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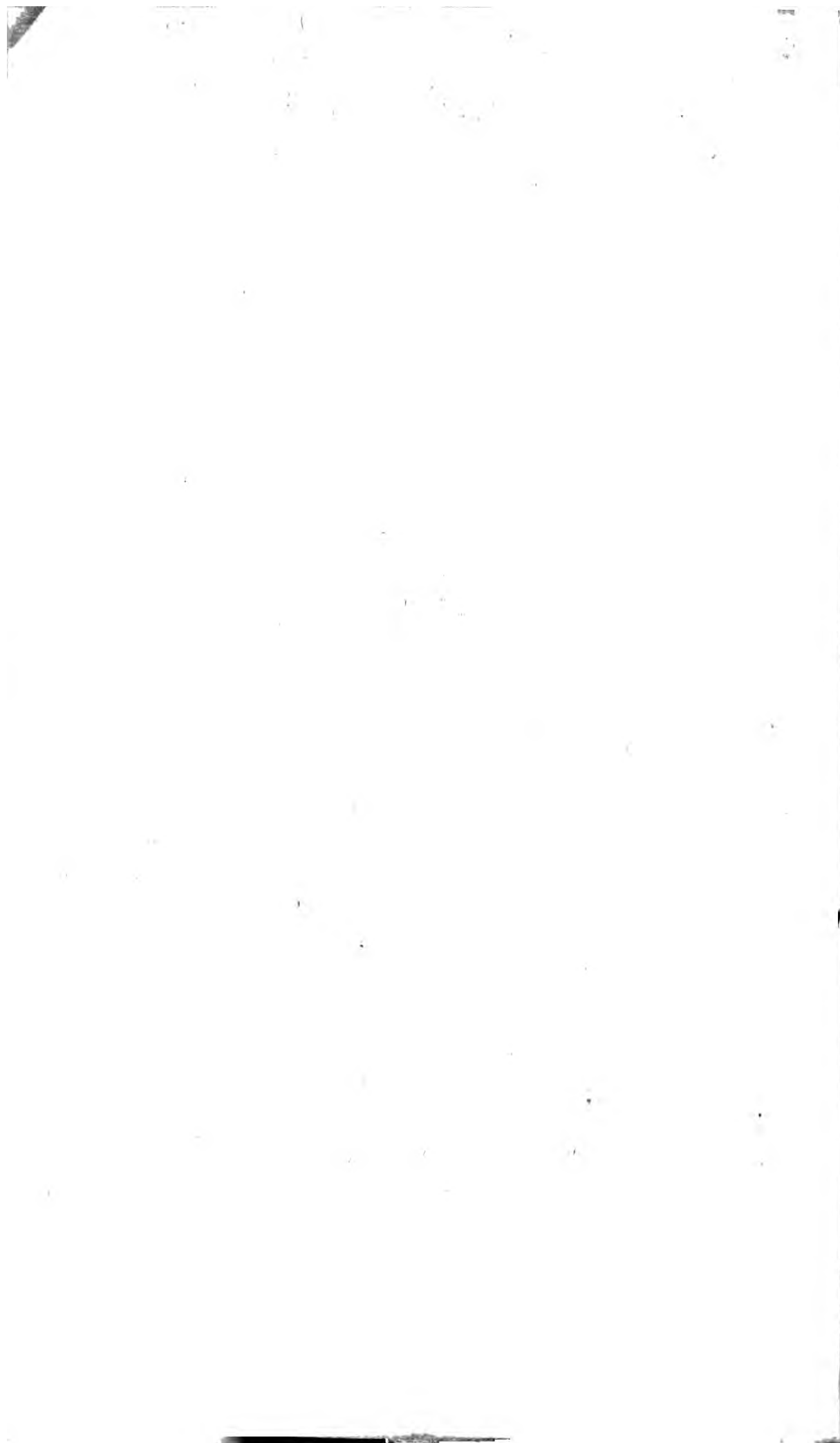
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CAROLI GODWYN, S.T.B.
COLL. BALL. SOC.
MDCCCLXX.













GEORGE R.

GEORGE the Second, by the Grace of God, King of *Great-Britain, France and Ireland*, Defender of the Faith, &c. To all to whom these Presents shall come, Greeting. Whereas *James Buckland, James Waugh, John Ward, Thomas Longman, and Edward Dilly*, Citizens and Bookfellers of our City of *London*, have by their Petition humbly represented unto Us, that they have purchased the Copy-Right of the **WHOLE WORKS** of the late **DOCTOR ISAAC WATTS**, and that they are now printing and preparing for the Press, new Editions with Improvements, of several of the separate Pieces of the said Doctor *Isaac Watts*. They have therefore most humbly prayed Us, that We would be graciously pleased to grant them our Royal Licence and Protection for the sole printing, publishing, and vending the said Works, in as ample Manner and Form as has been done in Cases of the like Nature; We being willing to give all due Encouragement to Works of this Nature, which may be of publick Use and Benefit, are graciously pleased to condescend to their Request, and do therefore by these Presents, as far as may be agreeable to the Statute in that Behalf made and provided, grant unto them, the said *James Buckland, James Waugh, John Ward, Thomas Longman, and Edward Dilly*, their Executors, Administrators, and Assigns, our Royal Privilege and Licence, for the sole printing, publishing, and vending the said Works for the Term of fourteen Years, to be computed from the Date hereof, strictly forbidding and prohibiting all our Subjects within our Kingdoms and Dominions, to reprint, abridge, or translate the same, either in the like, or any other Volume or Volumes whatsoever, or to import, buy, vend, utter, or distribute any Copies thereof reprinted beyond the Seas, during the aforesaid Term of fourteen Years, without the Consent and Approbation of the said *James Buckland, James Waugh, John Ward, Thomas Longman, and Edward Dilly*, their Executors, Administrators and Assigns, by Writing under their Hands and Seals first had and obtained, as they and every of them offending herein, will answer the contrary at their Peril, whereof the Commissioners and other Officers of our Customs, the Master, Wardens, and Company of *Stationers* of our City of *London*, and all other our Officers and Ministers, whom it may concern, are to take Notice, that due Obedience be rendered to our Pleasure herein signified.

Given at our Court at *St. James's* the Twenty First Day of *March*, 1758. in the Thirty First Year of Our Reign.

By His Majesty's Command.

W. PITT.

*The Knowledge of the HEAVENS and
the EARTH made Easy :*

OR, THE

First Principles

O F

ASTRONOMY

A N D

GEOGRAPHY

Explain'd by the Use of GLOBES and MAPS.

WITH A

Solution of the Common PROBLEMS by a *plain
Scale and Compasses*, as well as by the *Globe*.

WRITTEN several Years since for the USE of
LEARNERS.

By I. WATTS, D. D.

