the Separation. So 54321, multiplied by 4, the Roods in an Acre, produces 217284, from which Product cutting off 5 Places of Figures towards the Right, leaves 2 Roods on the left; and that Remainder fo cut off, being multiplied by 40, produces 691360; and from this laft Product, feparating 5 Places by a Point, gives 6 Poles on the Left, and the Remainder $\frac{91360}{100000}$ Parts of a Pole.

From what hath been faid, the general Rule for cafting up the Content of a Piece of Land may be given.

General Rule.

Set down the Number of Chains and Links in the Order of Multiplication, making the Links poffefs two Places after the Chains; and from the Product cut off by a feparating Point 5 Figures to the Right-hand, fo fhall thofe on the Left be Acres : Then multiply the five Figures fo cut off by 4, (the Roods in an Acre) feparating five Places alfo from that Product towards the

Right

Right Hand; then the Figures on the left of the feparating Point are Roods.

Laftly, Multiply this laft Remainder by 40, (the Poles in a Rood) and feparate five Places to the Right from that Product, and the Figures on the Left fhew the Number of Poles.

So in *Fig.* 10. the Field *a l m o b* being divided into the Triangle *l m o*, whofe Bafe is 660, and the Perpendicular let fall from the Angle *m*, on the Bafe Line *l o*, is 252.

Therefore half 660, multiplied by whole 252; or whole 660 by half 252; or whole 660, by whole 252, then the half of this laft Product is the true Content. Ufe any of thefe Methods, the Content of the Triangle *l m o* will be 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 feparately caft 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 Bafe to both Triangles, and halve the half Product for the true Content of the Trapezia. See the following Work.

C 4   Bafe

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

                   166320 ⎫ Product
                   449600 ⎭
                   ——————
                   615920 double Content.

Acres ——— 3.07960 true Content.
                4
               ——
Roods ——— .31840
               40
              ——
Poles ——— 12.73600

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

The Bafe *l o* multiplied by the Perpendicular
m y, produces 166320, which is double the Con-
tent of the Triangle *l m o* in fquare Links.   Alfo
the Perpendicular *a x*, added to the Perpendi-
cular *o z*, makes the Sum of both 562, which
multiplied by 800, the common Bafe to both
Perpendiculars, produces 449600, which is dou-
ble the Content of the Trapezia *l o b a* in fquare
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

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 *a l m o b*; 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.* 10. 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 or-
derly manner, one under another, and add them
all together into one Sum, the half of which Sum
is the Content of the Field in square Links,
which reduce into Acres, *&c.* as aforesaid.

But remember to measure the Bases and Per-
pendiculars by the same Scale that the Plott 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, and let
the Perpendiculars just touch the Line, but not
pass over it, at the nearest Distance from the
Angle that may be; and for this End a good
Pair of Compasses, and a Diagonal Scale are most
proper; and the larger Scale you use the better,
if the Compass of the Plott will admit thereof.

SECT.

SECT. V.

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

Let *Fig.* 11. represent a Field to be plotted by the Plain Table.

Now 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 hindred by Firze, 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 this Field, he will be obliged to measure a great Number of such Lines.

'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 Plott, as Convenience shall determine.

Note, This Mark ⊙, always represents a Station, ... a Prick Line represents the Station Line, and ——— a Black Line the Bounder.

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*.

But instead of using a Scale and Compasses, you may set on the Distance by the Plotting Scale only, such as aforementioned, whose Edge is

cham-

champered, and the Numbers, and Divisions set close thereto ; (being much readier than Compasses, and generally used by the best Surveyors) each Division representing a Chain, being numbred 1, 2, 3, &c. and each of those Divisions being again sub-divided into ten Parts, one of which ten Parts represents ten Links.

Therefore lay the Edge of this Plotting Scale close to the Line *a b*, the Beginning of the Numbers coinciding with *a*, and encreasing towards *b*, and because the Length of the Line *a b*, is 840, make a Mark with a Needle or protracting Pin against 840, close to the Edge of the Scale.

But if the Number had been 845, &c. you must guess at the odd Links, which you may do by a Scale of $\frac{1}{4}$ of an Inch within 2 in an Hundred, and not mistake, but with a larger Scale much nearer.

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 Line 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 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 Plott, if your Work be true, and the Needle good, as aforesaid ; but because 'tis 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 'tis communicated to the following Part of the Work.

<div align="right">In</div>

In the next place, Measure the Distance from ⊖ *b*, to the Hedge 17 Links, which set from ⊖ to *g*, and draw the Bounder *f g*, also measure the Distance from ⊖ to *h*, which set on the Paper from ⊖ to *h*, and continue the Bounder *f g*, in a Strait Line, as you see it 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, as by former Directions, and measure from *b*, towards *c*, with the Chain, but when you come over against the Bend in the Hedge at *i*, measure the Distance from the Chain Line *b c*, to that Bend 7 Links, which set from the Chain Line *b c*, to *i*, and draw the Bounder *i h*, through *h*, till it cuts the Bounder *f g*, constituting that Corner of the Field.

Measure on to *c*, 620 Links, which set from *b* to *c*; now 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.

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The Line *b c*, being truly laid down, and the Table ftanding at *c*, in the fame Pofition, 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*, alfo direct the Sights to the Middle of the Barn, the Index being turned about on the fame Point *c*, and draw the Obfcure Line *c x*, croffing the other Obfcure Line *b z*, fo fhall the Point of Interfection determine the Situation of the Barn in the Middle of the Field, which you may prove by meafuring on the Ground thereto, from any Part of the Field.

Next meafure the Diftance from the ☉ at *c*, to the Hedge 6 Links, which fet from ☉ to *k*, and draw the Bounder *i k*, continuing the Line through *k*, alfo meafure the Diftance to the other Hedge *c d*, from ☉ *c*, 15 Links, which fet off to *l*.

Remove the Table from *c*, and place a Mark there, and meafure the Diftance from *c* to *d*, 481 Links, which Diftance fet on the Line *c d*, then plant the Table at *d*, and lay the Index on *c d*, and turn the Table about till you fee a Mark at *c*, and then fcrew the Inftrument faft.

Next, Examine the Length and Pofition of *c d*, in refpect of *b c*, as before directed, then turning the Index about on *d*, direct the Sights to *e*, and draw the Line *d e*, and fet off the Diftance from ☉ *d*, to the Hedge at *m* 10 Links, and from *m*, draw the Bounding Line *m l*, continuing it ftreight through *l*, till it croffes *i b*, as you fee it to do it in the Field.

Leave a Mark at *d*, and plant the Table at *e*, having firft meafured the Length of *d e*, 364 Links, and fet it on its proper Line from *d* to *e*, on which Line *d e*, lay the Index, and turning the Table about till you fee the Mark at *d*, there fcrew it faft, and having proved the Line

d e,

d e, to be truly laid down in respect of *c d*, turn
the Index about on *e*, till you see the Mark at
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 measure with the Chain the Distances
⊙ *p*, and ⊙ *q*, setting those Distances on their
proper Lines, and draw the Bounders *p o*, and *q p*.

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

In the same manner measuring on the Line *e a*,
set off the Distances from the Chain Line to the An-
gles in the Bounder *s* and *t*, and draw the Bounders
r f, *f 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 *f*, 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 the next,
if you don't 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;

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 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 us'd, is at too great a Distance from you, or lyes 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.* 11. 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 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, and the Instrument 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

of Interſection determine the Diſtance of the Barn from *b* or *c*, which you may find by meaſuring from *q* 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 'tis convenient to make the Stations *b* and *c*, at ſuch a Diſtance from one another, that the Angle at the Point of Interſection may not be too Acute, leſt you be not able to diſtinguiſh nicely the Point of Interſection.

If *Fig.* 11. was a Wood, ſo that you could not meaſure the Station Lines within, you may as well make them on the Outſide, for the Plott will be the ſame, only the ſmall Pieces of Ground between the Station Lines, and Bounders, are excluded by the Bounders from being any Part of the Plott. Particular Directions in this Caſe are needleſs; *ſee the Figure.*

When you are about to meaſure a Plott of Land, and in doubt whether it will lye on one Sheet of Paper, you may place a Line or two croſſe the Plott, as you walk about to chooſe 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.

Alſo 'tis 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 Plott.

Alſo as ſoon as you have drawn the Plott of a Field, 'tis 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.* 12. and direct the
<div align="right">Sights</div>

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 Ta-
ble at the other Station *b*, measuring the Dis-
tance 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 lay the Index to the Point *b*, and turn
it about thereon, directing the Sights to the seve-
ral Angles round the Field as before at *a*, and
towards every one of them draw a Line, which
will interfect the Lines before drawn at *a*, so shall
the Points of Interfection determine the Place of
all the Angles round the Field, and Lines drawn
from Point to Point shall give the Bounders 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 Interfecting one another at very acute An-
gles you may commit grofs Miftakes.

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 Interfection of
Right Lines are beft determined when thofe
Lines Interfect each other neareft Right Angles.

Therefore when Triangles laid down by the
Length of their Sides interfecting one another
with acute Angles, the Point determining where
thofe Lines interfect, is not fo well determined
as it ought to be.

D   C H A P.

C H A P. II.

Shewing how to Survey any Piece of Land, by the Theodolite or Circumferentor, and to protract the same.

S E C T. I.

T HE Plain Table is very useful for taking the Ground Plott 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 dry'd again, and thereby the Lines drawn thereon are disorder'd, making the Content less than it should be; and in the least Rain or Mist, the Instrument becomes altogether useless; also, when the Plott proves larger than will lye 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

Paper be joyn'd together after the Plott is drawn
thereon, fo as to meet exactly, and lye fo flat as
it ought to do; and if to thefe Inconveniences be
added the tedioufnefs of compleating the whole
Plott in the Field, when a Surveyor has his
Affiftants about him, that alone might be Objection
enough to induce any Perfon to make ufe of
fitter Inftruments.

*Here follows the Defcription and Ufes of a
New Theodolite, being the moft abfolute
Inftrument yet invented for Surveying
Land.*

If we be not very exact and curious in mea-
furing the Angles in the Field, the Plott on the
Paper can never be truly laid down; and if the
Inftrument with which we meafure thefe Angles
be not well fram'd and divided, all the care we
can take in making the Obfervations in the Field
will be to little purpofe; therefore, I thought it
might not be improper firft of all, to give a ge-
neral Defcription of a new Theodolite, which
hath met with a general Applaufe from all Ma-
thematicians that have feen it, and far exceeds
any other Inftrument that hath yet been in-
vented.

For the Ball and Socket is fo contriv'd, that
the whole Inftrument may be fet as truly Hori-
zontal, as by the help of any Rack, and with
lefs than a tenth Part of the Trouble and Time,
and this in meafuring every Angle is abfolutely
neceffary; for Inftance, fuppofe we were to mea-
fure an Angle on the fide of an Hill, by one of
the Theodolites as commonly made, and had fet
the Inftrument as near a level as we could by
the Eye, and then proceeded to make an Ob-

fervation; if then the Limb be out of the Horizon, suppofe but two Degrees; (and it can fcarce be fet nearer if fo near, for the Ground being on a Declivity will deceive us) the Angle thus meafured will be confiderably falfe ; for the Inftrument thus planted on the fide of the Hill, let the Tellefcope be directed to the firft Object, and that part of the Limb next your Eye fixed two Degrees out of the Horizon, and then let the Tellefcope or Sights be turn'd round to the other Object, and elevated thereto, fuppofe ten Degrees; then the Index will cut on the Limb, the Number expreffing the Angle, fuppofe ninety Degrees; now this Angle of ninety Degrees is meafured above twenty one Minutes falfe, and if the Lines that form the Angle, happen to be long, this Error will be very confiderable in regard of the true Content of that Piece of Land, and the Plott can never be expected to clofe, if the Angles be thus meafured; but in the ufe of this Theodolite, this Inconvenience is remedied, the Inftrument being fo eafily fet exactly Horizontal.

There is a Quadrant nearly, the Radius of the Inftrument fo fix'd over the Center, as to move exactly in a vertical Circle, within which is a Spirit level, and over that the Telefcope fix'd thereto, fo contriv'd that when the Bubble refts in the middle of the Spirit-tube, the Horizontal Hair in the Telefcope will cut an exact Level, and by its Motion in a vertical Circle, whatever Object this Hair cuts above or below, the true Level, its Elevation or Depreffion will appear by the faid Quadrant divided and grav'd for that Purpofe; there is alfo in the Telefcope a vertical Hair to be us'd in the meafuring Horizontal Angles, fo that both the Horizontal and vertical Angles are obferv'd at the fame time, which is extream Ufeful in laying down

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the Plotts when the Hynothenusal are to be re-
duc'd to horizontal Lines.

This Inftrument is well contriv'd for working
with the Needle only ; for as foon as the In-
ftrument is fet fteady on the Ground ; the Needle
will lye in the direction of the magnetick Meri-
dian, and there be at reft; and then the Point in
the Box mark'd with 360, may be brought to
the north End of the Needle, and there fix'd
without ftirring the Needle ; alfo the Index and
Telefcope may be mov'd round to any Object in
the fame Manner ; for the Head of the Staff is
made of Brafs, and not liable to fhake as the
wooden ones are, which contributes much to the
true meafuring of an Angle, and the Index is
mov'd round a conical Center, touching the Limb
in three Places at 120 Degrees Diftance, and if
by much wearing it fhould fhake, that is inftantly
help'd by a Screw for that Purpofe; for if the
Index grows loofe and fhakes, it will not cut the
Minutes on the Limb to any Exactnefs.

The Pin, on which the Needle hangs, is made
of temper'd Steel turn'd and polifh'd in the
Lath, and may be taken out and put in at Plea-
fure, and is not fcrew'd to the Box, but remains
fix'd always in the fame Pofition, whilft the Box,
Index, and Telefcope are mov'd round it, and the
Telefcope fix'd to an Object without ftirring the
Needle, fo that an Obfervation may be made both
by the Limb and Needle at the fame Inftant.

And when the Telefcope is directed to an Ob-
ject, the whole Inftrument is fix'd there in fo
firm a Manner, with fmall Power, that the Mo-
tion of the Index when the Telefcope is directed
to the next, fhall not move the Limb from the
Pofition in which it was firft fix'd ; which in
other Theodolites is very difficult to be done.

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The whole Instrument is made very portable, and the Uses thereof plain and simple; one Telescope being apply'd to all the Operations, neither is any thing to be added or taken from it when we make use thereof.

Being thus provided with a good Theodolite; we now proceed to shew the Manner of using it in measuring Land.

The most material Things to be done in the Field are two; First, to measure the Length of the Lines; and Secondly, the Quantity of the Angles.

The manner of measuring Lines in the Field is already laid down; we now proceed to the Angles.

SECT. II.

The Description of an Angle.

An Angle is the meeting of the two Lines in a Point; provided the two Lines so meeting don't make one strait Line, as the Lines *a, a,* and *x, o, Fig.* 12. meeting together in the Point *o,* form the Angle *a, o, x.*

Angles are measured by the Arch of a Circle describ'd from the angular Point as a Center; so the Angle *a, o, x,* is measur'd by the Arch of the Circle, *Fig.* 13. describ'd from the angular Point *o*: The Arch of this Circle that measures the Angle *a, o, x,* being intercepted between the Lines *a, o,* and *x o.*

An Angle is said to be equal to, greater or less than another, according as the Arch which measures it contains as many more, or fewer of the equal Parts into which the Circle is suppos'd to be divided.

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The Circle is divided into 360 Parts or Degrees, and each Degree into 60 other Parts call'd Minutes; or suppos'd to be so divided, so that any Portion of the Circumference is expres'd by the Number of Degrees and Minutes it contains.

'Tis no matter whether the Circle be great or small, for each is suppos'd to contain 360 Degrees (except that the Minutes are better estimated on a great Circle than a small.)

The Line *o b*, is the Radius of the Circle, *Fig. 13. z, d*, is the Diameter, and passes through the Center *o*, dividing the Circle into two equal Parts; the Line *z e*, is the Chord of 60 Degrees joining the Extremities of the Arch *z e*.

Z o b, is a Right angled Triangle, *z o* the Base, *o b* the Perpendicular, and *b z* the Hypothenusal. Then the Angle *z o b*, contains 90 Degrees, which is the Measure of a right Angle.

A o x, is an acute Angle, containing less than 90 Degrees.

A o y, is an Obtuse Angle containing more than 90 Degrees,

'Tis no matter of what Length the Lines of an Angle be; 'tis their meeting one another in a Point that forms the Angle, for the Angle *z o b*, contains 90 Degrees, and *a o c*, contains 90 Degrees also.

Let the Circle *Fig. 13.* represent the Limb of the Theodolite, and let the Index be brought to the beginning of the Numbers at *z*, then the Telescope which moves therewith, will be set in the Direction of *o a*: Now move the Telescope till it be in the Direction of *o x*, so shall the Index on the Limb shew the Number of Degrees of the Angle *a o x*.

Let *x o*, and *o y*, represent two Station Lines in the Field, then the Center of the Theodolite being planted over the angular Point *o*,

let

let the Telescope be directted to *x*, (the Index
being brought to the beginning of the Numbers
on the Limb at *o*) and the Instrument fix'd there:
Now move the Telescope till you see *y*, so shall
the Index shew the Quality of an Angle *x*, *o*, *y*,
on the Limb, 119 Degrees.

In working with the Theodolite we only mea-
sure 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 Di-
rections we may draw the exact Plan of the Land,
which is call'd Protracting.

Provide a Field-Book rul'd with three Co-
lumns, in the middle Column insert the Quan-
tity of the Angles, and Length of the Station
Lines; in the outer Columns the Offsetts from
the Station Lines to the Bounders, and on each
Side note the Remarks which you meet with in
the Survey.

S E C T. III.

*Shewing the Uses of the Theodolite in measuring
the Angles round any Field or other Piece
of Land.*

The Theodolite before mention'd is numbred
on the Limb, from the Left to the Right, and
the Box from the Right to the Left; and there-
fore the Circuit is most conveniently made (ac-
cording to the common Phrase) *contra solem.* i. e.
with the Fences on the right Hand.

Let *Fig.* 14. represent a Field of which a
Plott is desired: First, chuse some convenient
Place therein, to begin the Work as at ☉, near
the Corner of the Field *a*, and set up a Staff
with a Mark thereon, as a Piece of Paper, or a
<div align="right">white</div>

white Rag, fo that you may plainly fee it at the
next Station; then lay the Chain in a ftrai
from *a* towards *b*, having firft fet up a
at *b*.

The Chain lying in this Direction on the Ground,
meafure with the Offset Staff from ☉, the Di-
ftance to the Hedge 56 Links, and enter in the
middle Column of the Field Book *o*, and
in the right Hand Column 56, denoting an Off-
fett laid off from ☉, 56 Links to the right
Hand of the Station Line.

Meafure forwards on the Station Line *a b*,
till you come againft the next Bend in the Hedge,
then let the Chain lye on the Ground in a right
Line between the Stations *a*, and *b*, and with
the Offset Staff, meafure the Diftance from the
Chain to that Bend in the Hedge 140 Links.

Take notice at what Length of the Station
Line each Offset is laid off; as here at the Length
of 540 Links on the Station Line, I lay of an
Offset of 140 Links, therefore in the middle
Column of the Field-Book that reprefents the
Station Line enter 540, and againft 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 of an Offset to the right
140 Links.

Alfo take Notice that thefe Offsets are to be
meafured from the Station Line to the Hedge
or Bounder, in fuch Manner that the Line repre-
fenting the Offset may ftand at right Angles
with the Chain or Station Line, as the Line
o c, with *z d. Fig.* 13.

Here I would advife a young Beginner in this
Art, not only to enter thefe Obfervations in the
Field-Book, but alfo on a Piece of wafte Paper,
to draw firft a Line that fhall reprefent the pre-
fent Station Line, and then upon that, to fet of
the

the Offsets as he meafures them in the Field, drawing the Bounders as he goes along, not regarding the Length of any Line, a refemblance of each Line being fufficient; becaufe 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 ufeful Inftruction, in drawing his Angles inward or outward, and laying the Corners of the Field in their true Pofition, with other little Difficulties to be met with in Practice; but when he is accuftom'd to a right Method of keeping the Field-Book this Trouble will be fpar'd.

I proceed to meafure on the Station Line to the next Bend in the Hedge, and there lay of an Offset at 8 Chain 26 Links, therefore againft 826 in the middle Column of the Field-Book; write in the next Column on the Right; 36 Links the Length of the Offset.

The Hedge continuing ftreight to ⊙ 2, meafure up thereto, and enter the Length in the Field Book 1120, and meafure the Diftance to the Hedge 36 Links, which enter in the Column of Offsets againft 1120, and draw a Line crofs the Field-Book.

Now remove the Staff from *b*, and caufe it to be fet up in a convenient Place, as at *c*, then plant the Center of the Theodolite exactly over the Hole, in which the Staff ftood at *b*, by the help of the String and Plummet, as directed in the Ufe of the plain Table, making the Staves of the Inftrument to ftand firm on the Ground, then bring the Index to 360 on the Limb, and turn the whole Inftrument about till the Hair in the Sights cuts the Staff at *a*, and there Screw it faft, that the Motion of the Index may not caufe it to ftirr from this Pofition; then turn the Index about till the Hair in the Telefcope

cuts

cuts the Staff at *c*, so shall the Index shew the Quantity of that Angle *a b c*, on the Limb, *viz.* 102 Degrees 20 Minutes, which note in the Field-Book for the Quantity of that Angle.

Now for certainty that you have measured this Angle Right, you may 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 was posited at *b*, but leave some Remark at *a*, that you may find it again when you come round the Field to close the Plott : and lay the Chain from *b*, towards *c*, and at ⊙, measure the Offset to the Hedge 20 Links, at 236, in the Station Line, I lay of the Offset 36, at 428 in the Station Line, the Offset is 92, and at 796 the End of the Line, the Offset is 30, to the Corner, therefore against 30 in the Column of Offsets, write Corner, denoting that Offset laid of at Right Angles from the Station Line, reach'd the Corner of the Hedge.

Place the Instrument at *c*, and as before directed, measure the Angle *b c d* 110 Degrees 40 Minutes, 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 can't be so well describ'd as by the Sight of the Instrument; only this may be said, that we can thereby estimate the Quantity of an Angle to 2 or 3 Minutes, which is as
<div align="right">exact</div>

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*, and send another forwards to *d*, then measure on the Line *c d*, and lay of the Offset to the Corner at 434, and against that Offset write Corner in the Field-Book, and measure up to *d*, entring the Length 468 in the Field-Book.

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

But no Angle is greater than 180 Degrees, therefore if you would know the true Quantity of this Angle, subtract 230 Degrees, 50 Minutes, from 360 Degrees, the Remainder is 129 Degrees 10 Minutes, the true Quantity of that Angle.

Note, When you meet with an outward Angle, remember to Mark it in the Field-Book with >, or some such Mark, as a Direction when you come to protract this Angle; to draw it outwards as it is in the Field.

In the same Manner deal with the rest of the Lines and Angles round the Field, till you come to Station *a*, but there is no necessity to measure the last Angle, or the two last Lines, unless it be to prove 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 direct the Telescope to the Tree

in

in the Middle of the Field, and note the
Degrees, &c. which the Index cuts on
the Limb, and the same at *g*, and note these
Degrees, &c. in the Field-Book, in the Column
of Remarks, you may protract the true Situa-
tion 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

The Field-Book.

Remarks	Offsets	Station Lines	Offsets	Remarks
		$a \odot 1$		
		- - - - -		
		0	56	
		540	140	
		826	36	
		1120	36	
		$b \odot 2$		
		0		
	Angle	102.20		
		- - - - - -		
		0	20	
		236	36	
		428	92	
		796	30	*Corner*
		$c \odot 3$		
		0		
	Angle	110.40		
		- - - - -		
		434	30	*Corner*
		468		
		$d \odot 4$		
		0		
	Angle ⟶	230.50		
		- - - - -		
		420	30	

The Field-Book Continued.

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

S E C T. IV.

The next Thing to be done, is to protract the Obfervations made in the Field, *Fig.* 14. fo that the feveral Lines and Angles therein, may be laid

down

down on Paper of the same Length, and in the same Direction as in the Field it self. In proportion as the Scale we make use of is to the Chain.

The Protractor generally used, is a Semicircle, though a whole Circle is better. Numbred and divided in the same manner as the Limb of the Theodolite, which it should always be; the Protractor being esteem'd an Epitome of Instruments.

But because the Degrees on the Protractor, are so much smaller than those on the Limb of the Theodolite, they can't be well estimated nearer than 10 Minutes; yet if any one will be curious, he may lay down the Angles on the Paper, to a Minute or two as exactly as they can be observed in the Field.

Mr. *Ward's* Protractor being commonly used for this Purpose, is made with an Index to move on the Center of the Semicircle, which Index is divided into 2 Parts, so fram'd, that each may be the Diagonal of one Degree; so that if the distance at the extream Ends be 10 Degrees, that next the Limb must be 8 Degrees, the Space between the two Limits in each Diagonal being divided into 60 Parts or Minutes; but these Divisions will be very unequal, being those of the Tangent Line, which fall near Infinite.

Mr. *Sisson* hath removed this Inconveniency, by making each Edge the Arch of a great Circle passing through the Center of the Protractor; the Space between the first and last Divisions being two Degrees thereof, and is divided into 60 equal Parts or Minutes.

The Reason depends on the 27 *Prop.* of the 3d, of *Euclid, viz.* That the Angle at the Center of a Circle is double to that at the Circumference.

The

The same Person hath contrived another Protractor, to lay down Minutes without any Index at all, and therefore preferable to both the former, because 'tis exceeding difficult to make the Index move exactly round the Center, and if it shakes the least that can be, the Instrument is useless; but this last is made of one Piece of Brass, and may be us'd as a common one, without regarding the Minutes when Expedition is requisite.

It may be thought here are too many Words spent about describing these Protractors as well as the Theodolite before mentioned; but if any one pleases to consider, that if we be not very exact in measuring the Angles in the Field, and laying them down in the same manner on Paper, (which is impossible to be done without good Instruments) we shall commit very great Mistakes; for Instance, If I mistake half a Degree in the measuring of an Angle, one of whose Sides is 20 Chains, the Area or Content of that Piece of Ground so left out or added to the Plott, by drawing this Line in a false Position, will be above 23 Poles; and this Error communicated to the following Work, will be very considerable in the whole.

S E C T. V.

The Manner of Protracting the aforegoing
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 on the Paper by the Scale, and the Angles by the Protractor.

Provide a Skin of Parchment, if the Plott is desired to be on Parchment, according to the

E   large-

largeneſs 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 Plott will extend, draw an obſcure Line on the Paper to repreſent the firſt Station Line, and mark the End thereof with ⊙ *a*, ſo ſhall that Point repreſent the firſt Station in the Field, and cloſe to this obſcure Line, lay the edge of your plotting Scale, 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 offsets 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 offsets 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 offsets on the ſame Side of the obſcure Line as noted in the Field-Book; ſo at ⊙ I prick off 56 at 500, the next Length I prick off 140, at the next Point, which is at the Length 826, I prick off 36, and at 1120 the End of the Line, I prick off 36.

Now if Lines are drawn from Point to Point, they ſhall repreſent the Bounders of this Side of the Field; and becauſe the Hedges, eſpecially in old Encloſures, are generally in the Form of a curve rather than ſtrait Lines, therefore if you draw the Bounders from Point to Point with a Quill-Pen with your Hand only, they will be more naturally expreſs'd, than if you lay a ſtrait Ruler from Point to Point, (except the Diſtan-

ces

ces are very long, or you take a multitude
of Offsets;) and to be exact, 'tis sometimes ne-
cessary to express the Nature of these little Irre-
gularities in the Fences, by a Sketch on one Side
of the Field-Book; but if you will be very curi-
ous, you may have an Instrument in Form of a
Steel-Bow, which by the help of Screws may be
drawn in any curve Form, and by this the
Bounders may be readily drawn.

The Length of the first Station Line being
1120, mark that Distance from ⊙ *a*, with ⊙ *b*,
and let the obscure Line be produc'd, 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
lyes on the Line ⊙ *a*, ⊙ *b*, the beginning of
the Numbers on the Protractor being laid to-
wards ⊙ *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 Degrees 20 Minutes, therefore with a
Protracting Pin or Needle, make a Mark against
102 Digrees 20 Minutes, 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 An-
gle *a b c*, the same.

Lay the Plotting Scale to the obscure Line
b c, the beginning of the Numbers coincid-
ing with the present Station, and the Num-
bers encreasing towards the next, then close to
the edge thereof, against *c*, 236, 408, 796, the
Lengths where the Offsets were taken, make
Marks with the Protracting Pin, and turn the
Scale perpendicular to the obscure Line, and
Prick off the several Offsets, 20, 36, 92, 30.

And

And now if Lines are continued from the Fences before drawn to these Offsets, they shall represent the Bounders on this Side of the Field.

The Offset 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, held close to the Line *b c*, and against 110 Degrees 40 Minutes on the Limb of the Protractor, make a Mark, through which draw the Line *c d*.

At the Length 434, in this Line lay of the Offset 30 Links, to which continue the Bounders before drawn, so is this Side of the Field finished.

Note, the next Angle at *d*, being noted in the Field Book, 230 Digrees 50 Minutes, you must either subtract 2°30 5′0, from 3°60: ′00 the Remainder is, 129 Degrees 10 Minutes for the true Quantity of that Angle; and because 'tis marked External, it must be plotted outward, and the beginning of the Numbers on the Protractor must be laid the contrary way, *viz.* towards the next Station.

Or if the Protractor be numbred 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 Angle 230 Degrees 50 Minutes, 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.

<div align="right">But</div>

But if you use a femicircular Protractor, ob-
ferve to lay the Diameter on that Line which
brought you to the prefent Station, and to lay
the beginning of the Degrees of the Protractor
towards the laft Station when the Angle is lefs
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 Num-
bers being laid the contrary way to *c*, and a-
gainft 230 Degrees 50 Minutes on the inner Cir-
cle of the Protractor, make a Mark, through
which draw the Line *d e*.

In the fame manner lay down the Angle at
e, and draw the Line *e f*, continuing the Boun-
ders as before directed.

When you have marked the Angle at *f*, let
the Protractor lye in the fame Pofition, and make
a Mark againft 38 Degrees 30 Minutes, as noted
in the Field-Book for the bearing of the Tree
from that Station, and through that Mark draw
an obfcure Line from *f*.

Do the fame at *g*, continuing the obfcure
Line from thence till it croffes that drawn from
f, fo fhall the Interfection of thefe two Lines
determine the Scituation of the Tree in the Mid-
dle of the Field.

In the fame manner may any other inacceffible
Diftance be meafured 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 fame as that noted in the Field-
Book, and the Angles at *g*, and *a*, (if you
had meafured it) the fame which proves the
Plott to be truly laid down.

<center>E 3   S E C T. VI.</center>

S E C T. VI.

IT may not be improper to take notice in this Place, of the Method propofed by fome Authors, as a Proof that the feveral Angles in a Field are truly meafured, by collecting the Quantities of all the Angles into one Sum, and then to multiply 180, by a Number lefs by two than the Number of the Angles in the Field; and if the Product of this Multiplication be equal to the total Sum of the Angles, the Work is concluded to be right.

But thefe two Numbers may agree, and yet a Miftake may be committed in meafuring the Angles; as for Inftance:

Let the Number of Angles in the Field be 7, and the Quantities collected into one Sum be 900; then multipling 180, by a Number lefs by two than the Number of the Angles, *viz.* 5, the Product is 900, equal to the Sum of the Angles.

Let the true Quantity of the firft Angle be 160 Degrees, and the true Quantity of the Second 190 Degrees; thefe two Numbers when added together make 350; but fuppofe you had made a Miftake in eftimating the Degrees on the Inftrument, or noting them in the Field Book, and for the Firft Angle had noted 190 Degrees, and for the Second 160 Degrees, their Sum will ftill be 350; fo that by this Method you will not difcover your Error; but hereafter will be inferted a Method, whereby an Error may be corrected at every Station in the Field before we leave it by the help of the Needle and Limb together, but firft I proceed to fhew the Ufe of the Needle only in furveying Land.

<div align="right">S E C T.</div>

SECT. VII.

Of the Circumferentor.

THE Circumferentor is an Inftrument ufed to meafure Angles in the Field ; it confifts of a Box and Needle, fcrewed to the Index with plain Sights thereon, or inftead of the plain Sights with a Telefcope mounted over the Box, that may be either elevated or depreffed to an Object as there fhall be occafion ; the Index is mov'd by a Ball and Socket, and fupported by a three legged Staff.

In Surveying Harbours, Seacoafts, Counties or large Commons, where the Lines are very long, or thick over grown Woods, where we may be forced to make a multitude of Angles, and the Sight of the two Lines conftructing the Angle, may be hindred by the Brufh or Underwood ; in thefe Cafes the Angles may be meafured fufficiently exact by the Needle only, (though better, and as quick by the Theodolite, as will be fhew'd hereafter) yet in furveying Lordfhips, Enclofures, or plain Pafture Land, (a fmall piece of which got or loft is of a confiderable Value, and each particular Field ought to clofe exactly) the Angles are without doubt more furely meafured by the Limb of the Theodolite, becaufe the Degrees in the Box can't be fo nearly eftimated, and the Needle is liable to be drawn afide by fome hidden magnetick Power.

The Pofition or bearing of a Line obferv'd by the Needle, is expreffed by fuch a Number of Degrees and Minutes as it is diftant from, or Quantity of the Angle, which that Line makes with the Meridian.

E 4   And

And if a Perfon wholly unacquainted with the ufe of this Inftrument, will take the Pains to try this following Method, it may be an help to conceive the manner of ufing it in the Field.

Upon a Sheet of Paper let there be drawn right Lines parallel one to another at any Diftance, and upon a Table let there be fixed a Pin with the Point upwards, let the Pin fo fixed, be run through one of the Lines in the Paper, and upon the Point of the Pin, let there be put a Magnetick Needle, let it traverfe about till it refts of it felf; then turn the Paper about on the Table till the Needle hangs directly over the Line, in which the Pin is placed, which is difcovered by fixing the Eye over its center; then with fealing Wax faften the Paper to the Table by the four Corners; fo may the Paper be fuppofed to reprefent the Surface of the Earth, and the Lines the magnetick Meridian (which mark at the top with North, and at the bottom with South.)

For if the Pin be removed into any other of the Lines, and the Needle be made to traverfe thereon, it will, when at reft, hang directly over the Line in which the Pin is placed, if it be drawn parallel to the firft Line, over which the Needle hung when the Paper was fixed.

The Needle then points always to or lyes in the direction of the Meridian, by virtue of the magnetick Power; fo if I had faftened to the Table a Sheet of blank Paper, and had laid a Ruler in the fame direction with the Needle when at reft, and had drawn a meridian Line, and removed the Needle to another part of the blank Paper, and drawn another fuch a Line by the direction of the Needle, that would have been a Parallel,

When

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.

But with the Theodolite, the Angle is formed by the meeting of the two Lines or Fences themselves.

Set one Foot of a Pair of Compasses in some one of the Meridians on the Paper, and describe a Circle, then the 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 a venture, and imagine this Line represents an Hedge or Station-Line in the Field, and to find its bearing or Angle that it makes with the meridian, look what Degreee, &c. it cuts on the Circle, for that is the Quantity of the Angle or Number, expressing its bearing, counted from the beginning of the Numbers.

So the Needle used in the Field points out the magnetick Meridian, and the Divisions in the Box mov'd under it measure the Angle, that any Line in the Field makes with that Meridian.

The Box of the Circumferentor is commonly numbred from the right to the left ; the Numbers beginning at N or North, which is mark'd also with a Flower de luce, and encrease towards E or East, and the direction is to be taken from the North end of the Needle.

Let it be required to observe the bearing of the several Station-Lines that encompass the Wood, *Fig.* 15.   S E C T.

S E C T.   VIII.

The Use of the Circumferentor in Surveying Land.

Firft plant the Circumferentor, at fome conve-
nient 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 mark the Di-
vifion which the North end of the Needle points
to in the Box when at reft, which is 260 De-
grees 30 Minutes; therefore note this Number
260 Degrees 30 Minutes in the Field-Book, for
the bearing of the Line *a b*.

Obferving former Directions for removing the
Inftrument from one Station to another, and mea-
furing the Station-Lines and Offsets from thence
to the Bounders as you pafs along the Station-
Lines, let the Inftrument be removed from *a*, and
planted at *b*, the next Station; then keeping the
Flower de luce in the Box from you; turn the In-
ftrument 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 Degrees 12 Mi-
nutes, which note in the Field-Book for the bear-
ing of the Line *b c*.

The Inftrument planted at *c*, and the Sights
directed to d, the bearing of that Line *c d* will
be 331 Degrees 45 Minutes.

In the fame manner proceed to take the bear-
ing of the other Lines round the Wood, obfer-
ving this general Law.

To keep the Flower de luce in the Box from
you, and to take the bearing of each Line from
the North end of the Needle.

The Numbers in the Card of fome of thefe Cir-
cumferentor are made to encreafe towards the
right, but that before mentioned is beft; for
<div align="right">when</div>

when you turn your Inftrument to the Eaftward, the Needle will hang over the Weftward Divifion on the contrary Side.

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

So if the Inftrument 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 fame as before obferved; alfo the Bearings of the Lines *c d*, and *d e*, might be obferved at *d*, and *e f*, and *f a*, at *f*; fo that inftead of planting the Inftrument 6 times, you need in this cafe plant it but 3 times, which faves fome Labour.

But fince you muft go along every Station Line, to meafure it or fee it meafured, the trouble of fetting down the Inftrument is not very great, and then alfo you may examine the Bearing of each Line as you go along; and if you fufpect an Error in the Work by the Needles being acted on by fome hidden magnetick Power, or from your own Miftake, in obferving the Degrees that the Needle points to, you may correct fuch Error at the next Station before you proceed.

As when the Inftrument was planted at *a*, and the Sights directed to *b*, the Flower de luce from you, the North end of the Needle pointed to 260 Degrees 30 Minutes; now being come to *b*, direct the Sights back to a Mark at *a*, keeping the Flower-de-luce towards you : So fhall the North end of the Needle Point to 260 Degrees, 30 Minutes, as before at *a*, and then you may be fure the bearing of the Line *a b*, is truly obferved.