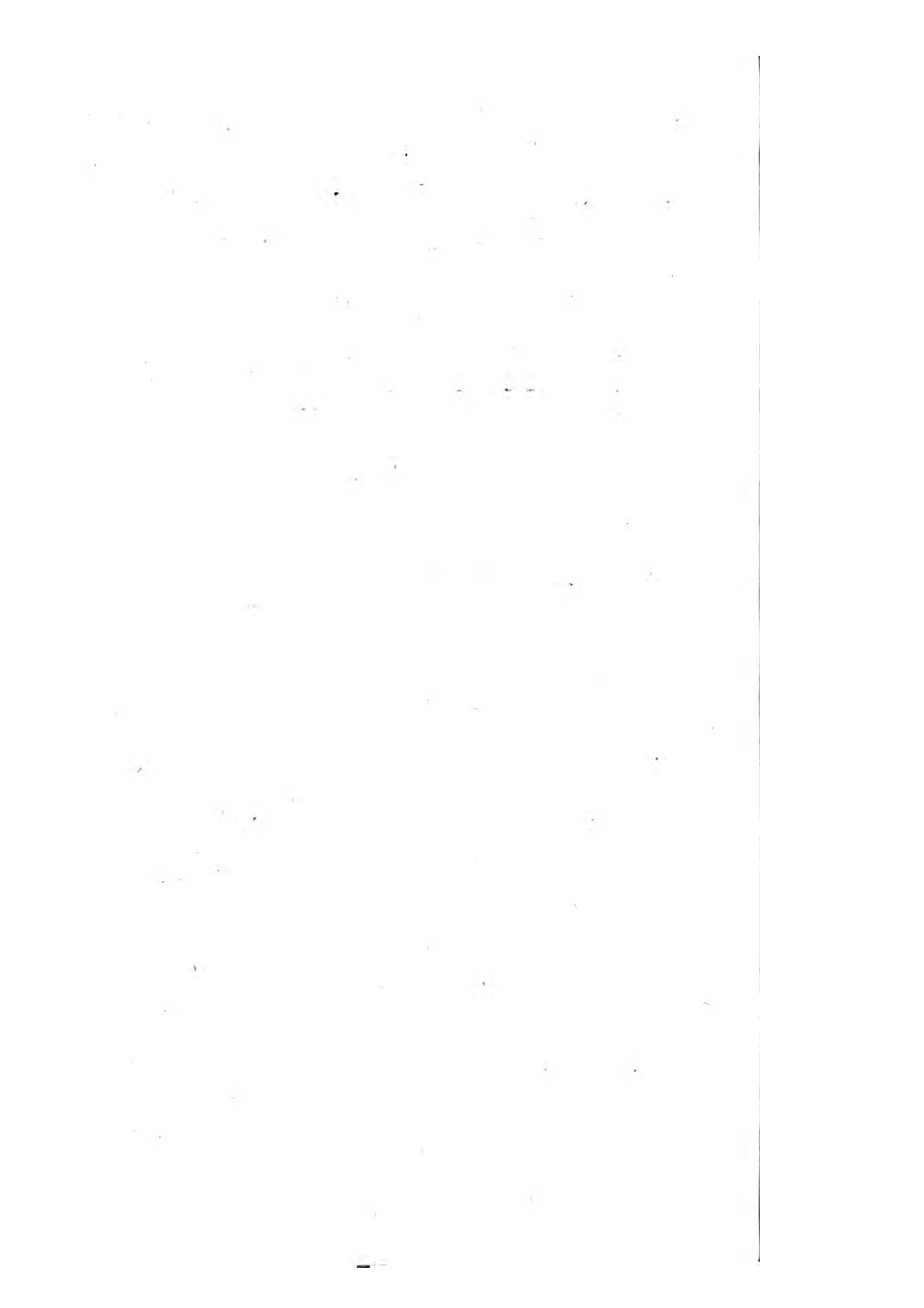
The SIXTH EDITION, Corrected.

Pfal. viii. 3. — *I consider thy Heavens, the Work of thy Fingers,
the Moon and the Stars which thou hast ordained.*

L O N D O N :

Printed for T. LONGMAN, J. BUCKLAND, and W. FENNER,
in Pater-noster-row; J. WAUGH in Lombard-street;
J. WARD in Cornhill; and E. DILLY in the Poultry.

M. DCC. LX.





To my LEARNED FRIEND

Mr. *JOHN EAMES,*

Fellow of the ROYAL SOCIETY.

Dear Sir,

IT would be mere trifling to say any thing to you of the Excellency and great Advantage of those *Sciences*, whose first Rudiments I have here drawn up. Your large Acquaintance with these Matters hath given you a just Relish of the Pleasure of them, and well informed you of their solid use. But, perhaps, it is necessary to excuse my self to the World, if I publish some of the Fruits of my former Studies on such Subjects as

these. I would therefore willingly have the unlearned Part of Mankind apprized of the Necessity and general Use of this sort of Learning; and that not only to Civil, but to Sacred Purposes.

If you, Sir, would please to take upon you this Service, you would make it appear with rich Advantage how far the Knowledge of Things Human and Divine are influenced and improved by these Studies.

You can tell the World, that it is the Knowledge of this *Globe of Earth* on which we tread, and of those *Heavenly Bodies* which seem to roll around us, that hath been wrought up into these two kindred Sciences, *Geography* and *Astronomy*. And there is not a Son or Daughter of *Adam* but has some Concern in both of them, though they may not know it in a learned way.

This *Earth* is given us for an Habitation: It is the place of present Residence for all our Fellow-mortals: Nor is it possible that there should be any Commerce maintained with those who dwell at a Distance, without some Acquaintance with the different Tracts of Land, and the Rivers or Seas that divide the Regions of the Earth.

The

The *Heavenly Bodies*, which are high over our Heads, measure out our Days and Years, our *Life* and *Time*, by their various Revolutions. Now *Life* and *Time* are some of the dearest things we have, and it is of important Concern to distinguish the *Hours* as they pass away, that proper Seasons may be chosen and adapted for every Business.

You know, Sir, that those necessary and useful Instruments, *Clocks*, *Watches* and *Dials*, owe their Origin to the Observations of the Heavens: The Computation of *Months* and *Years* had been for ever impracticable without some careful Notice of the various Situations and Appearances of those shining Worlds above us.

I shall be told, perhaps, that these are not my special Province. It is the Knowledge of God, the Advancement of Religion, and Converse with the Scriptures, are the peculiar Studies which Providence has assigned me. I know it, and I adore the Divine Favour. But I am free and zealous to declare, that without commencing some Acquaintance with these Mathematical Sciences, I could never arrive at so clear a Conception of many things delivered in the *Scriptures*; nor could I raise my Ideas of *God the Creator* to

so high a Pitch: And I am well assured that many of the sacred Function will join with me and support this Assertion from their own Experience.

If we look down to the *Earth*, it is the Theatre on which all the grand Affairs recorded in the Bible have been transacted. How is it possible that we should trace the Wandrings of *Abraham* that great Patriarch, and the various Toils and Travels of *Jacob*, and the *Seed of Israel* in successive Ages, without some *Geographical* Knowledge of those Countries? How can our Meditations follow the *Blessed Apostles* in their laborious Journies through *Europe* and *Asia*, their Voyages, their Perils, their Shipwrecks, and the Fatigues they endured for the Sake of the Gospel; unless we are instructed by *Maps* and *Tables*, wherein those Regions are copied out in a narrow Compass, and exhibited in one View to the Eye?