But if the Needle doth not point to the fame number of Degrees, &c. there hath been fome
<div align="right">Error</div>

Error in that Obfervation, which muft be cor-rected before you proceed.

If you have a fufpicion that the Needle doth not play well, when the Inftrument 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 wafte Paper; then with a clean Knife, Key, or any bit of po-lifh'd Steel, that hath touched a Loadftone, move the Needle by applying it to the Box, and examine when it hath fettled again what De-grees it then Points at, the Sights being ftill di-rected to the preceding Mark at *b*; and if the Degrees are the fame, they may be entred in the Field-Book, but if not, the Cap and Pin muft be cleanfed with fome brown Paper and a little Putty, and thereby freed from fuch Duft or Dampnefs that hath gotten to it; if after all the Needle does not play freely, place in the Box another Pin, or ufe another Needle, or do both, and thefe Neceffaries a Surveyor ought to have in his Pocket while he is in the Field.

If you would meafure the Quantity of any Angle by the Needle, place the Inftrument at the angular Point, and take the Bearing of the two Lines conftructing that Angle, and fubtract-ing the leffer out of the greater, the Remainder is the Quantity of that Angle, if lefs than 180 Degrees, but if the Remainder is greater than 180 Degrees, fubtract it out of 360 Degrees, and that laft Remainder is the Angle.

· The manner of entring the Offsets in the Field-Book, is before fhewn in the ufe of the Theodolite; it will be fufficient in this place, to infert 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 Plott of the

<div align="right">fame</div>

same Length and in the same Direction as in the Field. *Vide Fig.* 15.

SECT. IX.

The manner of Protracting the aforegoing Observations made by the Circumferentor.

Lines	Bearings		Links	
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 Draught, at Distances not exceeding the Breadth of the diametrical Part of your Protractor, as in *Fig.* 15, and mark them with N, and S, for North and South; then considering which way the Plott 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, 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 mark'd with N, or Northwards, when the Degrees are fewer than 180, but Southwards when more; the Protractor thus placed, look in the Field-Book for the Bearing of the first Line *a b,* which is 260 Degrees 30 Minutes; therefore with the beginning of the Numbers on the Protractor towards *f,* close to the Limb against 260 Degrees 30 Minutes make a Mark, and through

through that Mark from the 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 of the
Meridian, but the Protractor to lay down these
Observations must be numbred contrary to the
Box of the Circumferator; and if it be a Semi-
circle it must be numbred, first to 180, and then
on the inner Circle whose Numbers must en-
crease the same way as the outer Circle to 360,
and the Bearings greater than 180, are pricked
off from this inner Circle, and the beginning of
the Numbers must be laid Northward or South-
ward as the Degrees of Bearing are more or less
than 180; but if your Protractor be a whole Cir-
cle, the beginning of the Numbers may be kept
always one way, as the Numbers of the Circum-
ferentor were in the Field, (the Protractor being
an Epitome of the Instrument you make use of
in the Field) but the Diameter must be always
laid upon a Parallel to the meridian Lines, and
may be mark'd with N S at the Ends as a Di-
rection 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
of the Offsets therefrom, which gives the Boun-
ders of that side of the Wood, *Fig.* 15.

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 Semicircular Protractor towards S, and
against 292 Degrees 12 Minutes, make a Mark,
through which Mark from *b*, draw the Line *b c*,
setting of the Offsets therefrom, and draw the
Bounders of that side of the Wood.

In

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
through 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 Off-
sets with a black-lead Pencil, and the Bounders
with Ink; you may with a piece of Bread rub
off those Lines, so shall the true Bounders of the
Wood only remain, which gives the exact Fi-
gure thereof.

S E C T. X.

*The manner of casting up the small irregular
Pieces of Ground, which lye 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
Bounders, but at such a Distance from thence
that we may see clearly from one Station to ano-
ther, 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 di-
viding the same into the largest Trapezias and
Triangles that may be, and measuring the Bases
and Perpendiculars by the same Scale that the
Plott was laid down by.

But in order to cast up the small irregular
Pieces comprehended between the Station-Lines
and Bounder; if you reduce them into Triangles,
&c.

&c. as they will be a great many in Number, fo
you will very much err in laying of them down
firſt, and taking them off afterwards, eſpecially if
the Scale you protraƈt by, be very ſmall, where
10 or 12 Links of a Chain is hardly to be eſti-
mated though the Scale be well divided, and
the Points of the Compaſſes very fine: For the
removal of this Inconvenience, I ſhall here ſhew
a way whereby you may caſt up theſe ſmall
Quantities, let the Scale be never ſo ſmall, as ex-
aƈtly as any of the greater parts of the Field.

Suppoſe the ſmall irregular Pieces between the
Station-Lines and Bounders, *Fig.* 14, were to be
caſt up.

Firſt lay the Field-Book before you, where
you will find the Length of the firſt Offset
(as meaſured in the Field with your Offset Staff)
from ⊙ 1 at *a*, to be 56 Links, and the ſecond
at 540, in the Chain-Line 140, forming the
ſmall Trapezia, *a*, *Vide Fig.* 16.

Now if you add the Offset 56 to the next
140, the Sum is 196, the half of which is 98,
the equated Breadth ; multiply the Length 540
by 98, the Produƈt is 52920, the content of the
Trapezia, *a*, in ſquare Links.

Add 140 to 36, the Sum is 176, the half
Sum 88, ſubtraƈt 540 from 826, the Remainder
is 286, the Length of the Trapezia, *b*; there-
fore multiply 286 by 88, the Produƈt is 25168,
the Content of the ſmall Trapezia, *b*.

Subtraƈt 826 from 1120, the Remainder is
294, the Length of *c*; and becauſe both the
Offsets are alike, multiply 294 by 36 , the
Length of the perpendicular Offset, the Pro-
duƈt 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

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 re-
duce into Acres, &c. as before directed.

Note, The Performance of this being tedious,
I shall in the next Chapter lay down a more
Practical Method for casting up the Content of
any Piece of Land.

F   C H A P. III.

C H A P. III.

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

S E C T. I.

IN this Method of Surveying Land, the Angle which every Line makes with the Meridian is meafured by the Limb of the Theodolite, and there- fore much preferable to that before mentioned in the aforegoing Chapter by the Nee- dle only, becaufe the Degrees and Minutes are better eftimated on the Limb of the Inftrument than 'tis poffible they fhould be in the Box of the Circumferentor; and this gives the Theodo- lite the preference to any other Inftrument, be- caufe we can work by the Limb only, without regarding the Needle at all; but if it be more con- venient to make ufe of the Needle, we may do it in the following manner, being the moft exact and abfolute Method yet known for Surveying large and fpacious Tracts of Land.

For the Needle being obferved to play well, when it hath fettled in the direction of the Meri- dian and is at reft, the Box may be moved round the fixed Center by turning the Index on the Limb and the Point mark'd with 360 in the Box, brought directly againft the north End of the

Needle

Needle, with greater Exactness than a Degree, and
its Parts can be estimated 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 *o a, b c, d e, f,* in *Fig.* 17. re-
present the Station Lines near the Bounders of a
Field; then the Angle which each makes with the
Meridian may be observed in the following man-
ner.

First, having set up a Mark at *o,* Measure for-
wards with the Chain on the Line *o a* to *a*
600 Links.

Plant the Instrument at *a,* and bring the Index
to 360 on the Limb, and turn the whole Instru-
ment about (whilst the Needle hangs in the di-
rection 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 *o,* and note in
the Field Book the Degrees and Minutes which
the Index cuts on the Limb, *viz.* 207 Degrees
20 Minutes, being the Quantity of the Angle
which the Line *a o* 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 Degrees 10
Minutes, which is the bearing of *b a* or Quan-

tity

tity of the Angle which that Line makes with
the Meridian.

It would be Tautology 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 fre-
quently observe the Needle by moving it from
the Point at 360 with a Knife, &c. then if it
swings backward and forward freely without jog-
ging or stopping, and settles again to 360 exactly;
we may conclude the Instrument is right in the
direction of the Meridian to make an Obser-
vation.

If you suspect the Needle to be acted upon by
some hidden magnetick 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 whe-
ther 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 Tellescope forwards to *f*, and note the Angle
which the Index cuts on the Limb; *viz.* 200°
5'o, then the Instrument being planted at *f*, because
the bearing of *e f*, observed at *e*, is more than 180°;
subtract 180 there-from and to the Remainder
2'o 5'o on the Limb, set the Index exactly; but
if the bearing of *e f* had been less than 180, add
180 thereto, and to that Number, being 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

For the magnetick 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.

Now follows the manner of protracting these Observations,

Lines	Links		Sta.	Deg.	Min.
a, *0*,	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
0, *f*,	500	——	*0*,	289	15

SECT. II.

A new Method of protracting any Observations made in the Field by the Needle.

BY which a Plan 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 by the help of a parallel Ruler, being very exact and expeditious.

Provide a circular Protractor, whose Numbers encrease 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.* 17. (with a black lead Pencil) for a Meridian, and assign a Point therein, as at *0*, to which Point apply the Center of the Protractor, and turn it about till the Diameter lyes on the Line N S, with 180 towards N, (that part of the Limb

of

of the Theodolite being always kept Northward
of the Field.)

The Protractor held in this Position, lay the
Field Book before you, and against 207 Degrees
20 Minutes, the bearing of the First Line *a o*
close to 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 Degrees 10 Minutes, the bear-
ing 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
Degrees the bearing at *c*, make a Prick and write
c, against 91 Degrees 55 Minutes write *d*, against
125 Degrees 20 Minutes write *e*, &c. *Vide Fig.* 17.

Having mark'd the bearing of each Line round
the Protractor, lay it aside, and apply the edge
of your plotting Scale to *o* at the Center, and
a mark'd by the Limb of the Protractor; the
beginning of the Numbers coinciding with *o*,
and encreasing towards *a*, and prick off 6 Chains
the Length of the Line *o a*, and with Ink draw
the Line *o a a*.

Lay the parallel Ruler to the prick'd Line
p o b r, so that the edge cuts the central Point
at *o*, and the Point at *b*, as mark'd 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

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 obferve in what Direction the Letter *b*, as mark'd by the Limb of the Protractor, ftands from the central Point *a*, in the fame direction muft the Line *a b* be fet from the Station Point *a*; alfo when the Ruler is laid to the Station *b*, you cannot be at a lofs whether you fhould draw the Line *b c* upwards or downwards; if you obferve in what direction the Letter *c* ftands from the central Point *a*; therefore in the fame Direction draw *b c* from *b*, or the Angles mark'd external in the Field Book will be a fufficient Direction.

Lay the parallel Ruler to the central Point *a*, 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, fetting 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 *a*, and to the Mark at *d*, and move it up to *c*, and draw *c d*.

In the fame manner deal with the other Lines and Angles, fo fhall the laft Line *f o* cut through the Point *o*, and its Length be 5 Chains, as noted in the Field Book, which proves the Plott to be truly laid down.

In thefe Obfervations the Station Lines only are inferted, the Offsets from thence to the Bounders are omitted, the manner of plotting them being already laid down before.

When the Bounders of the Field are drawn, and the Name thereof entred in the middle of the Plott, you may with a piece of Bread rub

F 4 off

off the Marks that were made with the Pencil
round the Edge of the Protractor and meridian
Line, fo will the Plott be ready for cafting up.

But if feveral Fields are to be plotted to-
gether, you muft draw a Line through the firft
Station Point in each, parallel to the Meridian
in the firft Plott, from which the Plott of each
Field may be laid down in the fame manner as
Fig. 17.

Obferve, neither the Circle nor Figures, ex-
preffing the Angle which each Line makes with
the Meridian, are ufed in Practice, though in-
ferted in the Scheme to demonftrate the Nature
of the Work; alfo if you lay the Edge of the
thin plotting Scale clofe to the Edge of the pa-
rallel 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 begin-
ning 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 Pofition to 500, the Length
of the Line without drawing any other but the
Station Line it felf.

SECT. III.

*A New Method of calculating or cafting up
the Area of a Plott of Land in Acres, &c.*

ACcording to the Rules before mentioned in
Chap. 1. the whole Plott muft be reduced
into Trapezias and Triangles, and the Length of
each Bafe and Perpendicular meafured by the Scale;
but fince it is often neceffary to lay down the
Plott by a fmall one, as ¼ of an Inch or lefs;
if you err 8 or 10 Links in taking off the
Length of the Bafes and Perpendiculars (which
may eafily happen if the Lines be not drawn
very

very neat and small) and there being several such
Bases and Perpendiculars, the Error may be
considerable in the whole Plott, 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 by this Method the whole Plott,
(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 Multi-
plication, and the Truth of the Work is demon-
strated by the first Theorem in Chap. 1. *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.* 18. be
reduced to a Triangle, whose Area shall be e-
qual 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 Ru-
ler 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 *d o e*, and *b o a*, having
Bases of the same Length, and lying between
the same Parallels are evidently equal ; then 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 e-
qual ; 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.

<div style="text-align: right;">Again</div>

Again, let *Fig.* 19. be reduced into a Triangle.

First extend the Line *f a*, and apply the parallel Ruler to the Points *a* and *b*, and move it up parallel 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 *h*, and make a Mark in the extended Line or Base at *h*.

Lay the Ruler to the Points *h* 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 Plott was laid down to the Base, and measure its Length, also measure the Length of the Perpendicular; multiply these two Sums together; the half of their Product is the Content of the Plott 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 Plott to be 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 em off again with a Piece of Bread, as soon as the Content of the Field

Field is entred with its Name in the middle thereof.

If in using the parallel Ruler at the first Tryals you find it apt to slip on the Paper, which you may do if you be not very careful to hold it close down thereto, that Inconvenience may be prevented, if you make use of three small Pins or Needles, 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 Edge to the Second at *a*, take out the Pin at the Second, and put it in the Base or Line extended where the Ruler cuts it as 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 Plott is reduced.

S E C T. IV.

Shewing how to reduce the irregular Boun-
ders 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.* 20. represent the Bounders of a Field, whose Content is desired.

First, produce some one of the longest Sides as *i k*, 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

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*; Secondly, lay the Ruler from *y* to *d*, and move it up to *e*, it cuts the extended Line *e g* at *z*; Thirdly, 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 one, and then to a Triangle which may be cast up by one Multiplication only.

This is the same Method before laid down for reducing a many sided Figure to a Triangle, but if you have not a parallel Rule, do thus :

Having produc'd 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 in this manner instead of a parallel Ruler.

Provide a plate of thin Brass in form of an Arch of a Circle, near whose ends let there be drill'd small Holes, through which string it with a very fine Hair; and then an Hedge as *g c*, *Fig.* 20. bends in and out in several Places, and those Bends contain very small Spaces; lay the Hair over it length-ways, so that the Quantities cut off from the Figure thereby, may be equal

to

to thofe added to it, and with a protracting Pin near the ends of the Hair, make two Marks, through which, draw a ftrait Line, and fo will this irregular Side be reduced to a regular one; and here it may be obferv'd that in very fmall Bends by the Eye, you may judge better than by the Compaffes.

But if Hedges confift of large Curvatures, chufe out fuch Points, and fo many of them that Right-lines drawn from Point to Point may vary the Quantity by fuch Quantities only as may be rejected, and herein the Hair will be a Ready Affiftance

SECT. V.

The manner of reducing hypothenufal to horizontal Lines.

WHEN we meet with an Hill in Surveying a Piece of Land; we can only meafure the hypothenufal or flope Lines thereof, on the Superficies of the Hill, which being confiderably lon
ger then the Bafe or level Lines on which the Hill is fituated, as the Lines *a b, b c, Fig. 21.* are longer than *a o, o c,* therefore when we plott this Hill (becaufe we cannot make a convex Superficies upon a piece of plain Paper) we muft reduce the hypothenufal to horizontal, Lines that all the Lines in the Plott may be laid down alike in *Plano.*

For the Lines of level only muft be exprefs'd in a Plott; that every Field therein may lye in its true Situation; for if *a b,* and *b c,* were laid down on Paper as meafured in the Field, they would reach to *d,* and not only thruft the next Hedge out of its true Pofition, but alfo take up

a great

a great Space in the next Field, making that too little.

Let *Fig.* 21. reprefent an Hill; at the foot of which the Theodolite is planted, which being fet level in order to meafure the Angle at *a*, the Telefcope when directed towards *b*, at the top of the Hill, cuts the Ground; therefore take the Pin out of the Quadrant, and elevate the Telefcope to the Mark at *b*, (which muft be fet the fame Diftance from the Ground as the Telefcope is) and when the Hair cuts the Mark at *b*, the Index fhews the horizontal Angle on the Limb, and the Quadrant the Angle of Elevation *b a o*, 25 Degrees 50 Minutes both at the fame time, which note in the Field Book one over againft the other.

The Inftrument removed from *a*, and planted level on the top of the Hill at *b*, the Telefcope when directed towards *c*, cuts the Element, therefore take out the Pin from the Quadrant, and deprefs the Telefcope to the Mark at *c*, and then the Quadrant will cut 21 Degrees 34 Minutes, and the Length of *a b*, as meafured up the Hill, by the Chain is 1200 Links, and *b c* 1416.

In order therefore to plott thefe Obfervations, firft, draw the Right-line *a d*, but do not fet the Length 1200 Links thereon, becaufe the Angle of Elevation is noted in the Field Book againft the horizontal Angle, which fhews 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 againft 25 Degrees 50 Minutes, the Angle of Elevation, make a Mark, and through it draw the obfcure Line *a b*, fetting thereon 1200 Links the Length of the Hypothenufe, at the End of which make a Mark at *b*.

Having drawn the Angle of Elevation *b a o*,

take

take a fquare Protractor or any other Square that
hath one Right Angle, and two ftrait Edges, and
apply one Edge thereof to the Right Line *a d*,
whilft the other Edge cuts the Point *b* in the ob-
fcure Line *a b*, and thereby let fall a Perpendi-
cular from the Point *b*, which falls on the Line
a d at *o*, fo fhall the Line *d o*, be the true hori-
zontal Line which muft be laid down in the Plott.

In the fame Manner reduce the Hypothenufe
b c, by firft drawing the Angle of Depreffion
d o e, 2° 3′ 4 fetting the Length of the Hypo-
thenufe *b c* 14, chain 16 Links on the obfcure
Line *o e*, and where that Length 1416 Links
reaches from *o*, make a Mark at *e*. Laftly, from
e let fall a Perpendicular on the Line *d*, which
falls at *c*, fo fhall the Line *o c*, be the true Ho-
rizontal Line.

Or elfe having noted the Quantity of the An-
gle of Elevation, and Length of the Hypothe-
nufe in the Field Book, you may find the ho-
rizontal Line by the help of the following Table.

*A Table fhewing how many Links to de-
duct out of every Chain's Length in the
Hypothenufal-Line.*

Deg.	Min.	Lin.	Deg.	Min.	Lin.	Deg.	Min.	Lin.
4	3	¼	19	57	6	29	31	13
5	44	2	21	34	7	30	41	14
7	1	¼	23	4	8	31	47	15
8	6	1	24	30	9	32	52	16
11	29	2	25	50	10	33	54	17
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

Having the Angle of Elevation 25 Degrees 50 Minutes, 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 Degrees 50 Minutes, 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 requires 10 Links to be deducted from thence, 12 Chains or 1200 Links, requires 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 Degrees 34 Minutes, and the Length of the Hypothenuſe or ſlope Line *b c* 1416 Links, you will find in the Table againſt 21 Degrees 34 Minutes 7 Links, then if 100 : 7 : 1416 : 99, therefore ſubtract 99 Links out of 1416 the Length of the ſlope Line, the Remainder is 1317 Links, the Length of the level Line *o 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 above 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

may carry a small Quadrant in your Pocket, with which measure the Angle of Altitude, and note it in the Field-Book against the Chord or Sextant of 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.