If we look upward with *David* to the Worlds above us, *we consider the Heavens as the Work of the Finger of God, and the Moon and the Stars which he hath ordained.* What amazing Glories discover themselves to our Sight? What Wonders of Wisdom are seen in the exact Regularity of their Revolutions?
Nor

Nor was there ever any thing that has contributed to enlarge my Apprehensions of the immense Power of God, the Magnificence of his Creation, and his own transcendent Grandeur, so much as that little Portion of *Astronomy* which I have been able to attain. And I would not only recommend it to *young Students* for the same Purposes, but I would persuade *all Mankind* (if it were possible) to gain some Degrees of Acquaintance with the Vastness, the Distances, and the Motions of the Planetary Worlds on the same Account. It gives an unknown Enlargement to the Understanding, and affords a divine Entertainment to the Soul and its better Powers. With what Pleasure and rich Profit would Men survey those astonishing *Spaces* in which the Planets revolve, the Hugeness of their *Bulk*, and the almost incredible Swiftnes of their *Motions*? And yet all these governed and adjusted by such unerring Rules, that they never mistake their Way, nor lose a Minute of their Time, nor change their appointed Circuits in several thousands of Years! When we muse on these things we may lose our selves in holy Wonder, and cry out with the Psalmist, *Lord what is Man that thou art mindful of him, and the Son of Man that thou shouldest visit him?*

It was chiefly in the younger Part of my Life indeed that these Studies were my Enter-

tainment; and being desired both at that time, as well as since, upon some Occasions, to lead some young Friends into the Knowledge of the first Principles of *Geography* and *Astronomy*, I found no Treatise on those Subjects written in so very plain and comprehensive a Manner as to answer my Wishes: Upon this Account I drew up the following Papers, and set every thing in that Light in which it appeared most obvious and easy to me.

I have joined the *general Part* of these two Sciences together: What belongs particularly to each of them is cast into distinct Sections. And I wish, Sir, you would present the World with the *Special Part of Astronomy* drawn up for the Use of Learners in the most plain and easy Method, to render this Work more complete.

Most of the Authors, which I perused in those Days when I wrote many Parts of this Book, were of older Date: And therefore the Calculations and Numbers which I borrowed from their *Astronomical Tables*, cannot be so exact as those with which some later Writers have furnished us: For this Reason the Account of the *Sun's Place* in the Ecliptick, the *Declination* and *Right Ascension* of the *Sun* and the *Stars* in some Parts of the Book, especially in the Solution of some of
the

the *Problems* in the 20th Section, may perhaps need a little Correction; though I hope the *Theorems* will appear true in the Speculation, and the *Problems* so regular and successful in the Practice as is sufficient for a Learner. However, to apply some Remedy to this Inconvenience, there are added at the End of the Book some later *Tables*, which are formed according to the celebrated Mr. *Flamsteed's* Observations.

I have exhibited near forty *Problems* to be practised on the Globe, and thirty-five more of various kinds, to be performed by manual Operation with the Aid of some *Geometrical* Practices. These were very sensible Allurements to my younger Enquiries into these Subjects, and I hope they may attain the same Effect upon some of my Readers.

It was my Opinion that it would be a very delightful Way of learning the *Doctrine* and *Uses of the Sphere*, to have them explained by a Variety of *Figures* or *Diagrams*; this is certainly much wanting in most Authors that I have perused. I have therefore drawn thirty *Figures* with my own Hand, in order to render the Description of every thing more intelligible.

I have endeavoured to entertain younger Minds, and entice them to these Studies, by all

all those easy and agreeable Operations relating both to the *Earth* and the *Heavens*, which probably may tempt them on to the higher Speculations of the great Sir *Isaac Newton* and his Followers on this Subject.

Yet there should be a due Limit set to these Inquiries too, according to the different Employments of Life to which we are called: For it is possible a Genius of active Curiosity may waste too many Hours in the more abstruse Parts of their Subjects which God and his Country demand to be applied to the Studies of the *Law*, *Physick*, or *Divinity*; to Merchandize or Mechanical Operations.

If I had followed the Conduct of mere Inclination, perhaps I should have laid out more of my serene Hours in Speculations which are so alluring: And then indeed I might have performed what I have here attempted in a Manner more answerable to my Design, and left less for the Criticks to censure, and my Friends to forgive. But such as it is, I put it intirely, *Sir*, into your Hands to review and alter whatsoever you please, and make it answerable to that Idea which I have formed of your Skill. Then if you shall think fit to present it to the World, I persuade my self I shall not be utterly disappointed in the Views I had in
 putting

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putting these Papers together, many of which have lien by me in Silence above twenty Years.

Farewel, *Dear Sir*, and forgive the Trouble that you have partly devolved on your self by the too favourable Opinion you have conceived both of these Sheets and of the Writer of them, who takes a Pleasure to tell the World that he is, with great Sincerity,

S I R,

Your most obedient Servant,

Theobalds in
Hertfordshire,
June 11. 1725.

I. WATTS.

T O

T O T H E
R E A D E R.

I Think my self obliged, in Justice to the ingenious Author as well as the Publick, to assure them that the Alterations I have ventured to make in the Revisal of this Work, are but few and small. The same Perspicuity of Thought and Ease of Expression which distinguish his other Works running through the whole of this, I don't question but the World will meet with equal Pleasure and Satisfaction in the Perusal.

August 20.
1725.

JOHN EAMES.

A
T A B L E

OF THE
C O N T E N T S.

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To the Bookbinder.

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dication, and before the first Page of the
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Book, and the Plates after them.**

THE FIRST
 PRINCIPLES
 OF
 Geography and Astronomy.

SECT. I.

*Of the SPHERES or GLOBES of the
 HEAVEN and EARTH.*

THERE is nothing gives us a more easy or speedy Acquaintance with the *Earth* and the *visible Heavens* than the Representation of them on a *Globe* or *Sphere*; because hereby we have the most natural Image of them set before our Eyes.

The *Terrestrial Globe* represents the Earth with its several Lands, Seas, Rivers, Islands, &c. The *Celestial Sphere* or *Globe* represents the Heavens and Stars.

Several *Points* and *Circles* are either marked or described on these *Spheres* or *Globes*, or are represented by the Brass and Wooden
 Work

Work about them, to exhibit the *Places* and the *Motions* of the Sun, Moon or Stars, the *Situation* of the several Parts of the Earth, together with the Relation that all these bear to each other.

The *Earthly Globe*, with the *Lines* and *Signs* and *Points* that are usually marked upon it, is sufficient to inform the Reader of almost every thing that I shall mention here, even with Regard to the *Heavens*, the *Sun* and the *Planets*; unless he has a Mind to be particularly acquainted with the *fixed Stars*, and the several *Uses* of them; then indeed a *Celestial Globe* is most convenient to be added to it.

Note 1st, Half the Globe is called a *Hemisphere*; and thus the whole Globe or Sphere of the Heavens, or of the Earth, may be represented on a Flat or Plane in *two Hemispheres*, as in the common *Maps* of the Earth, or in *Draughts* or *Descriptions* of the Heavens and Stars.

Because *Globes* are not always at Hand, the several *Points* and *Circles*, together with their Properties, shall be so described in this Discourse as to lead the Reader into some general and imperfect Knowledge of these Things (as far as it may be done by a *Map* of the World, which is nothing else but a *Representation of the Globe of Earth and Waters on two Flat or Plain*

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Plain Surfaces;) or at least I shall so express these Matters, that a Map will assist him to keep them in Remembrance, if he has been first a little acquainted with the Globe itself.

Note 2d, Though the latest and best Astronomers have found that the *Sun* is fixt in or near the Centre of our World, and that the *Earth* moves round its own Axis once in twenty-four Hours with a *Circular Motion*, and round the Sun once in a Year with a *Progressive Motion*; yet to make these Things more easy and intelligible to those that are unskilful, we shall here suppose the *Sun* to move round the *Earth*, both with a *daily* and *yearly* Motion, as it appears to our Senses; (*viz.*) daily going round the Earth, and yet every Day changing its Place a little in the Heavens, till in a Year's Time it returns to the same Place again.