You must shade over that part of your Plott where the Lines are thus reduced with the Representation of Hills, left another Person should measure them by the same Scale with the other Lines, and find them to differ.

If a Field have 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, though the side Lines must be reduced to make a regular Plott in respect of the adjacent Fields that are level; but if a 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, thereof the Superficies 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 on the Earth; (that is, grow strait upwards) as much will

G   grow

grow on the horizontal Line as on the Hypo-
thenuse, and therefore the Lines ought to be all
reduced to a level, and the Content to be de-
duced from the Plott 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 Plott.

'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.

C H A P.

C H A P.   IV.

Shewing how to Survey and make a
perfect Draught of several pieces
of Land lying together as a Man-
nor, &c. Also how to compare the
Bearing and Angles one with a-
nother, at each Station, as observ'd
by the Theodolite, in order to cor-
rect any Error that may arise
in measuring the Angles in the
Field as well as protracting them
on Paper.

S E C T.   I.

AVING in the former Chapters
laid down the best and most practi-
cal Methods for measuring any Piece
of Land by the most proper In-
struments, I here subjoin the manner
of Surveying several Parcels lying
together; an Example of which may be taken
from the small Tenement or Farm, *Fig.* 22.

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 Fields, 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 Offsets greater than a Chain or a Chain and half, or thereabouts, for Offsets taken too long are not so easily laid off at right Angles from the Station Line) and to that Staff at ⊙ 2, I direct the Telescope, and note the Degrees in the Box cut by the north End of the Needle, *viz.* 356 Degrees 10 Minutes, 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 plac'd, 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 lye on the Ground in that Direction; till the Occurrences in this Chain's Length are entred in the Field-Book, *viz.* I measure the Distances of the Chain from the Bounders of each Field, which I enter in the Columns of Offsets, that on the right Hand of the Chain in the right Hand Column, and that on the left in the left Hand Column; and if the Land is Part of that which I am about to survey, I write in one
of

of the outside Columns by what Name it is call'd,
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 Offset Staff at right Angles with the
Chain, and measure the Distance from thence to
the corner of Turfy Leas, which I find to be 15
Links; therefore in the middle Column repre-
senting the Station Line I write 20, and against
it in the right Hand Column of Offsets 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 Offset 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 Offsets a-
gainst 40 in the middle Column, denoting that
at the Length of 40 Links from ☉ 1 the Offset,
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 Offsets 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 Offset on the left Hand of the Chain
Line, because the Hedge varies its Direction, ma-
king 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
Offsets 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 Curviture, then I take Offsets at every
Chain or half Chain's Length, or oftner as the
Thing requires.

<center>G 3</center>

In this manner I proceed with the Chain till I come to the Staff at ⊖ 2, obferving as I go along the Bends in the Fences on each fide of the Lane, to every one of which I take an Off-fet, writing the Length of each on the right or left fide of the middle Column in the Field-Book reprefenting 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*, fome remarkable Object on the farther fide of the Hedge, as another Fence fhooting up thereto; *ret.* return to a former Station, &c.

Being come to ⊖ 2, I there plant the Inftru-ment, and fend the Station Staff forwards in the Lane as far as I can fee it, as to ⊖ 3, and then bring the Index to 360 on the Limb, and turn-ing the whole Inftrument about I direct the Telefcope to the Staff left at ⊖ 1, and there fix the Inftrument; and then turn about the Index on the Limb, till through the Telefcope I fee the Staff at ⊖ 3, and then find that the north End of the Needle points at 338 Degrees, and the Index cuts on the Limb 161 Degrees 50 Minutes; therefore under ⊖ 2, in the middle Co-lumn of the Field-Book, I enter 338 Degrees, and under that 161 Degrees 50 Minutes, denoting that at the fecond Station the Bearing of the fe-cond Length is 338 Degrees, and the Angle which the Index cuts on the Limb is 161 De-grees 50 Minutes.

The Rule I obferve in meafuring each Angle is this; firft I bring the Index to 360, and with that part of the Limb towards me, I direct the Telefcope to a Mark at the laft Station, and there fix the Inftrument; then I turn about the

Index

Index on the Limb, till I see the Hair in the Tellescope 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 it self 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 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 Θ 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 Θ 1, 356° 10', the Remainder is 161° 50 equal to the present Angle.

Likewise, if to the Bearing at Θ 3 1° 30', you add 180 Degrees, the Sum is 181° 30', which is less than 33800', the Bearing of the last Station, therefore 181° 30' must be encreased 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

G 4   be

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 there-from; and then, if the Angle thus calculated from the Bearings, doth agree with that which the Index cuts on the Limb, you may conclude the Angle is rightly observed, and therefore may be entred 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 can't 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, tho' 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.

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-Leas; therefore I take an Offset thereto perpendicular from the Chain Line, and enter in the Field-Book *a g* 17 Links, and this will hereafter be of Use in closing the Plott.

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

⊙ or the present Station, I measure an Offset to
the right 10 Links, and to the left 20 Links; at
41 in the Chain Line; I am against the Or-
chard 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 Offset from the Chain Line, and
enter them in the Field-Book.

In going from ⊙ 4 to ⊙ 5, the Chain touches
the Brow of the Ditch at 2 Chain 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, and 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 far-
ther 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, and if that can't
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 Thick-
ness thereof, and always measure the nearest Di-
stance between Station and Station that can possi-
bly 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 Bounders meet, to which
I measure from ⊙ 9; so shall the End of this Line
coincide with the Offset which I took to this
corner from the Station Line in the Lane, which
will

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
Bounders of the present Field are already observed
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 Tellescope to a
Mark, at the last Station before I came to this,
viz. ☉ 8, and fixing the Instrument there, I next
direct the Tellescope 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 Offset to the Fence where each Partition
Line joins it on the other Side, by the Help of
which, together with the other Offsets on the fur-
ther 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 Offset 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 Offset-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 plant-
ing the Instrument at ☉ 8, I direct the Telle-
scope

scope to the Mark left at ☉ 7, and here also I
observe as a general Law, to observe the Angle
with that Line which was measured immediately
before I came to the Station where I took the
Angle the first time: So here I observe the An-
gle made with ☉ 7, ☉ 8, and not with any other,
as ☉ 8, ☉ 9; therefore according to this constant
Law I direct the Tellescope back to ☉ 7 in the
Stockin, and fixing the Instrument there, I next
direct the Tellescope 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 my self o-
ver against the Fence that parts *Out-Wood* from
Crab-tree-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
Offset, denoting, that at the Length of 4
Chains 76 links from ☉ 11, I laid off an Offset
to the left, 61 Links, and proceed to observe and
enter in the Field-Book the rest of the Occur-
rences 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 *Turfey-Leas* at the Corner ; to which I
took the first Offsett from ☉ 1, in Charlton-Field.

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

At ☉ 17, I cause a Staff to be set up close to
the Fence where the Hedges join one another ;
to which Staff I measure strait from ☉ 17, clo-
sing *Outwood* at the Extremity of the Station-
Line, which coincides with the Offsett 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 Neces-
sity 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-Leas*,
and closed first *Turfy-Leas*, and then *Crabtree-
Clofe*, &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 Tellescope to a Staff set up by the Ri-
ver 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, ta-
king Offsets 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 Bounders are very irregu-
lar, 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 *Garrott-Field*, I entred it so in the Field-
Book, but now it belongs to *Cow-pasture* ; there-
fore I write *Hedge* to *Cow-pasture*.

Then returning to ☉ 19, I direct the Tellescope
first to ☉ 18, and then to   20, and find

☉ 19

⊙ 19 to be in a ſtrait Line with ⊙ 18 and ⊙ 20 ;
therefore I enter in the Field-Book 18o, or
Station-Line continued, proceeding to obſerve and
enter down the ſeveral Occurrences at ⊙ 20,
⊙ 21, and ⊙ 22, round *Magg-meadow*, and then
return to ⊙ 21.

From ⊙ 21, I go to ⊙ 23 in *Cow-paſture*, clo-
ſing 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 it ſelf : And in your Table of Refe-
rences 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.

Obſer-

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

Remarks	Offsets	Station Lines	Offsets	Remarks
		Θ 1 *in* Charlton-Field		
	B	356°. 10'		
Corner of Cow Pasture, Hedge to Pasture.		20	ag. 15	Corner of Turfy Leas, Hedge to Turfy Leas.
	ag. 80	40		
	10	280		
		300	20	
	18	563		
		Θ 2 *in the* Lane		
338°. 00'	B	338°. 00"		
180. 00		161.50		
518.00	10	0		
356.10		20	ag. 17	Hedge to Home-Close.
161.50		446		
		Θ 3 *in the* Lane		
	B	1°. 30'		
	∨	203.30		
	20	0	10	
1°. 30'		41	ag. 10	Orchard-Hedge
180 00		204	ag. 15	Orchard-Pales
181.30 (*Gate into Cow Pasture. Hedge to Ditto.*)	35	261	20	Gate into the Yard.
360.00		290	18	Corner of Barn
541.30	20	388	ag. 24	Calves Croft-Hedge.
338.00				
203.30		435		

<div align="right">Gate</div>

Remarks	Offsets	Station Line	Offsets	Remarks
		Θ 4 in the Lane		
	B	349°.30'		
	∨	168.00		
	ag. 20	90		
	13	140		
		220	o	on Stockin
	16	500		Hedge.
Gate into Garrot Field, Hedge to Field.		626		
		Θ 5 in the Lane		
	B	13°,50'		
	∨	204,20		
	10	0	20	
		64	12	
	35	152		
	30	236	10	
		Θ 6 in the Lane		
	B	93° 39'		
	∨	259 40		
Corner of Stockin	o	10 int.		
		into Stockin		
	6	270		
	3	500		
	40	750		
		Θ 7 in Stockin		
	B	193°.39'		
	∨	280.00		
Hedge to Wood	23	0		
	60	335		
	45	620		
	ag.20	668		
		680		

Hedge

Remarks.	Offsets	Station Lines	Offsets	Remarks.
		☉ 8 in Stockin		
	B	229°00′		
	⋀	215.30		
Hedge to Stokin	10	0		
	10	268		
		☉ 9 in Stockin		
	B	268°30′		
	⋖	219.20		
Corner.	30	22		
Hedge to Stokin				
		300	20	Close Stockin here

Hedge to Lane, in corner next to Calves Croft.

Remarks.	Offsets	Station Lines	Offsets	Remarks.
		☉ 9	ret.	
	B	192°00′		
	⋁	143. 00		
		20 int.		
		Into home Close.		
		90	20	Calves crof: Hedge
		220	20	Garden Pales.
		350	20	Corner of Orchard Hedge.
		361		
		☉ 10 in Home-Close		
	B	264°40′		
	⋖	252. 40		
		205	0	on Orchard Hedge
		250	20	close here
		255		

Out-lines of Orchard, Garden, &c. close on Hedge next the Lane.

Remarks.	Offsets.	Station Lines.	Offsets.	Remarks.
		☉ 8 ret.		
	B	105°00'		
	≤	91. 30		
		19 int.		
	into home Close.			
Hedge to Wood.	corner 5	24		
	37	353		
	28	465		
		☉ 11 *in Home Close.*		
	B	193°30'		
	<	268:30		
	60	130		
Hedge to home Close	ag: 61	476		
Corner	18	727		
		☉ 12 *in Home-Close.*		
	B	259°00'		
		<246:20		
	ag: 28	65		
	48	268		
		667	*close here*	
Close Home Close on Hedge to Lane, next Turfy-leas				

Remarks.	Offsets.	Station Lines.	Offsets.	Remarks.
		⊖ 12 *ret.*		
	B	189°, 20′		
	⋁	176, 00		
		20 *int.*		
		into *Crabtree close*		
		60	55	Corner Hedge to *Turfy-lease.*
		612	12	Corner.
		618 *int.*		
		into *Charlton Field.*		
		642		
		⊖ 13 *in Charlton Field.*		
	B	262, 40		
	⋖	253, 20		
		10	28	
		510	20 *close here.*	
		530 *reaches first Station.*		
Turfy-leas, Closes on Corner of Hedge next the Lane.				
		⊖ 13 *ret.*		
	B	103°, 00		
	⋖	94, 00		
Touch on Hedge to Crabtree-close.	o	135		
	17	310		
		⊖ 14 *in Charlton-Field.*		
	B	69°, 00′		
	⋖	146, 00		
	3	320		
	26	545		
		618		

⊖ 15

Remarks.	Offsets.	Station Line.	Offsets.	Remarks.
		☉ 15, *in Charlton Field.*		
	B	5°, 00		
	<	146, 00		
	15	60		
		166 *int.*		
		Into Charlton Common.		
	120	337		
Hedge to	16	563		
Crabtree close.		645		
		☉ 16 *in Charlton-common.*		
	B	276°, 35′		
	<	91, 35		
		16 *int.*		
		Into Crabtree-close		
		22	30	*Hedge to Wood.*
		710 *close here.*		
Close Crabtree Close on Corner next Home-Close and Wood.				
		☉ 16, *ret.*		
	B	10°, 20′		
	>	185, 10		
	22	220		
	60	386		
	69	434		
A Gate into	50	611		
the Wood.	10	930		
	32	1110		
	86	1268		
	142	1353		
		1553		

Remarks.	Offsets.	Station Line.	Offsets.	Remarks.
		Θ 17, in Charlton Field.		
	B	264°, 30'		
	<	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 Clemson's Field.				
		Θ 6, ret. into Lane.		
	B	270°, 50'		
	<	77, 00		
		28 int.		
		33	10	Hedge to W. Green.
		288	40	
		560	10	
		932	98	corner to River.
		Θ 18 in Garrot Field.		
	B	186°, 00		
	<	95, 10		
	>	131, 10		Angle to a Bend in the River, from Θ 18.
		26	75	
	56	175	82	
	25	248	53	
		300		
		225		O Touch the Rivers Brink
		422	145	
		536	110	
		620	116	

Remarks.	Offsets.	Station Line.	Offsets.	Remarks.
		Θ 19, *in* Garrott *Field.*		
	B ∠	96°, 30′		
		90, 30		
		0	8	Hedge to Garrot Field continu'd 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.*				
		Θ 19 ret.		
	B ∠	186°, 00′		
		180, 00		
		8 int.		
	Into	Magg-Meadow.		
		57	126	
		143	120	
		280	42	
		348	21	
		572	97	
		665	46	
		780	8	*A Bridge.*
		900	0	
		1004	25	
		1045		
		H 3		Θ 20,

Remarks.	Offsets.	Station Lines.	Offsets.
		Θ 20, *in Magg-Meadow.*	
	B ‹	151°, 00′	
		145, 40	
		78	40
		154	82
		280	75
		395	30	*Corner to River.*
		Θ 21, *in Magg-Meadow.*	
	B ‹	54°, 30′	
		83, 35	
		0	28 *Hedge to Magg Meadow.*
		100	64
		245	78
		380	59
		452	27
		Θ 22, *in Magg-Meadow.*	
	B ‹	358°, 00′	
		123, 20	
		0	28
		147	53
		378	28	*A Gate.*
		600	6
		790	30
		890	60
		1010	137	*Close here.*
		1032	

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

Θ 21

Remarks.	Offsets.	Station Lines.	Offsets.	Remarks.
		Θ 21, ret.		
	B	143°, 35′		
	<	172, 35		
		22 int.		
		Into Cow-pasture		
		90	6	
		244	60	*Corner to* River
		Θ 23, *in Cow-pasture.*		
	B	92°, 50′		
	<	129, 05		
		205	55	*Hedge to Cow-paft.*
		245	60	
		302	68	
		428	24	
		560	20	
		680	38	
		755	58	
		842	45	*Clofe here.*
		936		

Cow-pasture closes on Corner next Charlton-Field.

H 4　　　　　　　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 Protractor
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; and
the Diameter of this Protractor is laid Parallel to
the Meridians, by the Help of equal Divisions
graved on the Protractor.

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 Plott) 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 Practiser 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
<div align="right">the</div>

the other End of the Line, and through the ut-
moſt Convex of theſe Two Arches you may draw
a Line Parallel to the firſt.

Having drawn Parallel Right Lines at conve-
nient Diſtances throughout the Paper marked
with N. S. repreſenting Meridian, or North and
South Lines, I pick out ſome Place in one of
theſe Lines, to repreſent the firſt Station, as at
☉ 1, Fig. 22, and lay the Center of the Protractor
on the Point ☉ 1, the Diameter being Parallel to
the Meridian Line, and the Beginning of the De-
grees 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 Protract-
ing Pin againſt that Number, cloſe to the Limb
of the Protractor, to which Mark I draw an ob-
ſcure 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 ob-
ſcure Line ☉ 1 and ☉ 2; and becauſe I find in the
Field-book that the Offsets 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 Plotting-Scale; and 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 Offsets on the re-
ſpective 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-Leas: Alſo againſt the ſecond Prick in the
obſcure Line, I prick off 80 Links to the Left,
which give the Corner of *Cow-paſture*; at 280,
or the Third Mark in the obſcure Line, I prick
off 10 to the Left; at 300, 20 to the Right;
<div align="right">and</div>

and at the End of the Line 563 I prick off 18
Links to the Left : Laftly, I draw Lines with
Ink from Point to Point on the Outfides of this
obfcure Line, thereby conftituting the Bounders
of the *Lane* fo far.

At the firft and fecond Diftances, I was againft
the Corners of *Turfey-Leas* and *Cow-pafture* ;
therefore, with a Black-lead Pencil I draw Two
fhort Lines, cutting the *Lane*, to denote that the
South Fences come up to the *Lane* at thofe Cor-
ners, and will hereafter be of Ufe in clofing thefe
Plots.

Having thus finifhed my firft Length, I pro-
duce the obfcure Line, if Occafion 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 $\odot$ 2, and turn it about
thereon, keeping the Beginning of the Degrees
towards $\odot$ 1 ; the laft Station ; till the Diameter
coincides with the Station-Line $\odot$ 1, $\odot$ 2 ; then
clofe to the Edge of the Protractor, right againft
161° 50', the Degrees of the prefent Angle, I
make a Mark with my Protracting-Pin ; and to
that Mark from $\odot$ 2, draw an obfcure Line, re-
prefenting the Station-Line, from $\odot$ 2, to $\odot$ 3.

And that I may be fure the Line $\odot$ 2, $\odot$ 3, is
drawn in its true Pofition, I turn about the Pro-
tractor, the Center ftill coinciding with $\odot$ 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 $\odot$ 2, $\odot$ 3, before drawn, meet
the Limb of the Protractor againft 338°, 00', the
Bearing of the Line $\odot$ 2, $\odot$ 3, which proves the
Line $\odot$ 2, $\odot$ 3, to be truly laid down.

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

The

The conftant Rule I obferve in drawing the
Angles is this: To lay the Diameter of the Pro-
tractor on that Line which brought me to the
prefent Station, where the Angle about to be laid
down, was taken; and to keep the Beginning of
the Numbers on the Protractor towards the laft
Station.