S E C T. II.

Of the greater Circles.

THE *Greater Circles* are such as divide the Globe into two equal Parts, and are these four; (*viz.*) the *Horizon*, the *Meridian*, the *Equator*, and the *Ecliptick*.

1. The *Horizon* is a broad flat Circle, or the Wooden Frame in which the Globe
B stands.

stands. Its upper Edge divides the *Globe* into the upper and lower Halves or *Hemispheres*, and represents the Line or Circle which divides between the upper and the lower Parts of the Earth and Heavens, and which is called the *Horizon*. This circle determines the *Rising* or *Setting* of Sun or Stars, and distinguishes *Day* and *Night*.

When the Sun is in the East Part of the *Horizon*, it is *Rising*. When in the West Parts it is *Setting*. When it is above the *Horizon*, it is *Day*: When below it is *Night*.

Yet till the Sun be 18 Degrees below the *Horizon* it is usually called *Twilight*; because the Sun-Beams shooting upward are reflected down to us by the Atmosphere after Sun-set or before Sun-rise: And it is upon this Account that in our *Horizon* at *London*, there is no perfect *Night* in the very Middle of Summer for two Months together, because the Sun is not 18 Degrees below the *Horizon*.

The *Horizon* is distinguished into the *Sensible* and the *Rational*. See *Fig. 1*.

The *Sensible Horizon* supposes the Spectator placed on *s*, the Surface of the Earth or Water, and it reaches as far as the Eye can see. But the *Rational* or *True Horizon* supposes the Spectator placed in the Centre of the Earth *c*, and thus divides the Globes both of the Heavens and the Earth into Halves.

Sup-

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Suppose in *Figure 1.* the Circle $s d p e$ is the Earth, $u b b n r g$ the Heavens, $b s g$ the Line making the Sensible Horizon, $b r$ the Rational Horizon.

The *Sensible Horizon* on the Earth or Sea includes $a s o$, and it reaches but a very few Miles; for if a Man of six Feet high stood on a large Plain, or on the Surface of the Sea, at s , he could not see the Sea itself, or the Land, further than three Miles round.

Thus it appears that the *Sensible Horizon* on the Earth or Sea $a s o$, differs very much from the Extent of the *Real* or *Rational Horizon* $d s e$. But as to the Heavens where the fixt Stars are, the *Sensible Horizon* $b u g$ scarce differs at all from the *Rational Horizon* $b u r$: For the Eye placed in the Centre of the Earth c , or on the Surface of it s , would find no evident Difference in the *Horizon* of the fixt Stars, because they are at so immense a Distance, that in comparison thereof half the Diameter of the Earth, that is $s c$ or $g r$ the Distance between the Surface and the Centre is of no Consideration.

But let it be observed here, that the *Planets* are much nearer to the Earth than the *Fixt Stars* are: And therefore half the Diameter of the Earth, *i. e.* $s c$ or $g r$ is of some Consideration in the *Horizon* of the *Planets*.

It may not therefore be improper to note in this Place, that suppose a *Planet* to be at g , if the Eye of the Spectator were on the Surface of the Earth at s , he would behold it as level with the *Horizon*: But if his Eye were at the Centre of the Earth at c , he would behold it raised several Degrees or Minutes above the *Horizon*, even the Quantity of the Angle $g c r$, or (which is all one) $s g c$.

Now the Difference between the Place where a *Planet* appears to a Spectator, placed on the *Centre* of the Earth, and to a Spectator placed on the *Surface*, is called the *Parallax* of that *Planet* at that time; and therefore the Difference between those two Places g and r , or rather the Quantity of the Angle $g c r$, or $s g c$, is called its *Horizontal Parallax*. And this is of great use to adjust the real Distances, and consequently the real Magnitudes of the several *Planets*. But this Doctrine of *Parallaxes* belongs rather to the second or *special* Part of *Astronomy*.

II. The *Meridian* is a great Brazen Circle in which the Globe moves; it crosses the *Horizon* at right Angles, and divides the Globe into the *Eastern* and *Western* Hemispheres. It represents that Line or Circle in the Heaven which passes just over our Head, and cutting the *Horizon*
in

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in the *North* and *South* Points of it, comes just under our Feet on the opposite Side of the Globe.

This Circle shews when the Sun or Stars are just at *North* or *South*, and determines *Noon* or *Midnight*.

When the Sun is on the Meridian and above the Horizon to us in *Great Britain*, it is just in the *South*, and it is *Noon*. When it is on the Meridian and under the Horizon, it is just in the *North*, and it is *Midnight*.

Note, Whensoever we move on the Earth, whether *East*, *West*, *North*, or *South*, we change our Horizon both *Sensible* and *Rational*; for every Motion or Change of Place gives us a Hemisphere of Sky or Heaven over our Head a little different from what it was; and we can see less on one Side of the Globe of the Earth and more on the other Side.

Whensoever we move toward the *East* or *West* we change our Meridian: But we do not change our Meridian if we move directly to the *North* or *South*.

Upon this Account the *Horizon* and *Meridian* are called *Changeable Circles*; and the Globe is made moveable within these Circles to represent this Changeableness, whereby every Place on the Earth may be brought under its proper Meridian, and be surrounded with its proper Horizon.

III. The *Equator* or *Equinoctial Line* crosses the *Meridian* at right Angles, and divides the Globe into the *Northern* and *Southern* Hemispheres; and distinguishes the Sun's yearly Path into the *Summer* and *Winter* Half-Years. It represents in the Heavens that very Line or Circle which is the Path of the Sun in those two Days in *Spring* and *Autumn* when the Days and Nights are of equal Length.

Among all the Circles of the Globe this is sometimes eminently called *The Line*; and passing over it at Sea is called by Sailors *Crossing the Line*.

Note, The Sun, Moon and Stars, with all the Frame of the Heavens, are supposed to be whirled round from East to West every twenty-four Hours upon the Axis of the Equator, or (which is all one) in their several Paths parallel to the Equator. This is called their *Diurnal* or *Daily Motion*.

IV. The *Ecliptick Line* is the *Sun's Annual* or *Yearly Path*, cutting the Equinoctial in two opposite Points obliquely at the Angles of $23\frac{1}{2}$ Degrees. On it are figured the Marks of the 12 Signs through which the Sun passes, (*viz.*) *Aries* the Ram φ , *Taurus*, the Bull σ , *Gemini* the Twins II , *Cancer* the Crab ♋ , *Leo* the Lion ♌ , *Virgo* the Virgin ♍ , *Libra* the Balance ♎ , *Scorpio* the Scorpion ♏ , *Sagittarius* the Archer

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cher †, *Capricornus* the Sea-Goat ♄, *Aquarius* the Waterer ♁, *Pisces*, the Fishes ♋.

These Signs are certain *Constellations* or Numbers of Stars which are reduced by the Fancy of Men for Distinction Sake into the Form of twelve Animals, and for the Use of the *English* Reader may be described thus.

*The Ram, the Bull, the heavenly Twins,
And next the Crab, the Lion shines,*

The Virgin, and the Scales :

The Scorpion, Archer, and Sea-Goat,

The Man that holds the Water-pot,

And Fish with glittering Tails.

Among these Signs, *Aries, Taurus, Gemini, Cancer, Leo, Virgo*, are called *North-ern*. But *Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces*, are *Southern*. *Capricorn, Aquarius, Pisces, Aries, Taurus, Gemini* are *Ascending* Signs, because they stand in Succession *Northward*, or rising gradually higher in our *European Hemisphere*: But *Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius*, are *Descending* Signs, for their Succession tends lower toward our *Horizon*, or rather toward the *Southern Hemisphere*.

Each of these Signs has 30 Degrees of the *Ecliptick* allotted to it. The Sun or any Planet is said *to be in such a Sign* when he is between our Eye and that Sign, or when

he appears in that Part of the Heavens where those Stars are of which the Sign is composed.

If it be enquired, How we can know the Place of the Sun among the Stars, since all the Stars near it are lost in the Sun-Beams? It is answered, that we can see plainly what *Constellation* or what Stars are upon the Meridian at *Midnight*, and we know the Stars which are exactly opposite to them, and these must be upon the Meridian (very nearly) the same Day at *Noon*; and thereby we know that the Sun at Noon is in the Midst of them. So that when you have a Globe at hand on which the Stars are delineated, you find on what Degree of any Sign the Sun is in on a given Day, and see the Stars around it.

The Sun is reckoned to go through almost one Sign every *Month* or 30 Days, and thus to finish the *Year* in 365 Days 5 Hours and 49 Minutes, *i. e.* near 6 Hours: So that the Sun may be supposed to move slowly as a Snail through almost one Degree of the *Ecliptick* Line every Day *from the West to the East*, while it is whirled round together with the whole Frame of the Heavens *from East to West*, in a Line parallel to the *Equator* in the Time of 24 Hours.

Note, We vulgarly call the *Sun's diurnal* or *daily Path* a *Parallel* to the Equator, though

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though properly it is a *Spiral Line*, which the Sun is ever making all the Year long, gaining one Degree on the *Ecliptick* daily.

From what has been now said it appears plainly, that the *Equinoctial Line*, or *Equator* itself, is the diurnal Path of the Sun about the 20th or 21st of *March* and the 23d of *September*, which are the two opposite Points where the *Ecliptick*, or Yearly Path of the Sun, cuts the *Equator*.

And these two Days are called the *Equinoctial Days*, when the Sun rises and sets at six a Clock all the World over, (*i. e.* where it rises and sets at all that Day :) and the Day and Night are every where of equal Length; and indeed this is the true Reason why this Line is called the *Equator* or the *Equinoctial*.

It may not be improper in this Place to remark that those 5 Hours and 49 Minutes, which the *Sun's Annual Revolution* requires above 365 Days, will in 4 Years Time amount to near a whole Day: Therefore every fourth Year has 366 Days in it, and is called the *Leap-Year*. Note, The super-added Day in that Year is the 29th of *February* in *Great-Britain*.

It may be farther remarked also, that the odd 11 Minutes which in this Account are wanting yearly to make up a complete Day of 24 Hours, are accounted for in the *New Style* by leaving out a whole Day once in

133 or 134 Years *. And it is the Neglect of accounting for these odd Minutes in the *Old Style* above a thousand Years backwards, that has made the Difference between the *Old Style* and the *New* to be at present *Eleven Days*.

Note, The *Zodiack* is fancied as a broad Belt spreading about 7 or 8 Degrees on each Side of the *Ecliptick*, so wide as to contain most of those Stars that make up the 12 Constellations or Signs.

Note, The *inner Edge of the wooden Horizon* is divided into 360 Degrees, or 12 Times 30, allowing 30 Degrees to every Sign or Constellation, the Figures of which are usually drawn there.

The *next Circle* to these on the Horizon contains an *Almanack* of the *Old Style* which begins the Year eleven Days later; and the *next Circle* is an *Almanack* of the *New Style* which begins so much sooner; and these shew in what Sign the Sun is, and in what

* This was contrived to be done by Pope *Gregory* in the Year 1582, in this manner. Since three Times 133 Years make near 400 Years, he ordered the additional Day to be omitted at the End of three Centuries successively, and to be retained at the 400th Year or 4th Century. But in this Reformation of the Calendar he looked back no farther than the Council of *Nice*. This Order almost all Foreign Nations observed: *Great Britain* did not observe it till the Year 1752, when it was introduced and established by Act of Parliament.

Degree of that Sign he is every Day in the Year, whether you count by the Old Style or the New.

Note, One Side or Edge of the brazen Meridian is also divided into 360 Degrees or 4 Times 90; on the upper Semicircle whereof the Numbers usually begin to be counted from the Equator both ways toward the Poles: On the under Semicircle they begin to be counted from the Poles both ways toward the Equator for special Uses, as will afterward appear. And it should be remembered that it is this Edge of the Brass Circle, which is graduated or divided into Degrees, that is properly the *Meridian Line*.

Note, The *Equator* and the *Ecliptick* are called *Unchangeable Circles*, because where-soever we travel or change our Place on the Earth these Circles are still the same.

S E C T III.

Of the Lesser Circles.

THE *Lesser Circles* divide the Globe into two unequal Parts, and are these four, all parallel to the Equator, (*viz.*) the two *Tropics*, and the two *Polar Circles*.

I. The *Tropic of Cancer* just touches the *North* Part of the *Ecliptick*, and describes the Sun's Path for the longest Day in *Summer*: It is drawn at $23\frac{1}{2}$ Degrees Distance from the Equator toward the *North*. And it

is

it is called the *Tropic of Cancer*, because the Sun enters into that Sign the 21st of *June*, the longest Day in the Year.

II. The *Tropic of Capricorn* just touches the *South* Part of the Ecliptick, and describes the Sun's Path for the shortest Day in the *Winter*: It is drawn at $23\frac{1}{2}$ Degrees Distance from the Equator toward the *South*. And it is called the *Tropic of Capricorn*, because the Sun enters into that Sign the 21st of *December*, the shortest Day in the Year.

Note, What I speak of the *shortest and longest Days*, relates only to us who dwell on the *North* Side of the Globe: Those who dwell on the *South* Side have their longest Day when the Sun is in *Capricorn*, and their shortest in *Cancer*.

III. and IV. The *North* and *South Polar Circles* are drawn at $23\frac{1}{2}$ Degrees of Distance from each Pole, or which is all one, at 90 Degrees Distance from the contrary Tropic; because the Inhabitants under the *Polar Circles* just lose the Sun under the Horizon one whole Day at their *Midwinter*, or when it is in the utmost Part of the contrary Side of the Ecliptick; and they keep it one whole Day or 24 Hours above their Horizon at their *Midsommer*, or when it is in the nearest Part of their Side of the Ecliptick.

The *North Polar Circle* is called the *Arctic Circle*, and the *South* is the *Antarctic*.

Here

Here I might mention the *Five Zones* by which the Ancients divided the Earth, for they are a sort of broad Circles: But perhaps these may be as well referred to the following Part of this Book.

S E C T. IV.

Of the Points.

THE most remarkable *Points* in the Heavens are these twelve or fourteen.

I, and II, are the two *Poles* of the Earth or Heavens, (*viz.*) the *North* and the *South*, which are ever stedfast, and round which the Earth or the Heavens are supposed to turn daily as the Globe does upon these Iron Poles. These are also the *Poles of the Equator*, for they are at 90 Degrees Distance from it.