And in Order to prove that each Angle is truly
laid down, I turn about the Center of the Pro-
tractor on the Point; reprefenting the prefent Sta-
tion, till the Diameter be parallel to the Meridi-
ans, with the Beginning of the Numbers towards
N. on the Meridian-Line; then will the Line laft
drawn, cut the Number, expreffing its Bearing
on the Limb of the Protractor, if that Line be
drawn in its true Pofition.

In like Manner, I lay down and prove the An-
gles taken at the 3d, 4th, 5th, 6th, 7th, 8th and
9th Stations; and alfo the correfponding Lengths
and Occurrences, continuing the Bounders to the
feveral Offsets as I go along, drawing a fhort Line
acrofs them with a Black-lead Pencil, where the
Remarks _a_, _g_, _&c._ are noted in the Field-book,
breaking off the Fences where there are Gates:
So at the laft Length, from ☉ 9, when I have
drawn that Line in its true Pofition, and made it
of its juft 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 Offset from 388
in the Station-Line ☉ 3, ☉ 4, in the _Lane_, which
proves that the Angles and Lengths enclofing the
Stockin, are truly laid down.

But if the Extremity of the laft Line does not
coincide with the Extremity of the laft Offset
laid off from the Station-Line ☉ 3, ☉ 4, both de-
noting the North-weft Corner of the _Stockin_, the
Lines and Angles defigned to enclofe the fame
Stockin,

Stockin, are not truly laid down, and therefore muſt be corrected before I proceed.

Next I lay the Protractor on ⊙ 9, the Diameter coincident with the Line ⊙ 8, ⊙ 9, being the ſame Line which brought me to that Station; and having laid down the Angle, ⊙ 8, ⊙ 9, ⊙ 10, I prick off the ſeveral Offsets, marking them as the Field-book directs, where the Lines of Partition within come up to the Hedge.

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

The Out-Lines round the Orchard, Garden, Yard, *&c.* being drawn, the Angles within, 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 Bounders 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 a 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

<div align="right">waſte</div>

wafte Paper, then I lay down the Angle of the
prefent Station with the Line I meafured imme-
diately before I came to it, and number it as in
the Field-Book.

But if the Number of the prefent Station is
greater than any in the wafte Paper by more than
an Unit, there hath been fome Omiſſion in the
wafte Paper, which muft be rectified.

If I come to a Station whofe Number is already
entred in the wafte Paper, then I return to that
Station in my Draught, and there lay down that
Angle with the Line meafured, immediately be-
fore I came to this Station the firft Time.

Thus obferving thefe Directions, may the Plot
be laid down without any Burthen at all to the
Memory; and if it was furveyed by one Man, it
may be plotted by another, provided the Perfon
who furveyed it did obferve thefe Rules; and
any Method of keeping a Field-book, that lays a
Burthen on the Memory, is imperfect, and not fit
for Practice.

The remaining Part of the Work is referved
for the Exercife of the Reader: The Plan there-
of was here laid down by a Scale of $\frac{1}{4}$ of an Inch:
I fometimes 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 caft up the Con-
tent of each feparately by that Scale; and for
this Purpofe, the Sheets with Meridians ready
printed thereon, are very ferviceable, though I
afterwards lay down the whole Plan together by
a Scale of a Quarter of an Inch or lefs, entring
the Content of each Field, as caft up by the
large Scale in the Middle thereof.

SECT.

S E C T. III.

Of Reducing Plots.

THE Plot of a Manor or Lordship confist-
ing 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 Com-
pass. Now for the Performance of this Work
there are several Instruments, as, a long Scale
made with a Center-hole at One Third Part there-
of; so that Two Third Parts may be numbred
one Way with equal Parts, from the Center-hole
to the End, and the other Third Part numbred
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 for Generality, Exactness and Dispatch
surpasseth all others, and is commonly made of
Six Wooden Rulers joined together, and support-
ed by Brass Feet, with Holes in the Rulers for
setting the Instrument to certain Proportions.

But I have lately seen one of these Instruments
made of Brass in a different Form from the
other, and much better, because it 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 Plott
may be reduced with the utmost Exactness to any
given Ratio, in Respect of the former, either in
Proportion, as the Length of the Sides of the
foul Plott shall be to the fair one, or else as the
Area of the one to the Area of the other; and
another Thing may be said of this Instrument,
                                                    that

that Curves are as well reduced thereby as Right-Lines; which by any other Inftrument is exceeding difficult, if not impoffible to be done.

The Parallellogram being fixed upon a very fmooth and even Table, and the foul Plott, and fair Paper faftened thereon, one over-againft the other, fet the Parallellogram to what Proportion you would have your reduced Plott be of, in Refpect of the former; then bring the Point of the Tracer to one of the outmoft Angles of the foul Plott, and put in the Point which is to draw, in its Place, letting it reft on the fair Paper; then move the Tracer with a gentle, equal Motion, over all the Lines of the foul Plott; fo fhall the Motion thereof occafion the Drawing-Point to draw upon the clean Paper or Parchment, the true and exact Figure of the former Plott, tho' of another Bignefs, according to what Proportion you fet your Inftrument; which will better appear by feeing the Inftrument once ufed, than Words can poffibly explain.

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

Note, This Inftrument is ufeful, not only for this Purpofe, but alfo for Copying any fmall Print, *&c.* in Miniature. But for Reducing great Plotts of Land, it fhould be made of a larger Size than is commonly ufed for other Purpofes.

S E C T.

S E C T. IV.

Directions for Beautifying and Adorning of Plotts.

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 Plott 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 Plott, at least such as border next to the Demesnes, ought to be fill'd with the adjacent Hedges, and the Tenants or Owners Names of the Grounds.

If you describe all Rivers, Highways, Windmills, great 'lone Trees, Gates, Stiles, &c. that fall within your Plott, it will add to the Beauty thereof.

The Ground-Plott of Buildings, ought in all Cases to be expressed by the same Scale that the rest of the Plott 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 of the Plott, so big as will cover an Acre or two of Land.

But

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, annext 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 Compartiment, blazoning the Coat in its true Colours : In one of the Corners at the Bottom, you may describe a Circle, with the 3 2 Points of the Mariners Compass, according to the Situation of the Ground, with a *Flower-de-luce* at the *North* Part thereof, ever allowing the Variation of the Needle: And in the other Corner, make a Scale equal to that by which the Plott 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 Enclosure, 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 Plott.

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 pumiced, to preserve the Paper from being pierced through with the Colours;

I lours;

lours ; or wet it over with Allom-Water, which will add to the Luftre of the Colours.

Then lay on the Colours in Manner following, being firft ground, and bound with Gum-Water very thin and bodilefs : Arable for Corn, you may wafh with pale Straw-Colour, made of yellow Oker and White-lead ; for Meadows, take Pink and Verdigreafe in a light green ; Pafture in a deep green of Pink, Azure and Smalts ; Fenns, a deep green ; as alfo Heaths of yellow and Indico ; Trees, a fadder green, of White-lead and Verdi-greefe ; for Mudd-Walls and Ways, mix White-lead and Ruft of Iron, or with Okers brown of *Spain* ; for white Stone, take Umber and White, Water or Glafs may be fhewn with Indico and Azure or Black-lead ; for Seas, a greenifh Sky-Colour, of Indico, Azure, Smalts, White-lead and Verdigreefe.

Having wafhed your Pencil very clean, take a fmall Quantity of the Colour, and on the Infide 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 Bignefs ; and having gone round the Field in this Manner, fwill the Pencil in fair Water, and ftrike along the Infide of the coloured Line, bringing it more down to-wards the Middle of the Field ; and this will foften your Colour, and make it fhew as if it loft itfelf by Degrees to the very Colour of the Paper : Laftly, with a Pen take fome of that Colour which fhadoweth the Colour you laid on the Field, and go over the Black-lead Line only ; fo fhall your Field be finifhed.

In this Manner, you may make 100 Fields in one Plott, of divers Colours, obferving, as near as you can, not to colour Two Fields adjoining to one another of the fame Colour ; and therefore it will be convenient to underftand what Colours

best

beſt ſet off one another ; and as near as you can, lay the Encloſures adjoining to one another, of Two ſuch Colours, that one Shadow may ſerve both.

This Colouring and Adorning of Plotts, 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 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 Plott reſemble one done from a Copper-Plate, if rightly managed.

The Water-Colours before-mention'd, 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 Mr. *Keyton's*, a Colour-Shop, in *Long-Acre, London.*

I 2   C H A P.

C H A P. V.

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

THE Content of any Piece of Land may be found, or a Plott thereof made, by the Chain only: So that if a Person is not furnished with Instruments more artificial, he may work with the Chain only in the following Manner, though it be somewhat laborious and tedious.

    S E C T. I.   *Let. Fig. 23. be the*

Representation of a Field, whose Content in Acres is desired, without any Plott thereof.

FIrst, I walk about it, and set up Marks at the several Angles, *a, b, d, e, g, h, k, l, n,* viewing (as I go along) from which Angle to which Angle it will be most convenient to run a Diagonal or Base Line, as the Line *a, g*; so that a Perpendicular from the opposite Angles, as *b* and *n,* may fall upon this Diagonal or Base, in a convenient Manner at Right Angles: And *note,* we commonly chuse the longest Line between any Two opposite Angles that form the Trapezia or Triangle, to be the Base Line.

                                        Having

Having a Sheet of Paper in Readiness, on which to draw an Eye-Draught of the whole Work, I make some Remark near the Angle, at *a*, and lay the Chain thereto, stretching it in a strait Line towards the opposite Angle *g*; then I draw a strait Line on the Paper, to represent the Line *a*, *g*, which I am about to measure; and proceed with the Chain towards the Angle *g*.

When I have measured 4 Chain on the Line *a*, *g*, I perceive my self almost over-against the Angle *b*, therefore having laid the Chain a Fifth Time, I set down an Arrow at the End of the Chain next *g*, and let it lie on the Ground in the Direction of *a*, *g*, and then endeavour to find a Point in the Base *a*, *g*; from which, a Right Line measured in the Angle *b*, may stand at Right Angles upon the Base *a*, *g*.

For this Purpose I provide a small Brass Cross, with four plain Sights thereon, having a Socket on the Backside, which I put on the Head of a short Staff, and set the Staff in the Ground close to the Chain; then I set two of the Sights in the Direction of *a*, *g*, by looking backwards and forwards through those Sights till I can see the Mark in each Angle *a* and *g*; 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, I move the Staff backwards and forwards by the Side of the Chain, in the Line *a*, *g*, till through Two of the Sights I see *a* and *g*, and through the other Two the Mark at *b*; then will the Staff be set in the Point *c*; and this is the exactest Way.

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; and stick a Pin fast and upright in the Line near every Corner, and make an Hole

in

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 *c*, in the Line *a*, *g*, there set down a Staff, and take Notice how many Chains and Links it is distant from *a*, *viz.* 418, therefore I apply a Scale to the Right Line on my Eye-Draught, and near 418 make a Mark at *c*, but don't regard whether it be exact or no, so it be within 20 or 30 Links, because the true Lengths of each Line are measured on the Ground.

Then I measure on the Ground, in a strait Line, the nearest Distance between *c* and *b* 600 Links, and erect a Perpendicular on the Point *c* on the Paper, as near as I can guess, by applying the End of the Scale to the Line *c*, *a*, and by the Edge thereof draw the Line *c*, *b*, setting close thereto 600 Links, the Length of the Perpendicular; but don't regard whether the Line *c*, *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 I return to the Arrow, and measure forwards on the Line *a*, *g*, till I am near against the Angle *n*; and by a few Trials, I find the Point *o*, at the Distance of 616 Links from *a*; and then measure the Perpendicular *o*, *n*, setting the true Length thereof 368, close to its Representative on the Eye-Draught.

Now I look towards the Fences *a*, *b*, and *a*, *n*, and because they are strait Lines, I draw *b*, *a*, *a*, *n*, on the Eye-Draught, so is that Side of the Field finished.

From *o*, I proceed with the Chain in a strait Line to *g*, and find the whole Length from *a* to

g, 1375 Links; which I set close to the Right
Line on my Eye-Draught.

Then I make that Right Line on the Paper
nearly the Length of 1375, and draw the Right
Lines g, b, and g, n, cutting the Ends of the
Perpendiculars c, b, and o, n; so shall the great-
est Part of the Field be expressed on the Paper,
by the Trapezia, a, b, g, n.

From g, I measure in a strait Line towards d,
and when I come to f, I measure the Perpendi-
cular f, e, 60 Links, and then measure out the
Line g, d, to d 800 Links, and draw the Lines
g e, e d, on the Eye-Draught, to the Extremity
of the Perpendicular f, e. Now I number the
Angles round the Field, if I can see the Marks
at each, and compare 'em with those on the Eye-
Draught, and thereby discover what Part of the
Field I have already measured, and what remains
to be done.

In the same Manner as I measured the Trian-
gle g, d, e, I measure the Triangles g, b, k, and
k, l, n, and then if there be so many Angles ex-
pressed 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 mea-
sured in the Field, be expressed on the Represen-
tative of the Eye-Draught, you may proceed to
cast up the Work.

The same Lines in the Field, *Fig.* 23, are mea-
sured on the Land with the Chain, as we should
have done on the Paper, with the Scale, if the
true Plott 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 Man-
ner; for you have the true Length of each Base
and Perpendicular given on the Eye-Draught; so
the Sum of the Two Perpendiculars c, b, and N, o,
multiplied by the Base a, g; also the Bases and

Perpen-

Perpendiculars of the other three Triangles mul-
tiplied together, and added into one Sum, the half
of that gives the Content of the Field, *Fig.* 23,
in square Links, which reduce in Acres, &c. as
directed in Chap. I.

This is the best Way I can prescribe, for find-
ing the Content of a Field by the Chain only,
without making a Plott thereof, and is only pro-
per for plain, level Ground, and small Enclosures:
But even then, if the Fences are very irregular,
'tis better to go round and measure the Angles
by the Chain, taking Offsets 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.* 23.) you may make a true Plott
thereof well enough, by observing at how many
Chains and Links the Perpendiculars meet the
Base of the Triangles or Trapezias, by erecting
Lines on those Points Perpendicular to the Base,
which 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 longer 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.

SECT. II.

How to measure Angles by the Chain.

TO this End provide Three round Station-Staves, four or five Foot long a-piece; 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.* 24, set one of your Station-Staves 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 side-ways 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 'em in the Field-Book 88 ½.

When you plott 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*, let one Foot of the Compasses in *o*, and with the other describe an Arch *a*, *c*; then from the same Scale take 88 ½ 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

Obferve to plott your Angles by a large Scale, as an Inch, or two Inches, and the Length of the Sides by a fmaller, as a Quarter or Half an Inch: Alfo obferve, that when the Length of the Chord *a, b,* is longer than one Chain, then 'tis beft to lay out a Sextant, or two Sextants, in the following Manner.

2. The Manner of meafuring Angles with the Chain, by laying of 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.*

Let it be required to meafure the Angle *b, a, c, Fig.* 25 : Firft, fet up a Staff at *a,* and lay the Chain ftrait in the Direction of *a, b,* to *i,* and at 50 Links fet down an Arrow at *o* ; then let your Affiftants hold the Ends of the Chain at *o,* and *a,* whilft you with the Middle in your Hand, laying both Halves ftrait, fet down an Arrow at *e,* conftituting the equilateral Triangle *o, a, e ;* fo 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, fo that each Side of the equilateral Triangle be one Chain

Now the Chain's End ftill held at *a,* ftretch it through the Point *e* to *d,* where alfo fet down an Arrow : Laftly, meafure the Diftance from the Arrow at *d,* to a Staff fet up one Chain's Length from *a* at *u* ; fo fhall the Diftance *d, u,* be 76 Links, and Four Tenths of a Link ; Therefore enter in the Field-Book 1 ˢ. 764 ᵖ. implying 1 Sextant and 764 Parts.

In order to plott this Angle, *b, a, c,* thus meafured, chufe fome Line divided into 1000 Parts, and making this Line Radius, fet one Foot of the Compaffes in *a,* and with the other defcribe the Arch, *i, z* ; and the Compaffes continuing at the

the same Extent, let 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 made Radius; and set one Foot of the Compasses in the Mark at *d*, and let the other cross the Arch at *u*, and there make a Mark : Lastly, from *a*, draw a Line through 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 Offset-Staff, having a Link or two thereon, divided into Ten Parts.

2. If the Angle be more than Two Sextants, as in *Fig.* 26 ; 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 thro' *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.

And if you would protract the Angle of *Fig.* 26, then with the Length of the Line divided into 1000 Parts, describe the Arch *i, y,* and thereon lay *i, n,* and *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, as required.

<div align="right">Observe,</div>

Obſerve, if you were about to meaſure the Angle, *Fig.* 26, and had ſet up one of your three Staves where the Station-Lines meet in the angular Point *a*, another at *i*, and the other at *u*, in the Lines *a*, *b*, and *a*, *c*; before you proceed to meaſure the Angle *i*, *a*, *u*, you muſt be ſure that the Staves at *a*, and *i*, and the Mark at *b*, are exactly in the ſame Plane; and alſo the Staves at *a*, and *u*, and the Mark at *c*, in another Plane.

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.

S E C T. III.

Obſervations on Working with the Chain.

IF you would continue a ſtrait Line, you may ſignify it, by entring in the Field-Book 3 ^{s}. 000, that is, 3 Sextants.

If an Angle be external, and ſo contain more than 3 Sextants, as *b*, *a*, *e*, *Fig.* 27, put the Ring at one End of the Chain over the Staff at *a*; and taking 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 Plane, and then ſet down the other Staff at *c*, at the End of one Chain alſo; ſo that the Staves at *a*, and *c*, be in the ſame Plane with the Mark at *e*. Now meaſure the Angle *d*, *a*, *c*, in the

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 ˢ. 947, then *b, a, c,* will be 4 ˢ. 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.

2. 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.* 28, 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 those used in the 2d, or 4th Chapters, 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 if you were to measure the Field, *Fig.* 14, 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

<div align="right">Parts;</div>

Parts; but the Station-Lines, Offsets, &c. will ftill be the fame.

There are other Ways of Working with the Chain; but thefe before-mention'd are the beft and exacteft, and contain as much Variety as any one will commonly put in Practice: Alfo thereby you might meafure an inacceffible Diftance, and do feveral other Things; but thefe are only for a Shift, when we have no other Inftruments: And the fame may be faid of meafuring Angles.

S E C T. IV.

Obfervations on meafuring Land in Common-Fields.

WHen ploughed Lands in Common-Fields are meafured by the Chain, 'tis ufual to meafure 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 thefe Three Numbers together, to take the Third Part of the Sum for the mean Breadth; but 'tis not advifeable to take the Breadth very near the Lands Ends, becaufe the Turning of the Plough generally makes it confiderably narrower or wider; and if in meafuring down the Land, you find the Breadth is not nearly equal, 'tis beft to meafure crofs the Land oftener, as at every 3 or 4 Chains Length, and adding the feveral Breadths together, divide that Sum by the Number of Breadths, for the equated Breadth: And for this Practice, half the Four Pole Chain is moft convenient, remembring either to fet them down as whole Chains, or to make 'em fo, when you caft up the Content.

The

The several Furlongs in Common arable Fields, may be accounted as so many particular Enclosures, 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 Offsets to each Man's particular Lands ; and against that Offset write the Name of the Owner or Tenant : And when you plott 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, 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 in Parcels, as separate Fields, keeping good Marks at the Stations, than to venture the Closing of the Plott, by going round it all at once, and dividing it into Parcels afterwards.

C H A P.

C H A P. VI.

The Manner of Laying-out, or Dividing Land.

S E C T. I.

P R O B L E M 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 encreaſed, 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 encreaſed by the given Side, the Quotient will be the other Side, as if 100 Acres was to be laid out in a Parallelogram, one Side whereof ſhall be 20 Chains; therefore to the 100 Acres I add 5 Cyphers, which divided by 20 Chain, the Length

Length of the given Side, the Quotient is 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 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 I am to make a Triangle that shall contain 100 Acres; first, I double the Number of Acres, and annexing 5 Cyphers thereto, I divide it by 40 Chains, the limited Base, so shall the Quotient be 50 Chains; for the Height of the Perpendicular, which I set on any Part of the Base, and from the Extremities thereof, 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, altho' you meet in your Way with 100 Lines and Angles, yet you

K   may,

may, by making a Triangle to the firſt Station you began at, cut off any Quantity required.

SECT. II.

Of Dividing Lands.

E X A M P L E I.

SUppoſe it was required to divide *Fig.* 29, 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 $\begin{Bmatrix} 1 \\ 2 \\ 3 \end{Bmatrix}$ add $\begin{Bmatrix} 40 \\ 80 \\ 120 \end{Bmatrix}$ 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 $\begin{Bmatrix} 4 \\ 3 \end{Bmatrix}$ write $\begin{Bmatrix} 1 \\ 2 \end{Bmatrix}$ Cypher Cyphers 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:

$$\begin{Bmatrix} \overset{120}{16\ (1420000\ (88750} \\ \text{Square Links--1088750} \end{Bmatrix}$$

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 leſs than 544375, by 50000 Square Links, which ſhews that the Partition-Line muſt be ſet forwarder from *b, a.*

Now

Now, in order to know how much c, d, muft be fet forwarder, I divide the Excefs 50000 Square Links by the Length of the Line c, d, 953 Links, and it quotes 52 Links; therefore from c, I fet off 52 Links, and draw the Line f, e, parallel to b, a, and it will be fufficiently near the Partition-Line.

This is performed by the fecond Problem of the laft Section; but if thofe Parts of the Bounders c, f, d, e, be not nearly parallel, then 'tis beft to draw a Triangle to c, d, inftead 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, whofe Diftance might be found as before.

Examp. 2. Suppofe it was required to cut off from *Fig.* 30, 6 Acres towards g, f, by a Line drawn from a given Point in the Bounder g, a, at a.

Firft, reduce the given Quantity, 6 Acres, into Square Links, and they will be 600000; and then draw the Line a, b, by Guefs, from the given Point a, and caft 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, whofe 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 paffes between e, and b.

Now divide the Excefs 67280, by 380, half the Length of the Perpendicular a, c, in Links, the Quotient is 77 Links, which fet off from e, towards b, and draw a, d, which is the true Line of Partition.

K 2 *Examp.*

Examp. 3. Suppose *Fig.* 31, was to be divided equally amongst Three Tenants, in such 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 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*, *g*, 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.* 31, be divided into 3 equal Parts, by the Lines *b*, *a*, *h*, *o*, and *h*, *f*, *e*, *k*, *o*, and *k*, *d*, *c*, *b*, *o*,

c, b, o, as was required; and the Pond *o,* laid out to each Tenant apart.

These 3 Examples express all the Variety that moſt commonly comes 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 thro' a Point aſſigned in the Land.

If a Piece of Common was to be divided a-mongſt ſeveral Tenants, in Proportion to the Rent which each pays for his Farm: The Numbers reduced to the loweſt Denomination (except you expreſs the Parts of Acres and Pounds by Deci-mals, 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 encloſed, and divided amongſt ſeveral Tenants, according to the Number of Beaſt-Gates which each Tenant hath in the Common, it is to be performed *(mu-tatis mutandis)* 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 it ſelf, as divided on the Paper: Only take Notice, that the larger the Scale is, by which the Plott 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 can't 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

Hole at each, in which the Staff ftood; then having plotted the Wood, and divided it on the Paper-Plott, in fuch Manner as defired, 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-Plott, and bring the Index to 360, or fet it in the fame Pofition as it was at the forward Station when you meafured that Angle, turning about the Inftrument, till the Hair in the Tellefcope cuts the laft Mark; fo that the Tellefcope be fet exactly in the Direction of the prefent Station-Line, where the Dividing-Line cuts, and there fcrew the Inftrument faft; then meafure with your Protractor on the Paper-Plott, the Angle which the Dividing-Line makes with the prefent Station-Line; and turn about the Index on the Limb to the fame Angle; fo fhall the Tellefcope be fet in the Direction of the Dividing-Line; then by looking through the Tellefcope, you may caufe Staves to be fet up in the fame Direction: And thus proceed in a ftrait 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 muft continue them till they meet one another, as in the Paper-Plott.

The fame Thing may be performed by the plain Table, or the Chain only; but thofe Inftruments are not fo convenient to meafure a Wood, or hilly Ground, as the Theodolite.

<div align="right">S E C T.</div>

S E C T. 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 Mea-
sure of Land, by Act of Parliament, is but 160
Perches to an Acre, accounting 16 Feet and
an half to the Perch.

So if a Field measured by a Perch of 18 Feet,
accounting 160 such Perches to the Acre, doth
contain 100 Acres, how many Acres shall the
same Field contain by the Statute Perch of 16 ½
Feet ? Say, As the Square of 18 Feet, (*viz.*)
324, is to 100 Acres, so is the Square of 16 ½
Feet, (*viz.* 272, 25,) to 119 $\frac{2}{10}$ of an Acre
Statute.

K 4   C H A P.

C H A P. VII.

General Observations touching the
  Surveying and Plotting of Roads,
  Rivers, &c. With short Hints
  how to make the Draught of a
  County, or ground Plott of a City,
  &c.

N this Seventh Chapter I have added general Directions for Measuring of Roads, *&c.* omitting particular Forms of Charts, as *fac similes,* 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.

S E C T.

SECT. I.

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

INstruments fitteft for this Purpofe are 1. the Theodolite as before defcribed: The Angles which each Station-line on the Road makes with the Meridian, being obferved by the Limb in the fame Manner, as before defcribed in Chap. III. and the Bearings of the feveral Remarks from thence by the Needle. 2. The Wheel or Way-wifer to meafure the Length of the Lines, by driving the Wheel on the Road before you, fo fhall the Hands on the upper Part of the In-ftrument fhew how many Miles, Furlongs, and Poles you go at one Time from any Station. 3. The Protractor as before defcribed: A neat diagonal Scale of Brafs and a good Pair of Compaffes, or rather a Pair of beam Compaffes, with fuch a Scale on the Beam as fhall be agreeable to the Largenefs of your Plott; for thereby you may lay down the Length of your Lines much exacter than by any other Way, by fetting one Foot of the Compaffes at one End of the Line, and moving the Socket on the Beam to one of the equal Divifions near the other End of the Line you are about to lay down, reprefenting Chains or Furlongs; and then you may bring the Point of the Compafs which ftands perpendicular on the Paper to the Parts of that equal Divifion, reprefenting Links or Poles by the Help of a fmall Screw, there being Divifions on the Edge of the Socket fliding clofe on the Beam according to *Nonus*'s Projection; fo that the Links of a Chain or Poles of a Furlong are eftimated in the fame Manner as the Minutes of a Degree

on

on the Limb of the Theodolite; for in these large
Plans where the Distances of Places are deter-
mined by the Intersection of Right-lines from
your Stations; 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 Point is considerable.

In order therefore to make a Draught of the
principal Roads that lye through any County,
&c. first begin at some noted Market Town, or
rather at the County Town, placing the Theo-
dolite at some remarkable Church, &c. then ha-
ving a Field-book with large Margins to enter
the Remarks, and the middle Column represent-
ing the Station-Lines divided into three Parts,
at the Head of each 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 making ⊙ 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 Tel-
lescope 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 Num-
bers 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 Ob-
ject on either Side thereof; there let him stop
and direct the Tellescope to that Object, and
note the Degrees which the Needle points to in
the

the Box, and at what Diftance the Inftrument is planted from the laft Station, together with the Name of the Object to which the Tellefcope was directed.

Having entered this in the Field-book, go on with the Wheel till you fee fomething elfe remarkable on either Side of the Road; there ftop and take a Bearing there; and in this Manner proceed till you come up to the Man at the fecond Station, obferving as you go along on the Road from Station to Station: Firft, 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, and how they incline, whether forwards or backwards, or whether they be at right Angles with the Road you are meafuring, 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 make 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 meafure, then mark it down thus ⊐ : If another Road croffes that you are upon, note it thus ≠ : Likewife fet down at what Diftance from your Stations the Lanes or Roads do turn out from the Road you meafure, *viz.* at fo many Furlongs, &c. a Road to the Right or Left to fuch a Place.

Likewife, when you pafs over any Bridge, note it in the Field-Book, with the Diftance from the laft Station; as alfo the Name of the Water that runs under it, and from whence it hath its Rife, and where it doth empty it felf:

So

So muſt you do 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 thereof; alſo write down the right Name thereof; and if a Market-Town, take Notice on what Day the Fairs or Market is 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, Windmills, 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 Name 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,

Day, entring 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 Tellescope to the Man standing in the Middle of the Road.

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 'em 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, thus, (at so many Poles, *&c.* Distance from such a Station, such a Steeple did bear from you 207°, 40',) therefore, 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 doth interfect the first

<div align="right">Line</div>

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 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 have Hedges on both Sides, then draw your Lines black; but if your Road be open Way, then draw it with prick'd Lines; also you may 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 doth ascend, shadow very deep, and as the Hill doth more and more ascend, 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

are at a Diſtance from the Road ſtand on an Hill, make an Hill to repreſent the ſame.

If your Road paſs by or through a Park, Foreſt or Chaſe, write down on your Road protracted, where you did enter the ſame, and where you did leave 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 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, and at what Place the River doth empty it ſelf; and on the other Side of the 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 ſignify'd 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 have none.

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

S E C T.

S E C T. II.

*Containing general Directions for making the
Plott of a River or Brook, by the before-
mention'd 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
Tellescope to the Man that stands at the next
Bending of the River, and note down the An-
gle 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; and direct
the Tellescope 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 thus must you proceed all along the River,
to the Head thereof.

In order to take the Breadth of the River, it
will be convenient to send some Body on Purpose
cross the River, in a Boat, (unless a Bridge or
Ferry be near,) and let him set up a Staff by
<div align="right">the</div>

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 2 Marks, through which, from ☉ 1, draw 2 Lines at Length.

Set off the Distance between the 2 Stations on the 2d Line, and mark 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 the first Line drawn at your first Station, so shall the Point of Intersection shew the Breadth of the River.

In the same Manner, are the Distance of the Churches, &c. from your Stations on the Road, determined ; and in chusing the Distance of these Stations, 'tis very necessary to observe the Rule laid down at the Conclusion of Chap. I.

If there be a Ferry over the River, you must draw the River to its true Breadth, and make a prick'd Line cross the River, to represent the

L   Passage

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 Rivers 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 Ri-ver 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 doth run through, or by, with the Towns Names, and the Diſtance from your laſt Station and the Mouth of the River.

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 your 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

each Church is distant from the River: The same
you must do by all the Wind-mills, 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 like Ex-
actness with the great ones.

Note, All Rivers that are navigable, every
Bending of them 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
ble Bending ; and if your Scale will permit, you
may take Offsets to represent the small Turnings
and Windings thereof, as in *Fig.* 22: But in mea-
suring a small Brook, if your Scale is to be a
Mile or two in an Inch, then these small Turn-
ings and Windings can't be described in the
Map.

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

L 2   S E C T.

S E C T. III.

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

Irst, from the County-Town, or other Mar-
ket-Town, where you began your Work, lay
down the principal Roads throughout the County,
protracting 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 Pla-
ces within Sight of the Roads, from the Road
itself, or from one another.

Secondly, Lay down the chief River that runs
through the County, so will you have the Situa-
tion 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 plott 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 Plott before taken of the Coast, draw
Lines,

Lines, which shall intersect each 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 3 or 4 Market-Towns, or other Towns, to measure through, 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, you may place your Instrument, if you can, upon the Steeple, and from thence take the horizontal Angles to others, by having the horizontal Distance of those 2, from which you take your Angles given ; but observe, 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.

<div align="center">L 3</div>

Sixthly,

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

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

S E C T. IV.

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

T H E 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'l find the Work not very hard to be done : One that underſtands the fourth Chapter will make no Difficulty of this Section, for the ſeveral Streets, Lanes, &c. in a City are ſurvey'd and protracted in the ſame Manner as the Lane *Fig.* 22. The ſeveral Offsets 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 Offsets 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

to the Needle, for (besides the Danger of its being attracted) you will find it necessary to lay down every Line by some other, given in Position in the Plott it self, rather than by the Bearings from the Meridian.

2. The Chain ; and because the Ground-plott of the Houses, Pavements, &c. are 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 Plott be desired in Acres, you may reduce the Feet in any Line, to Links ; and for this Purpose the Table in Chap. I. will be a ready Assistant.

3. The Offsett-Staff, divided also into Feet, 5 of which 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 ⅓ Foot joined, like the Squares of a Drawing-Board ; and this will be a Direction to measure the Offsets from the Chain, at Right-Angles.

4. The Scale, (or rather a Pair of Beam-Compasses) according to the Bigness of the Plott, the Protractor, the Drawing-Pen, &c.

First, in one of the principal Sheets, as at ⊙ 1, in the Lane, *Fig.* 22, 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 Offsets as in the Lane ; taking Notice at how many Links from the last Station each is laid off ; and when any of those Offsets reach any

L 4   remark-

remarkable House, &c. or the Corner of a Street, Alley, or Court, enter such a Remark against the respective Offset, in one 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 thro' the Tellescope the Staff at ☉ 1 ; there fix the Instrument, and then turn about the Index, directing the Tellescope 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 Tellescope 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 ; and 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 Sheets.

It will be convenient, not only to enter your Observations 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

senting 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 4 or 5 principal Streets that lead out of one into another, enclosing between them several By-Lanes, Alleys, &c. And contrive your first Station in such Manner, that when you come round these 4 or 5 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 your self 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 other 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 Tellescope 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 I. Sect. 3. 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 Offsets only, from the Station-Line through the Middle.

Having

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 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-Plotts of Churches, must be very exactly taken, and laid down in the same Manner on the Draught, and shadowed very deep; the same of Houses.

Also if you use a Protractor that will lay down Minutes, as described in Chap. II. 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.

F I N I S.
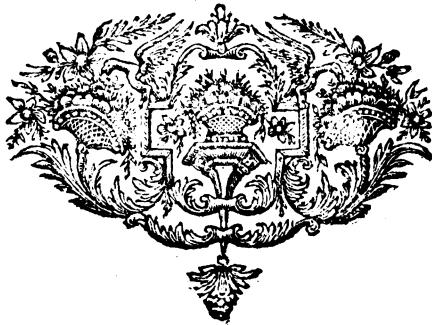
APPEN-

APPENDIX

TO THE

Practical SURVEYOR.

CHAP. I.

Of LEVELLING.

SECT. I.

THE Inftrument moft approved for this Purpofe, (a Figure whereof you have in the Beginning of this Book) confifts, 1. Of a Brafs Tellefcope of a convenient Length (the longer the Exacter, provided the Parts of the Inftrument that fupport it, be made proportionably ftrong:) Within this Tellefcope is fixed an horizontal Hair, and a fmall Micrometer, whereby Diftances may be determined at one Station near enough for the Bufinefs of Levelling : Upon this Tellefcope is fixed, with two fmall Screws, the Spirit Tube, and Bubble therein, which Bubble reft exactly in the Middle of the Tube, when the Tellefcope is fet truly level.

2. Under the Tellefcope, is a double Spring, with 2 Screws, by which the Bubble is brought exactly to a Mark in the Middle of the Tube ; to which Spring is fixed a Conical Ferril, which is a Direction for the Tellefcope to move horizontally at Pleafure. There is alfo a three-legged Staff, a Ball Socket, and 4 Screws, to adjuft the

horizontal

horizontal Motion the fame with that belonging to the Theodolite, before defcribed.

Provide 2 Station-Staves, each 10 Foot long, that may flide one by the Side of the other to 5 Foot, for eafier Carriage; let them be divided into 1000 equal Parts, and numbred at every 10th Divifion, 10, 20, 30, 40, &c. to 100, and from 100, 110, 120, &c. to 200, and fo on till you come to 1000; but every Centeffimal Divifion, as 100, 200, 300, to 1000, ought to be expreffed in large Figures, that the Divifions may be more eafily counted; and you may have another Piece 5 Foot long, divided alfo into 500 Parts, to be added to the former, when there fhall be Occafion.

Upon thefe Staves are Two Vanes, made to flide up and down, which will alfo ftand againft any Divifion on the Staff, by the Help of Springs. Thefe Vanes are beft, made 30 Parts wide, and 90 Parts long; let the Faces of them be divided into 3 equal Spaces, by 2 Lines drawn lengthways; let the 2 extreme Spaces be painted white, and let the middle Space be divided alfo into 3 fmaller equal Spaces, and let that in the Middle be painted white, the other 2 black, which will render them fit for all Diftances.

Being thus provided with a good Inftrument, Two Station-Staves, a Chain, and Two Affiftants, you may proceed to your Work; but firft it will be neceffary to make a Trial whether or no your Inftrument be well adjufted.

SECT. II.

How to adjuft the Inftrument.

CHufe fome Field or Meadow, that is nearly level, and fet down the Inftrument about the Middle thereof, and make an Hole in the Ground, under the Center of the Inftrument; from

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 Sta-
tion-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-Staves be in the same Line.

Then return to the Instrument, and set it ho-
rizontal, which is presently done by the Ball and
Socket, and turn the Tellescope about on its ho-
rizontal Motion, to your first Assistant, and move
the Tellescope by the Two Screws in the double
Spring, till the Bubble rests exactly in the Mid-
dle of the Spirit Tube; then observe where the
Hair in the Tellescope 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 Tellescope towards your second
Assistant, and proceed in the same Manner; so
are the Vanes on each Staff equidistant from the
Center of the Earth.

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 As-
sistant'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 Tel-
lescope, above or below the Middle of the Vane,
for so many Divisions must the other Assistant's
Vane be raised or depressed, which direct him to
do accordingly.

<div align="right">But</div>

But becaufe the Inftrument is 40 Chains di-
ftant from the Station-Staff, you muft make an
Allowance for the Earth's Curvature, which by
the following Table you will find to be 16 $\frac{4}{10}$ Parts,
therefore let the Vane on the Staff be raifed
16 $\frac{4}{10}$ Parts.

A T A B L E *of the* Earth's Curvature, *calcu-
lated to the Thoufandth Part of a Foot, at
the End of every Chain, from* 1 Chain *to* 40.