From one of these *Poles* to the other a supposed Line runs through the Centre of the Globe of Earth and Heavens, and is called the *Axis* or *Axle* of the World.

III, and IV, are the *Zenith*, or Point just over our Head; and the *Nadir* or the Point just under our Feet, which may be properly called the two *Poles of the Horizon*, for they are 90 Degrees distant from it every Way.

V, VI, VII, and VIII, are the four *Cardinal Points* of *East*, *West*, *North* and *South*: These four Points are in the Horizon which divide it into four equal Parts.

Note,

Note, For the Uses of Navigation, or Sailing, each of these Quarters of the Heavens, *East, West, North* and *South*, are subdivided into eight Points, which are called *Rhumbs*; so that there are 32 *Rhumbs* or Points in the whole, each containing $11\frac{1}{2}$ Degrees. These are described on the utmost Circle of the Wooden Horizon.

From the NORTH towards the *East* these Points are named *North and by East, North North-East, North-East and by North, NORTH-EAST; North-East and by East, East-North-East, East and by North, EAST, &c.* Then from the *East* toward the *South* it proceeds much in the same manner.

The whole Circle of 360 Degrees divided in this Manner is called the *Mariner's Compass*, by which they count from what Point of the Heavens the Wind blows, and toward what Point of the Earth they direct their Sailing, which they call *Steering their Course*. See Figure 11.

IX, and X, are the *two Solstitial Points*: These are the beginning of the Signs *Cancer* and *Capricorn* in the Ecliptick Line, where the Ecliptick just touches those two *Tropics*. These Points shew the Sun's Place the longest and shortest Days, (*viz.*) the 21st of *June* and the 21st of *December*.

Note, These two Days are called the *Summer and Winter Solstices*, because the Sun seems to stand still, *i. e.* to make the Length of
of

of Days neither increase nor decrease sensibly for 20 Days together.

XI, and XII, are *Aries* and *Libra*, or the *two Equino&ctial Points*, where the *Ecliptick* cuts the *Equator*: When the Sun enters into these two Signs, the Days and Nights are equal all over the World. It enters *Aries* in Spring the 21st of *March*, which is called the *Vernal Equinox*, and *Libra* in *Autumn* the 23^d of *September*, which is called the *Autumnal Equinox*.

These four Points, (*viz.*) two *Equino&ctial* and two *Solstitial*, divide the *Ecliptick* into the four *Quarters of the Year*.

Here let it be noted, that the twelve *Constellations* or *Signs* in the Heavens obtained their Names about two thousand Years ago or more; and at that Time the Stars that make up *Aries* or the *Ram*, were in the Place where the *Ecliptick* ascending cuts the *Equator*; but now the *Constellation Aries* is moved upward toward the Place of *Cancer* near thirty Degrees; and so every *Constellation* is moved forward in the *Ecliptick* from the West toward the East near thirty Degrees; so that the *Constellation* or Stars that make up the Sign *Pisces* are now in the Place where *Aries* was, or where the *Ecliptick* cuts the *Equator* in the Spring: And the *Constellation Virgo* is now where *Libra* was, or where the *Ecliptick* cuts the *Equator* in Autumn. So *Gemini* is in the Summer Solstice where *Cancer* was; and

and *Sagittarius* in the Winter Solstice where *Capricorn* was: And by this means the Sun is got into the Equinoxes in *Pisces* and *Virgo*, and is arrived at the Solstices in *Gemini* and *Sagittarius*, *i. e.* when it is among those Stars.

This Alteration is called the *Procession of the Equinox*, *i. e.* of the Equinoctial Signs or Stars, which seem to be gone forward, *i. e.* from West to East; but some call it the *Retrocession of the Equinox*, *i. e.* of the two Equinoctial Points, which seem to be gone backwards, *i. e.* from East to West. This comes to pass by some small Variation of the Situation of the Axis of the Earth with regard to the Axis of the Ecliptick, round which it moves by a Conical Motion *, and advances 50 Seconds or almost a Minute of a Degree every Year, which amounts to one whole Degree in 72 Years, and will fulfil a complete Revolution in 25920 Years. This Period some have called the *Platonical Year*, when some of the Antients fancied all things should return into the same State in which they now are.

Yet we call these *Equinoctical* and *Solstitial Points* in the Heaven, and all the *Parts of the Ecliptick* by the same antient Names still

* The Axis of the Earth is supposed to be fastened at its Middle in the Centre, while both Ends of it, or each of the Poles in this Motion describes a Circle round each Pole of the Ecliptick, which is the Base of the Cone. The Vertexes of each of these Cones meet in the Centre of the Earth; and by this Motion of the Earth, all the fixt Stars seem to be moved from their former Places in Circles parallel to the Ecliptick.

still in Astronomy, and mark them still with the same Characters (*viz.*) γ , δ , π , ϖ , Ω , &c. though the *Constellations* themselves seem to be removed so much forward.

XIII and XIV. Here it may not be improper in the last place to mention the *Poles of the Ecliptick* which are two other Points marked generally in the Celestial Globe.

If there were an *Axis* thrust through the Center of the Globe just at right Angles with the Plane of the Ecliptick, its Ends or Poles would be found in the two *Polar Circles*. So that a quarter of a Circle or 90 Degrees numbred directly or perpendicularly from the Ecliptick Line shew the *Poles of the Ecliptick*, and fix these two Points through which the two *Polar Circles* are drawn.

It is usual also in Books of this kind to mention two great Circles called *Colures*, drawn sometimes on the Celestial Globe through the Poles of the World, one of which cutting the Ecliptick in the two Solstitial Points is called the *Solstitial Colure*; the other cutting it in the Equinoctial Points is called the *Equinoctial Colure*, but they are not of much use for any common Purposes or Practices that relate to the Globe.

I think it may not be amiss before we proceed farther, to let the Learner see a Representation of all the foregoing *Circles and Points* on the Globe, just as they stand in

our *Horizon* at *London*, and so far as they can be represented on a flat Surface, and in strait Lines.

Let the *North Pole* be raised above the North Part of the *Horizon* $51\frac{1}{2}$ Degrees which are numbred on the brazen *Meridian*, then let the Globe be placed at such a Distance as to make the Convexity insensible, and appear as a flat or plain Surface, and let the Eye of the Spectator be just level and opposite to *c*, which represents the *East Point* of the *Horizon*; then the Globe and the Circles on it will appear nearly as represented in Figure III.

The large Circle divided by every 5 Degrees represents the *Meridian*, the rest of the larger and the lesser Circles are there named, together with the *North* and *South Poles*. *z* is the *Zenith* of *London*, *n* the *Nadir*, *h* the *South Point* of the *Horizon*, *o* the *North Point*, *c* the *East* and *West Points*, *s* the *Summer Solstice*, *w* the *Winter Solstice*, *a* the *Ecliptick's North Pole*, *e* the *Ecliptick's South Pole*. The two *Equinocetial Points* are represented by *c*, supposing one to be on this Side, the other on the opposite Side of the Globe.

If you would have the two *Colures* represented here in this Figure, you must suppose the *Meridian* to be the *Solstitial Colure*, and the *Axis of the World* to represent the *Equinoctial Colure*.

Note,

Note, This Representation or Projection of the Sphere in strait Lines is usually called the *Analemma*. See how to project it or to erect this Scheme, *Sect. XX. Probl. XV. Fig. XXIII.*

S E C T. V.

Of Longitude and Latitude on the Earthly Globe, and of different Climates.

THE various Parts of the *Earth* and Heavens bear various Relations both to one another, and to these several Points and Circles, which have been described.

First, The *Earth* shall be considered here.

Every Part of the *Earth* is supposed to have a *Meridian Line* passing over its *Zenith* from North to South through the Poles of the World. It is called the *Meridian Line of that Place*, because the Sun is on it at Noon.

That *Meridian Line* which passes through *Fero*, one of the *Canary-Islands*, has been usually agreed upon by Geographers as a *first Meridian*, from which the rest are counted by the Number of Degrees on the *Equator*. Others have placed their *first Meridian* in *Tenariff* another of the *Canary-Islands*, which is two Degrees more to the East, but all this is Matter of Choice and Custom, not of Necessity.

The *Longitude of a Place* is its *Distance from the first Meridian toward the East measured by the Degrees upon the Equator*. So the Longitude of *London* is about 20 Degrees, counting the first Meridian at *Fero*.

Note, In *English* Globes or Maps sometimes the Longitude is computed from the *Meridian of London*, in *French* Maps from *Paris*, &c. for it being purely arbitrary where to fix a *first Meridian*, Mariners and Map-Makers determine this according to their Inclination. When only the Word *Longitude* is mentioned in general, it always means the Distance eastward; but sometimes we mention the Longitude *westward* as well as *eastward*, *i. e.* from *London*, or *Paris*, &c. especially in Maps of particular Countries.

By the Meridian Circles on a Map or Globe the Eye is directed to the true Longitude of any Place according to the Degrees marked on the Equator: And upon this Account the Meridians are sometimes called *Lines of Longitude*.

The *Latitude of a Place* is its *Distance from the Equator toward the North or South Pole measured by the Degrees on the Meridian*. So the Latitude of *London* is 51 Degrees 32 Minutes, that is, about $51\frac{1}{2}$.

A Place is said to have *North Latitude* or *South Latitude* according as it lies toward the North Pole or South Pole in its Distance from

from the Equator. So *London* has $51\frac{1}{2}$ Degrees of North Latitude.

The *Elevation of the Pole* in any particular Place is the *Distance of the Pole above the Horizon of that Place measured by the Degrees on the Meridian*, and is exactly equal to the *Latitude of that Place*: For the Pole of the World or of the Equator is just so far distant from the *Horizon as the Zenith of the Place* (which is the Pole of the Horizon) is distant from the *Equator*. For which Reason the *Latitude of the Place* or the *Elevation of the Pole* are used promiscuously for the same thing.

The Truth of this Observation, (*viz.*) that the *Latitude of the Place and the Poles Elevation are equal*, may be proved several Ways; I will mention but these two. See Figure IV.

Let HCO be the *Horizon*, z the *Zenith*, or the Point over *London*, EZ the *Latitude of London* $51\frac{1}{2}$, PO the *Elevation of the North Pole above the Horizon*. Now that EZ is equal to PO is proved thus.

Demonstration I. The Arch zP added to EZ makes a Quadrant, (for the Pole is always at 90 Degrees Distance from the *Equator*.) And the Arch zP added to PO makes a Quadrant, (for the *Zenith* is always at 90 Degrees Distance from the *Horizon*.) Now if the Arch zP added either to EZ

or to PO completes a Quadrant, then EZ must be equal to PO .

Demonstration II. The Latitude EZ must be the same with the Poles Elevation PO : For * the Complement of the Latitude, or the Heighth of the Equator above the Horizon EH is equal to the Complement of the Poles Elevation PZ . I prove it thus. The Equator and the Pole standing at right Angles as $EC P$, they complete a Quadrant, or include 90 Degrees: Then if you take the Quadrant $EC P$ out of the Semicircle, there remains PO the elevated Pole, and EH the Complement of the Latitude, which complete another Quadrant.* Now if the Complement of the Latitude added to the Elevation of the Pole, will make a Quadrant, then the Complement of the Latitude is equal to the Complement of the Poles Elevation, and therefore the Latitude is equal to the Poles Elevation; for where the Complements of any two Arches are equal, the Arches themselves must also be equal.

* *Note,* The Complement of any Arch or Angle under 90 Degrees denotes such a Number of Degrees as is sufficient to make up 90; as the Complement of 50 Degrees is 40 Degrees, and the Complement of $51\frac{1}{2}$ is $38\frac{1}{2}$ Degrees. And so the Complement of the Sine or Tangent of any Arch is called the *Co-sine* or *Co-tangent*: So also in Astromony and Geography we use the Words *Co-latitude*, *Co-altitude*, *Co-declination*, &c. for the Complement of the Latitude, Altitude, or Declination, of which Words there will be more frequent Use among the *Problems*.

$$\begin{array}{l} \times \quad EH + PO = 2\text{rd. but} \qquad \qquad \qquad \text{As} \\ \quad \quad ZP + PO = 2\text{rd. therefore} \\ \quad \quad EH = ZP. \text{ \& therefore } EZ = PO \end{array}$$

As every Place is supposed to have its proper *Meridian* or *Line of Longitude*, so every Place has its proper *Line of Latitude* which is a Parallel to the Equator. By these Parallels the Eye is directed to the Degree of the *Latitude of the Place* marked on the Meridian, either on Globes or Maps.

By the *Longitude* and *Latitude* being given you may find where to fix any Place, or where to find it in any Globe or Map: For where those two supposed Lines (*viz.*) the *Line of Longitude* and *Parallel of Latitude* cross each other, is the Place enquired. So if you seek the Longitude from *Fero*, 20 Degrees, and the Latitude $51\frac{1}{2}$ Degrees, they will shew the Point where *London* stands.

Those *Parallels of Latitude* which are drawn at such Distances from each other near and nearer to the Poles, as determine the longest Days and longest Nights of the Inhabitants to be half an Hour longer or shorter, include so many distinct *Climates*, which are proportionally hotter or colder according to their Distance from the Equator. Though it must be owned that we generally use the Word *Climate* in a more indeterminate Sense, to signify a *Country lying nearer or farther from the Equator*, and consequently *hotter or colder*, without the precise Idea of its longest Day being just half an Hour shorter or longer than in the next Country to it.

The *Latitude* is never counted beyond 90 Degrees, because that is the Distance from the *Equator* to the *Pole*: The *Longitude* arises to any Number of Degrees under 360, because it is counted all round the *Globe*.

If you travel never so far directly towards *East* or *West*, your *Latitude* is still the same, but *Longitude* alters. If directly toward *North* or *South*, your *Longitude* is the same, but *Latitude* alters. If you go obliquely, then you change both your *Longitude and Latitude*.

The *Latitude of a Place*, or the *Elevation of the Pole* above the *Horizon* of that Place, regards only the *Distance Northward or Southward*, and is very easy to be determined by the Sun or Stars with certainty, as Sect. XX. Prob. VII, and IX. because, when they are upon the *Meridian* they keep a regular and known Distance from the *Horizon*, as well as observe their certain and regular Distances from the *Equator*, and from the two *Poles*, as shall be shewn hereafter: So that either by the Sun or Stars (when you travel Northward or Southward) it may be found precisely how much your *Latitude* alters.

But it is exceeding difficult to determine what is the *Longitude of a Place*, or the Distance of any two Places from each other *Eastward* or *Westward* by the Sun or Stars, because

because they are always moving round from *East* to *West*.