Chain	Dec.Foot	Chains	Dec.Foot	Chains	D.Foot	Chains	D.Foot
1	000	11	013	21	046	31	099
2	00	12	015	22	050	32	106
3	001	13	017	23	055	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 Tellefcope to the Vane thus
raifed, and if the Hair cuts the Middle thereof,
while the Bubble refts in the Middle of the
Tube, the Inftrument is right; but if not, you
muft raife or deprefs the Tellefcope by the Screws
in the double Spring, till the Hair cuts the Mid-
dle of the Vane, and then by the Help of the
Screws that fix'd the Tube to the Tellefcope,
move the Bubble till it refts in the Middle of the
Tube: So is the Level adjufted.

S E C T.

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 determined Place.

1. At the Head of the Spring set up one of your Station-Staves 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 determined Place you are going to, as far as you can see, so that through the Tellescope 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, by the Help of the Ball, and Socket and 4 Screws; and direct the Tellescope to your first Assistant's Staff, and then by the Help of the Spring-screws bring the Bubble exactly to the Middle of the Tube, and when it rests there, give a Sign for your

Assistant

Affiftant to note the Parts of the Staff where the Vane refts.

4. Turn about the Tellefcope to your fecond Affiftant's Staff, and by the Spring-fcrews, as before, fet the Bubble exact: Then direct your fecond Affiftant to move the Vane higher or lower till you fee the Hair in the Tellefcope cut the Middle of the Vane, (but in long Diftances the Hair will almoft cover the Vane; however, let it be fet in fuch Manner that as much may be above the Hair as below it, as near as you can guefs,) and then give him a Sign to note the Divifion on the Staff; and always let your Affiftants note the Divifion cut by the upper Edge of the Vane.

5. Let your firft Affiftant bring his Station-Staff from the Spring Head, and give it to the fecond Affiftant, and let your fecond Affiftant carry it forwards towards the determined Place you are going to, and at a convenient Place erect it perpendicular, whilft your firft Affiftant tarries at the Staff where your fecond Affiftant ftood before.

6. Place your Inftrument between your Two Affiftants, fomewhere about the Middle if you can, and firft direct the Tellefcope to your firft Affiftant's Staff, and when the Tellefcope is levelled to one of the Divifions on the Staff, let him note that Divifion in an orderly Manner under the firft Obfervation ; and let your fecond Affiftant do the fame : And in this Manner proceed over Hill and Dale, as ftrait forwards as the Way will permit, to the appointed Place, (by only repeating thefe Directions, tho' it be 20 Miles diftant from the Spring Head ; but in your whole Paffage let this conftant Law be obferved, otherwife great Errors will enfue, (*viz.*) That your firft Affiftant muft at every Station ftand between

the Spring-head and your Inftrument, and your
fecond Affiftant muft always ftand between the
Inftrument and the appointed Place to which the
Water is to be convey'd.

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

Firft Affiftant's Notes.		*Second Affiftant'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

Thefe Notes were collected from Obfervations
made with fuch an Inftrument, as before defcribed,
at feveral Stations between the Ground at the North-
gate of *Hanover-Square*, and the Surface of the
fquare Pond by the *New-River Head*, near *Iflington.*
The firft Affiftant's Notes, when added together,
amount to 7857; the fecond Affiftant's 3268, the
Difference 45, 89 Parts; that is almoft 46 Foot;
and fo much is the Pond higher than the Ground
of that Part of the Square where the firft Sta-
tion-ftaff was planted.

The following Obfervations were repeated in
the Afternoon of the fame Day, at quite diffe-
rent Stations; from the Pond before-mention'd, to
the faid North-gate of *Hanover-Square*; and then

the two Affiftants Notes ftood in the following Manner.

Firft Affiftant's Notes		Second Affiftant'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	306	☉ 9	1066
Sum.	3513	*Sum.*	8108

These Notes, as obferved in the Afternoon, being added together, and the leffer fubtracted out of the greater, the Difference is 4595 Parts, which very nearly agrees with the former Obfervations; being but $\frac{6}{100}$ of a Foot Difference, which is inconfiderable.

Note, If from the firft Affiftant's Staff you meafure any Number of Chains towards the Place you are going to, fuppofe 10, and there fet down the Inftrument, and then meafure 10 Chains forwarder and there place the other Station-ftaff, you will have no Occafion to make any Allowance for the Curvature of the Earth, becaufe the Inftrument being planted in the Middle of the Diftance between the Station-ftaves, the Errors mutually deftroy each other.

But this meafuring of the Diftances with the Chain, or otherwife, is very tedious, and indeed impracticable in many Cafes, unlefs you make a Multitude of Stations: So if the Way between the two determined Places, whofe diffe-

rent

rent Height you would know, lies over Hills
and Dales, as *Fig.* 32. 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, (as in the foregoing Ob-
ſervations,) in the following Manner.

S E C T. IV.

*How to make Allowance for the Curvature
of the Earth; when the Station-ſtaves are
planted at unequal Diſtances from the In-
ſtrument.*

SUppoſe the Inſtrument was planted on the
Eminence between the two Valleys *a*, and
b, and 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 Telleſcope to the firſt Aſſiſtant's Staff
at *c*, and by the Spring-ſcrews ſet the Bubble ex-
act, obſerving where the Hair cuts the Staff, and
by Signs cauſe him 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 by the Micro-
meter in the Telleſcope, I find the Diſtance from
the Inſtrument to the Staff at *c*, to be about
10 Chains.
   Then I direct the Telleſcope to *d*, and pro-
cede in the ſame Manner as before, and find that
the Hair cuts 849 Parts from the Ground; and
M 2   by

by the Micrometer the Diſtance to *d*, is determined to be about 35 Chains.

Next I look into the Table of Curvature and find againſt 10 Chain, 1 Part to be deducted for the Curvature of the Earth at that Diſtance; ſo will the firſt Aſſiſtant's Note be made 103 Parts.

Alſo againſt 35 Chains I find $12\frac{2}{10}$, which deducted out of 849, there remains $836\frac{1}{10}$ Parts which muſt be noted by the ſecond Aſſiſtant.

Now if 103, as noted by the firſt Aſſiſtant, be ſubtracted from $836\frac{1}{10}$, as noted by the ſecond, the Remainder will be $733\frac{1}{10}$; 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 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 $4\frac{1}{2}$ 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 be brought in a crooked or winding Way.

C H A P.

C H A P. II.

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

SECT. I.

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

But without Mathematical Rules this Repre-
ſentation cannot well be found; for when Objects
are drawn by only Viewing or Looking at them,
their true Repreſentations will often be miſs'd;
whereas by the following Method they may al-
ways be obtained.

For all Objects appear ſuch as the viſual An-
gle under which they are ſeen; which Angle is
taken at the Eye, where the Lines meet that do
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.* 32, muſt be drawn on the Perſpective Plane of different Dimenſions (altho' on the Building one of 'em is really as big 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 to 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 compos'd 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 Buſneſs of Perſpective conſiſts in finding only the Place of a Point.

But theſe Points can't 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.

For

For having noted the Obfervations made by the Theodolite, the Plan of any Building may be drawn in Perfpective, without meafuring fo much as one Line; or coming nearer the Building than where the Inftrument is planted.

S E C T. II.

Let Fig. 33. reprefent the Building as viewed from Z, *being the Place from which the Pro-fpect is defired to be taken.*

THE Inftrument being planted at z, and the Staves made to ftand firm on the Ground, I fet the Inftrument exactly level; and with the Index at 360, and the Quadrant at o Degrees, direct the Tellefcope to fome Part of the Building, as to o, by turning about the whole Inftrument, and there fcrew it faft, that it ftir not out of this Pofition, till the feveral Obfervations be finifhed.

The Inftrument being fet level, the Index, when turned round on the Limb, carries the Tellefcope in a Line Parallel to the Horizon, as *x, y :* And the Quadrant elevated or depreffed, moves always in a Circle vertical thereto, as *w, z.*

Now take the Pin out of the Quadrant, and with one Hand move the Index on the Limb, and with the other elevate or deprefs the Tellefcope as there fhall be Occafion, till you fee the crofs 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 thofe the horizontal Angles : Likewife note the Degrees and Minutes cut by the Quadrant in another Column, and call thofe the vertical Angles.

M 4   So

So the Tellescope 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 Tellescope to the Bottom of the Building at *c*, and the Index then cuts the same Angle on the Limb as at *b*, and the Quadrant 8°, 30': But this Angle of Depression must be marked with $\wedge$, 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 Tellescope 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 numbred 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 encrease 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 Tellescope to the Points 4, 3, 2, 1, and

note

note the Degrees, &c. cut by the Quadrant; which when protracted, will give the Breadth of the Facies 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 Tellescope moves towards the Left : And these Remarks thus noted, must be protracted on the Left Side of the Vertical Line *w, z,* *Fig.* 33.

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 Tellescope 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; *& è contra.*

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

The Observations of most of the Points, that need to be taken of *Fig.* 33, 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

Objects more irregular must be drawn by obſerv-
ing ſo many Points therein, as ſhall be neceſſary:
But Practice in this Caſe is the beſt Guide.

S E C T. III.

*The Manner of Protracting theſe Obſervations
in Order to find the Points of the Building,
Fig. 33.*

Horizon. Angles	Vertical Angles	
7° : 25	19° : 30	a
11 : 30	16 : 30	b
11 : 30	8 : 30	c ∧
19 : 20	26 : 50	d
19 : 20	13 : 30	e ∧
38 : 00	26 : 50	f
38 : 00	13 : 30	g ∧
4 19 : 20	26 : 50	
	25 : 30	
3 ————	18 : 40	
2 ————	9 : 35	
∧ : 1 ————	1 : 00	
i 18 : 30	19 : 00	
e 18 : 30	22 : 40	
u 16 : 50	17 : 50	

FIRST draw a right Line *x, y, Fig.* 33.
for the Horizontal-line; and at right An-
gles therewith draw another Line *w, z*, which
repreſents the Vertical-line.

Set off the Points of Diſtance from *o,* (*viz*)
from that Point where *x, y*, and *w, z*, inter-
ſect one another: And according to what Big-
neſs

nefs you would have the Plan of the Building
be, make the Diftance bigger or lefs. If you
would have the Draught large, make the Di-
ftance large: *Et è contra.* Therefore fet one
Foot of the Compafs at *o,* and with the fame
Extent mark the Points of Diftance *x, y, z.*

The Horizontal-angles muft 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 Verti-
cal-line *w, z.*

The Index being at 360, and the Quadrant at *o,*
when the Crofs-hairs in the Tellefcope cut the Point
o, on the Building: Therefore the Point *o,* fhall be
the firft Point of Sight on the Profpective-plain.

By the Table of Obfervations I find that the
Index cuts 7°. 25'. on the Limb; and the Qua-
drant 19° 30', when the Tellefcope was directed
to the Point *a*: Therefore lay the Center of the
Protractor to *z*: And becaufe 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 Diame-
ter coincident therewith; and againft 7°, 25';
make a Mark clofe by the Limb of the Protractor.

Lay the Edge of a ftrait Ruler to the Point of
Diftance *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 Diftance *y,* (becaufe *a* is noted on the Right
Side of the Columns) the Diameter coincident
with the Line *x, y*; and againft 19°, 30', on the
Limb, make a Mark.

Lay a ftrait Ruler to that Mark, and the Point
of Diftance *y*; and where the Edge cuts the Ver-
tical Line *w, z,* make a Mark at *r.*

Laftly, Lay a Parallel Ruler to the Horizontal
Line *x, y,* and move it Parallel thereto, till the
Edge

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 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 ৪ in the Vertical Line; so shall a Line drawn Parallel to *x*, *y*, from the Point ৪, 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.* 33, have the same Angles with *a*, *b*, *c*, *d*, *e*, *f*, *g*, on the Right, and therefore protracted in the same Manner; except 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*.

<div align="right">Observe,</div>

Obferve, That in Protracting thefe Points, 'tis convenient, that the Numbers on the Semicircular Protractor fhould be made to encreafe 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 Diftance 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; fo fhall the Interfection of the Two Parallels give the Point fought.

But thefe Points are found with much greater Expedition, if the Paper on which you draw the Plan of the Building, be faftened to a Drawing-Board, and the Angles laid down by the Sector in the following Manner :

For Example: Suppofe the Point a, *Fig. 33*, was fought.

Firft, Draw Two Lines by the Side of the Tee, crofling one another at Right Angles, as x, y, and w, z, *Fig. 33*.

Take between the Points of the Compaffes the Diftance z, o, and let the Sector be opened to the fame Extent, by fetting one Foot of the Compaffes 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, fet one Foot of the Compaffes 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 Diftance fet from the Point of Sight o, in the Horizontal-Line x, y, to t.

In

In the fame Manner take off from the Sector the vertical Angle 19° 30′ which fet on the vertical Line *w, z,* from *o* to *r.*

Laftly, lay the Tee on the Drawing-board, parallell to *w, z,* fo that the Edge cut through the Point *t,* and draw the Obfcure-Line *t, 9.*

Lay the Tee to the other Side of the Drawing-board parallel to *x, y:* And the Edge cutting through the Point *r.* Draw the Obfcure-Line *r, 5,* fo fhall the Interfection of thefe two Lines *t, 9,* and *r, 5,* give the Point *a* which was fought.

In the fame Manner may any other Point be found in as little Time as it could be obferved 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 Divifions, 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 thefe two Points, and continue a ftrait Line till it cuts the Horizontal-line *x, y,* as at *f,* that fhall be the accidental Point, (or, as the Draughts-Men fometimes call it, the vanifhing 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 muft 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 fuppofed parallel to the perfpective Plan or Picture)

So when you have protracted the vertical Angles of 4, 3, 2, 1, *Fig.* 33. and thereby found thofe Points. You may lay a Ruler to each of them, and the accidental Point *f,* and thereby
draw

draw the Facies on the Wings of the Building according to their Breadth and Diftance from one another on the perfpective Plane or Draught.

In like Manner having found the Points *e*, *i*, and *u* of the firft 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 Diftance; and by thefe Directions draw all the Windows on that Wing of the Building.

If a Statue, Coat of Arms, or other Object was placed at *o*, *Fig.* 33. and it was defir'd to place the fame (or another,) a good Deal higher, as at *r*; but fo, that the Object when placed at *r* fhould appear full as big, as when at *o*; being viewed from *z*.

Obferve with the Theodolite, the Angles under which the Object appears at *o*, as if it was a Statue, obferve 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 Telefcope to *r*, and fetting the Quadrant and Index to the fame Angles, you may give Directions how to make the Object at *r*, of fuch Dimenfions as being viewed from *z*, will appear of the fame Magnitude (or natural Height) with that at *o*; *& vice verfa*.

The fame may be done, if Objects are defired to be placed at a Diftance, to appear of the fame Size as thofe that are nearer; with feveral other Problems to be performed by this Inftrument, which the Ingenious will find out in the Ufe thereof: But I have already exceeded what I intended on this Head, and fhall only add two or three Aftronomical Problems, which the Surveyor perhaps may find very ufeful in Practice.

<div align="right">C H A P.</div>

C H A P.   III.

P R O B L E M   I.

*How to find a True Meridian-Line, by Ob-
serving with the Theodolite.*

T H E beft Time to make the Obfer-
vations, are in a clear Day, about 3
or 4 Hours before and after Noon.
In the Morning, having fet the
Inftrument exactly level, move the
Index Horizontally, and the Quadrant Vertically,
till through the Tellefcope you fee the crofs Hairs
in the Center of the Sun : Then obferve what
Degrees and Minutes are cut by the Index, fup-
pofe 3°, 25', which note in a Piece of Paper, as
alfo the Angle of Elevation cut by the Quadrant.

About fo many Hours after Noon, obferve ex-
actly, that the Quadrant be fet to the fame Angle
of Elevation as in the Morning ; and then move
the Index on the Limb till you fee the crofs 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, fuppofe 64°, 37'.

But Note, 'tis convenient in the Morning to
make 3 or 4 Obfervations 5 or 6 Minutes from
one another; becaufe in the Afternoon you muft
wait till the Sun falls into the fame Altitude as
it had when you made the Obfervation in the
Morning, (the Quadrant remaining at the fame
Angle at both;) and if it fhould happen to be
                                        obfcured

obscured by Clouds at that Inftant, your Labour will be loft for that Day, having made but one Obfervation in the Morning.

Now, if from 64°, 37′, the Evening Obfervation on the Limb, you fubtract 3°, 25′, the Morning Obfervation, the Remainder will be 61°, 12′, the half of which is 30°, 36′; to this half Sum 30°, 36′, add the Morning Obfervation 3°, 25′, and the Sum will be 34°, 1′.

Laftly, the Inftrument remaining in the fame Pofition, bring the Index on the Limb to 34°, 1′, and the Quadrant and Tellefcope will be exactly in the Plane of the Meridian: But if the Obfervation on the Limb in the Morning, exceed that in the Afternoon, you muft add to the Afternoon Obfervation 360, and work in like Manner; and if the Remainder fhould exceed 360, you muft fubtract 360 therefrom.

Now obferve what Point (on fome firm Wall of a Building) is cut by the crofs Hairs in the Tellefcope, there caufe a good Mark to be fixed, or caufe a Pillar with a Mark thereon to be fet up by the Direction of the Tellefcope: Alfo take Notice, If you could place the Mark a Quarter or Half a Mile diftant from the Inftrument, it is better than if it was nearer. And in making thefe Obfervations, you ought to be very exact; becaufe when a Meridian-Line is once well fixed, it is very ufeful for divers Purpofes.

Obferve, When the Sun is near the Tropicks, the Meridian-line may be found well enough by obferving as aforefaid: But when it is near the Equinox, there will be fome Variation; becaufe the Sun's Declination is greater or lefs at different Times in the fame Day: And confequently when in equal Altitudes, has different Azimuths. Therefore the Meridian-line may be more truly found, By the *Pole Star.*

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 on the West of the Meridian; add 11 h. 84 m. to 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	6
52	00	4	9
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 Tellescope, till you see the Pole Star in the Interfection 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 Tellescope will be set exactly in the Plane of the Meridian.

P R O B.

PROBLEM 2.

How to find the Latitude of any Place, by the Theodolite.

THE Inſtrument being ſet level, bring the Quadrant and Telleſcope into the Plane of the Meridian, and let the Index remain at the ſame Angle on the Limb; then elevate or depreſs the Telleſcope 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 Ephemeris, you may find the Sun's De-clination 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: And the exact Li-mits of the Natural Day.

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 Remainder will be the Sun's Meridian Altitude
<div align="right">for</div>

for the Day, as aforesaid, which suppose to be
42°, 15'.

Set the Quadrant to 42°, 15', and the Teles-
cope 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 Na-
tural 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 Observa-
tion, you will have the true Time of that Star's
coming to the Meridian for each Night follow-
ing.

And thus may a Pendulum-Clock or Watch
be adjusted to the Mean Motion of the Sun.

P R O B.

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 Telleſcope to any Star,
its Azimuth is ſhewn by the Index on the Limb ;
and the Altitude by the Quadrant both at the
ſame Time.

<div align="center">

F I N I S.

</div>

✦✧✦✧✦✧✦✧✦✧✦✧✦✧✦✧✦✧✦✧✦✧✦✧✦✧✦✧✦
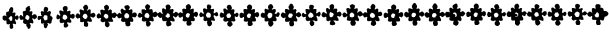
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TABLES,

SHEWING THE

ALTITUDE and DIAMETER

OF ANY

OBJECT

To the Hundreth Part of a Foot,

Anfwering to every Tenth Part of a Degree,
throughout the DOUBLE SEXTANT; obferved by
the New THEODOLITE, from a Station of ten,
twenty, thirty, &c. Feet Diftant.

AS ALSO

The Fourth Part of the Girt of any Timber-Tree
ftanding.

D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.
0	0	5:0	87	10:0	176	15:0	268	20:0	364	25:0	466
1	1	1	89	1	178	1	270	1	366	1	468
2	3	2	91	2	180	2	272	2	368	2	470
3	5	3	93	3	182	3	273	3	370	3	473
4	7	4	95	4	183	4	275	4	372	4	475
5	9	5	96	5	185	5	277	5	374	5	477
6	10	6	98	6	187	6	279	6	376	6	479
7	12	7	100	7	189	7	281	7	378	7	481
8	14	8	102	8	191	8	283	8	380	8	483
9	16	9	103	9	192	9	285	9	382	9	485
1:0	17	6:0	105	11:0	194	16:0	287	21:0	384	26:0	488
1	19	1	107	1	196	1	289	1	386	1	490
2	21	2	109	2	198	2	290	2	388	2	492
3	23	3	110	3	200	3	292	3	390	3	494
4	24	4	112	4	202	4	294	4	392	4	496
5	26	5	114	5	203	5	296	5	394	5	498
6	28	6	116	6	205	6	298	6	396	6	501
7	30	7	117	7	207	7	300	7	398	7	503
8	32	8	119	8	209	8	302	8	400	8	505
9	33	9	121	9	211	9	304	9	402	9	507
2:0	35	7:0	123	12:0	212	17:0	306	22:0	404	27:0	509
1	37	1	125	1	214	1	308	1	406	1	512
2	38	2	126	2	216	2	309	2	408	2	514
3	40	3	128	3	218	3	311	3	410	3	516
4	42	4	130	4	220	4	313	4	412	4	518
5	44	5	132	5	222	5	315	5	414	5	521
6	45	6	133	6	223	6	317	6	416	6	523
7	47	7	135	7	225	7	319	7	418	7	525
8	49	8	137	8	227	8	321	8	420	8	527
9	51	9	139	9	229	9	323	9	422	9	529
3:0	52	8:0	140	13:0	231	18:0	325	23:0	424	28:0	532
1	54	1	142	1	233	1	327	1	426	1	534
2	56	2	144	2	234	2	329	2	428	2	536
3	58	3	146	3	236	3	331	3	431	3	538
4	59	4	148	4	238	4	333	4	433	4	541
5	61	5	149	5	240	5	334	5	435	5	543
6	63	6	151	6	242	6	336	6	437	6	545
7	65	7	153	7	244	7	338	7	439	7	547
8	66	8	155	8	246	8	340	8	441	8	550
9	68	9	157	9	247	9	342	9	443	9	552
4:0	70	9:0	158	14:0	249	19:0	344	24:0	445	29:0	554
1	72	1	160	1	251	1	346	1	447	1	556
2	73	2	162	2	253	2	348	2	449	2	559
3	75	3	164	3	255	3	350	3	451	3	561
4	77	4	165	4	257	4	352	4	454	4	563
5	79	5	167	5	259	5	354	5	456	5	566
6	80	6	169	6	260	6	356	6	458	6	568
7	82	7	171	7	262	7	358	7	460	7	570
8	84	8	173	8	264	8	360	8	462	8	573
9	86	9	174	9	266	9	362	9	464	9	575
5:0	87	10:0	176	15:0	268	20:0	364	25:0	466	30:0	577

D. T.	Parts	D. T.	Parts	D. T.	Parts	D. T.	Parts	D. T.	Parts	D. T.	Parts
30:0	577	35:0	700	40:0	839	45:0	1000	50:0	1192	55:0	1428
1	579	1	702	1	842	1	1003	1	1196	1	1433
2	582	2	705	2	845	2	1007	2	1200	2	1439
3	584	3	708	3	848	3	1010	3	1204	3	1444
4	587	4	711	4	851	4	1014	4	1208	4	1449
5	589	5	713	5	854	5	1018	5	1213	5	1455
6	591	6	716	6	857	6	1021	6	1217	6	1460
7	594	7	718	7	860	7	1025	7	1222	7	1466
8	596	8	721	8	863	8	1028	8	1226	8	1471
9	598	9	724	9	866	9	1032	9	1230	9	1477
31:0	601	36:0	726	41:0	869	46:0	1035	51:0	1235	56:0	1482
1	603	1	729	1	872	1	1039	1	1239	1	1488
2	606	2	732	2	875	2	1043	2	1244	2	1494
3	608	3	734	3	878	3	1046	3	1248	3	1499
4	610	4	737	4	882	4	1050	4	1253	4	1505
5	613	5	740	5	885	5	1054	5	1257	5	1511
6	615	6	743	6	888	6	1057	6	1262	6	1516
7	618	7	745	7	891	7	1061	7	1266	7	1522
8	620	8	748	8	894	8	1065	8	1271	8	1528
9	622	9	751	9	897	9	1069	9	1275	9	1534
32:0	625	37:0	753	42:0	900	47:0	1072	52:0	1280	57:0	1540
1	627	1	756	1	903	1	1076	1	1284	1	1546
2	630	2	759	2	907	2	1080	2	1289	2	1552
3	632	3	762	3	910	3	1084	3	1294	3	1558
4	635	4	764	4	913	4	1087	4	1298	4	1564
5	637	5	767	5	916	5	1091	5	1303	5	1570
6	639	6	770	6	919	6	1095	6	1308	6	1576
7	642	7	773	7	923	7	1099	7	1313	7	1582
8	644	8	776	8	926	8	1103	8	1317	8	1588
9	647	9	778	9	929	9	1107	9	1322	9	1594
33:0	649	38:0	781	43:0	932	48:0	1111	53:0	1327	58:0	1600
1	652	1	784	1	936	1	1114	1	1332	1	1606
2	654	2	787	2	939	2	1118	2	1337	2	1613
3	657	3	790	3	942	3	1122	3	1342	3	1619
4	659	4	792	4	946	4	1126	4	1346	4	1625
5	662	5	795	5	949	5	1130	5	1351	5	1632
6	664	6	798	6	952	6	1134	6	1356	6	1638
7	667	7	801	7	956	7	1138	7	1361	7	1645
8	669	8	804	8	959	8	1142	8	1366	8	1651
9	672	9	807	9	962	9	1146	9	1371	9	1658
34:0	674	39:0	810	44:0	966	49:0	1150	54:0	1376	59:0	1664
1	677	1	813	1	969	1	1154	1	1381	1	1671
2	679	2	815	2	972	2	1158	2	1386	2	1677
3	682	3	818	3	976	3	1163	3	1392	3	1684
4	685	4	821	4	979	4	1167	4	1397	4	1691
5	687	5	824	5	983	5	1171	5	1402	5	1698
6	690	6	827	6	986	6	1175	6	1407	6	1704
7	692	7	830	7	989	7	1179	7	1412	7	1711
8	695	8	833	8	993	8	1183	8	1417	8	1718
9	698	9	836	9	996	9	1187	9	1423	9	1725
35:0	700	40:0	839	45:0	1000	50:0	1192	55:0	1428	60:0	1732

D. T.	¼ part of the Girt.
o	I. T.
1	0 : 1
2	0 : 3
3	0 : 5
4	0 : 7
5	0 : 9
6	1 : 0
7	1 : 1
8	1 : 3
9	1 : 4
1:0	1 : 5
1	1 : 7
2	1 : 9
3	2 : 1
4	2 : 3
5	2 : 4
6	2 : 6
7	2 : 7
8	2 : 9
9	3 : 1
2:0	3 : 3
1	3 : 5
2	3 : 6
3	3 : 8
4	4 : 0
5	4 : 1
6	4 : 2
7	4 : 4
8	4 : 6
9	4 : 7
3:0	4 : 8
1	5 : 0
2	5 : 2
3	5 : 4
4	5 : 5
5	5 : 7
6	5 : 9
7	6 : 1
8	6 : 2
9	6 : 4
4:0	6 : 6
1	6 : 8
2	6 : 9
3	7 : 1
4	7 : 3
5	7 : 5
6	7 : 6
7	7 : 7
8	7 : 9
9	8 : 0
5:0	8 : 2

A TABLE,

Shewing the Fourth Part of the Girt in Inches and Tenths, answering to every Tenth Part of a Degree, so far as ten Degrees.

The USE of these TABLES will appear very plain from one Example.

Measure from the Tree, ten, twenty, thirty, &c. Feet, and there plant the Theodolite Level.

Direct the Telescope to the Bottom of the Tree, and observe the Degree and Tenth of Depression, and to the Top of the Tree, the Degree and Tenth of Elevation.

Then find in the Table, the Parts answering to each, which being added together, make the exact Height of the Tree.

But, because the Fourth Part of the Girt in Inches must be taken in the Middle of the Tree; substract the Parts answering to the Depression, from half the Height of the Tree: The Remainder seek for in the Table, under Parts, against which, in the left hand Column, is the Degree and Tenth of Elevation; to which, if you set the Telescope, and observe the Diameter of the Tree, i. e. the Degree and Tenth on the Limb, answering to the Diameter, and bring them to this Table, you will have the Fourth Part of the Girt in Inches, and Tenths answering thereto.

	D. T.	Parts.
Depression	24 : 3	451
Elevation	58 : 8	1651
Height of the Tree		21.02
Half the Height		10.51
		451
Set the Telescope	31 : 0	600

	D. T.	I. T.
		¼ part of the Girt.
Diameter on the Limb	9 : 6	16 : 0

N. B. These Tables are calculated for the Distance of ten Feet; yet are they as perfect for twenty, thirty, &c. Feet, only by doubling, trebling, &c. the Length, Diameter, and Fourth Part of the Girt found thereby.

D. T.	¼ part of the Girt.
	I. T.
5:0	8 : 2
1	8 : 4
2	8 : 6
3	8 : 8
4	9 : 0
5	9 : 1
6	9 : 3
7	9 : 4
8	9 : 6
9	9 : 8
6:0	10 : 0
1	10 : 2
2	10 : 4
3	10 : 5
4	10 : 7
5	10 : 8
6	10 : 9
7	11 : 0
8	11 : 2
9	11 : 4
7:0	11 : 6
1	11 : 8
2	12 : 0
3	12 : 1
4	12 : 3
5	12 : 5
6	12 : 6
7	12 : 8
8	13 : 0
9	13 : 1
8:0	13 : 2
1	13 : 4
2	13 : 6
3	13 : 8
4	13 : 9
5	14 : 0
6	14 : 2
7	14 : 4
8	14 : 6
9	14 : 8
9:0	14 : 9
1	15 : 0
2	15 : 2
3	15 : 4
4	15 : 5
5	15 : 7
6	16 : 0
7	16 : 1
8	16 : 2
9	16 : 3
10:0	16 : 6
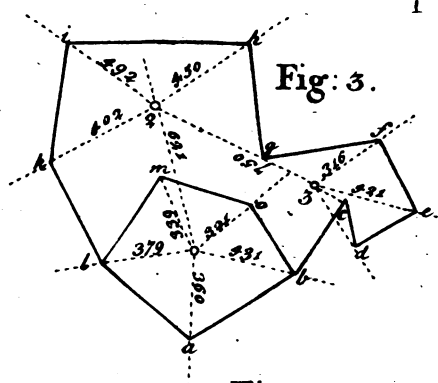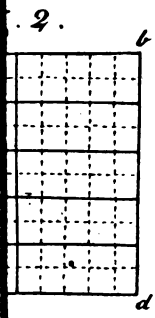
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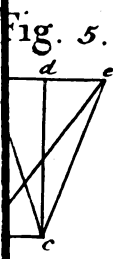
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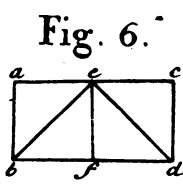
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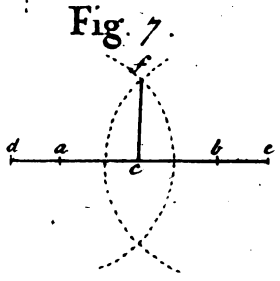
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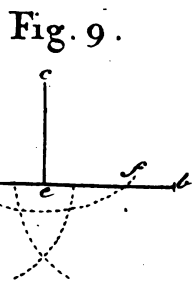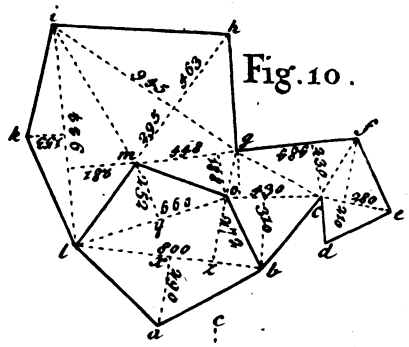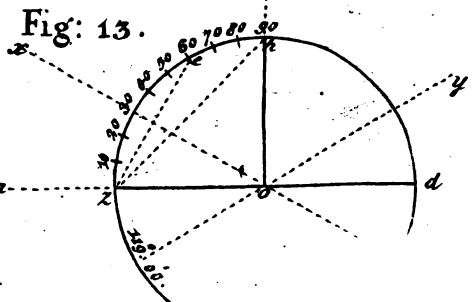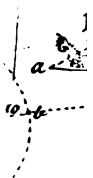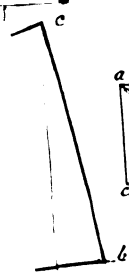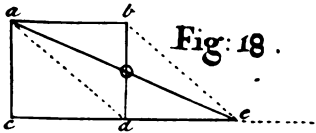
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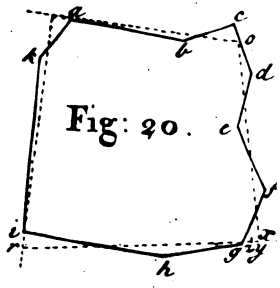
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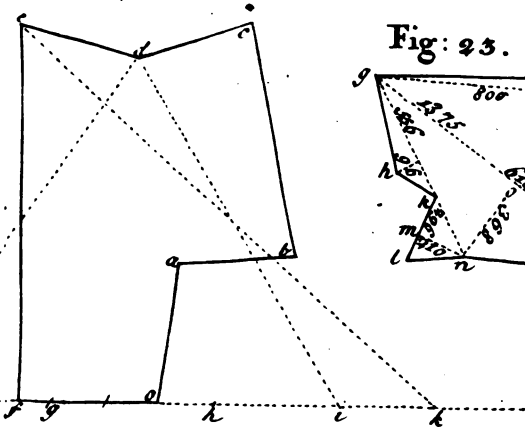
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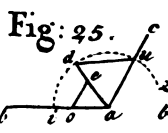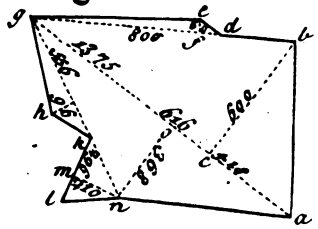
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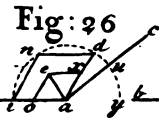
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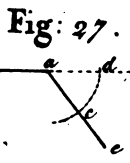
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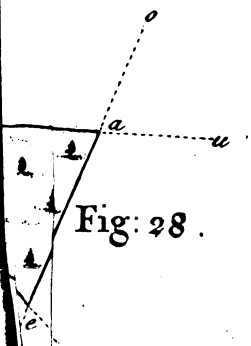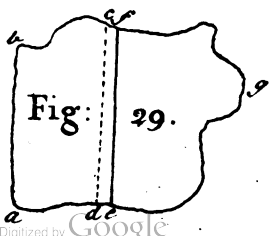
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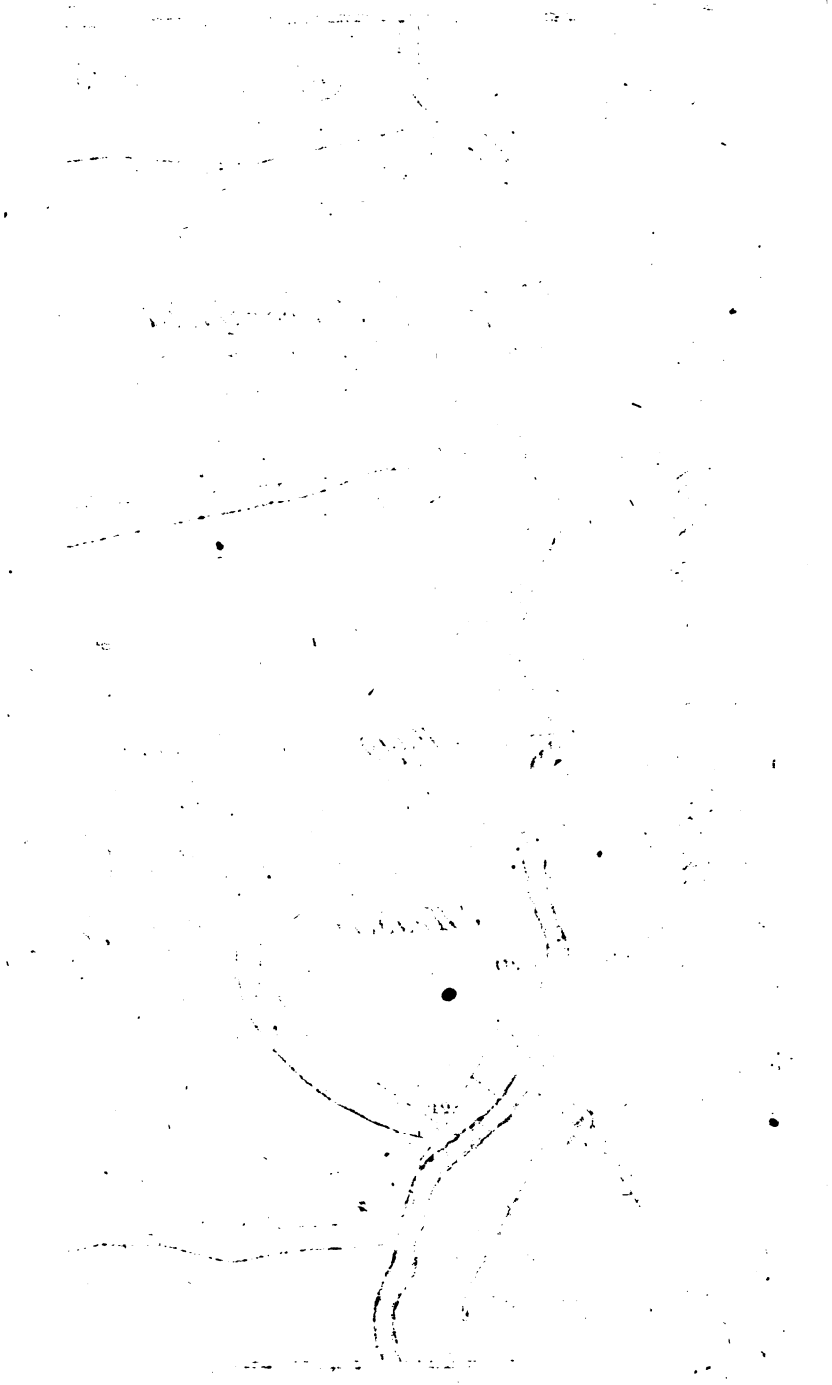
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