The Longitude of a Place has been therefore usually found out and determined by measuring the Distance travelled on the Earth or Sea, from the *West* toward the *East*, supposing you know the Longitude of the Place whence you set out.

S E C T. VI.

Of Right Ascension, Declination, and Hour Circles.

HA V I N G considered what respect the *Parts of the Earth* bear to these artificial Lines on the Globe, we come, *secondly*, to survey the several Relations that the *Parts of the Heavens*, the Sun or the Stars, bear to these several imaginary Points and artificial Lines or Circles.

The *Right Ascension* of the Sun or any Star is its *Distance from that Meridian which passes through the Point Aries, counted toward the East, and measured on the Equator*; it is the same Thing with *Longitude on the Earthly Globe*.

The *Hour* of the Sun or any Star is reckoned also by the Divisions of the Equator; but the *Hour* differs from the *Right Ascension* chiefly in this, (*viz.*) The *Right Ascension* is reckoned from that Meridian which

which passes through *Aries*; the *Hour* is reckoned on the Earthly Globe, from that Meridian which passes through the *Town or City required*; or it is reckoned on the heavenly Globe from that Meridian which passes through the *Sun's Place* in the Ecliptick, and which, when it is brought to the Brazen Meridian, represents *Noon* that Day.

There is also this Difference. The *Right Ascension* is often computed by single Degrees all round the Equator, and proceeds to 360: The *Hour* is counted by every 15 Degrees from the Meridian of Noon, or of Midnight, and proceeds in Number to 12, and then begins again: Though sometimes the *Right Ascension* is computed by *Hours* also instead of Degrees, but proceeds to 24. So the *Sun's Right Ascension* the 10th of *May* is 59 Degrees, or as sometimes it is called 3 Hours and 56 Minutes.

The same Lines which are called *Lines of Longitude* or Meridians on the Earth are called *Hour Circles* on the heavenly Globe, if they be drawn through the Poles of the World at every 15 Degrees on the Equator, for then they will divide the 360 Parts or Degrees into 24 Hours.

Note, As 15 Degrees make *one Hour*, so 15 Minutes of a Degree make *one Minute in Time*, and one whole Degree makes *four Minutes in Time*.

Note,

Note, *Degrees* are marked sometimes with (^d) or with a small Circle (°), *Minutes of Degrees* with a Dash (′), *Seconds of Minutes* with a double Dash (″), *Hours* with (^h), *Minutes of Hours* sometimes with (^m) and sometimes a Dash: *Seconds* with a double Dash.

By these *Meridians* or *Hour-Lines* crossing the Equator on the heavenly Globe, the Eye is directed to the true *Hour*, or the Degree of *Right Ascension* on the Equator, though the Sun or Star may be far from the Equator.

By these you may also compute on the Earthly Globe what Hour it is at any Place in the World, by having the true Hour given at any other Place, and by changing the Degrees of their *Difference of Longitude* into Hours.

But since several *Questions* or *Problems* that relate to the Hour, cannot be so commodiously resolved by these few *Meridians* or *Hour-Lines*, because every Place on the Earth hath its proper Meridian where the Sun is at 12 a Clock, therefore there is a Brass *Dial-plate* fixed at the North-pole in the Globe, whose 24 Hours do exactly answer the 24 Hour Circles which might be drawn on the Globe: Now the *Dial* being fixed, and the *Pointer* being moveable, this answers all the Purposes of having an infinite Number of Hour Circles drawn on the Globe, and fitted to every Spot on the Heavens

vens or the Earth. For the *Pointer* or *Index* may be set to 12 a Clock, when the Sun's true Place in the Heavens, or when any Place on the Earth is brought to the Brass-Meridian, and thus the Globe moving round with the *Index* naturally represents, and shews by the Dial-Plate the 24 Hours of any Day in the Year, or in any particular Town or City.

Note, The upper 12 a Clock is the Hour of *Noon*, the lower 12 is the *Midnight* Hour, when the Globe is fixed for any particular Latitude where there are Days and Nights.

The *Declination* of the Sun or Stars is their *Distance from the Equator toward the North or South Pole, measured on the Meridian*; and it is the same Thing with *Latitude on the Earthly Globe*.

Note, The Sun in the vernal or autumnal Equinoxes, and the Stars that are just on the Equator have no Declination.

Parallels of Declination are Lines parallel to the Equator, the same as the *Parallels of Latitude* on the Earthly Globe. In the Heavens they may be supposed to be drawn through each Degree of the Meridian, and thus shew the Declination of all the Stars; or they may be drawn through every Degree of the *Ecliptick*, and thus represent the *Sun's Path*, every Day in the Year. These parallel Lines also would lead the Eye to the Degree
of

of the Sun's or any particular Stars *Declination* marked on the Meridian.

The Declination is called *North* or *South Declination* according as the Sun or Star lies Northward or Southward from the Equator.

Observe here, that as any *Place, Town, or City* on Earth is found determined by the *Parallel of its Latitude* crossing its *Line of Longitude*; so the proper Place of the *Sun or Star* in the Heavens is found and determined by the Point where its *Parallel of Declination* crosses its *Meridian or Line of Right Ascension*; which indeed are but the self same things on both the Globes, though Astronomers have happened to give them different Names.

Note, The Sun's *utmost Declination Northward* in our Summer is but $23\frac{1}{2}$ Degrees; and it is just so much *Southward* in our Winter; for then he returns again: There the *Tropics* are placed which describe the *Path of the Sun* when farthest from the Equator, at Midsummer, or Midwinter: These two Tropics are his *Parallels of Declination* on the longest and shortest Day.

While the Sun gains 90 Degrees on the *Ecliptick*, (which is an oblique Circle) in a Quarter of a Year, it gains but $23\frac{1}{2}$ Degrees of direct Distance from the *Equator* measured on the *Meridian*; this appears evident on the Globe, and may be represented thus in Figure v.

Let

Let the Semicircle γ P \sphericalangle be the Meridian of the Northern Hemisphere, the Line γ C \sphericalangle be the Equator or the Sun's Path at *Aries* and *Libra*, the Arch γ ∞ \sphericalangle the Ecliptick, the Line T ∞ O the Summer Tropic, the Line a e the Sun's Path when it enters *Gemini* and *Leo*, the Line n s the Sun's Path when it enters *Taurus* and *Virgo*: Then it will appear that in moving from γ to δ the Sun gains 30 Degrees in the *Ecliptick*, in about a Month, and at the same Time 12 Degrees of *Declination*, viz. from γ to n . Then moving from δ to π in a Month more it gains 30 Degrees on the *Ecliptick*, and $8\frac{1}{4}$ Degrees of *Declination*, viz. from n to a . Then again from π to ∞ in a Month more it gains 30 Degrees on the *Ecliptick*, and but $3\frac{1}{4}$ Degrees of *Declination*, viz. from a to T. I might also shew the same Difference between its *Declination* and its Motion on the *Ecliptick* in its Descent from ∞ to ω , η , and \sphericalangle .

By drawing another Scheme of the same Kind below the Line γ C \sphericalangle , we might represent the Sun's Descent towards the Winter Solstice, and its Return again to the Spring; and thereby shew the same Differences between the *Sun's Declination* and its Motion on the *Ecliptick* in the Winter Half-Year as the present Scheme shews in the Summer Half-Year.

Hereby it is evident how it comes to pass, that the *Sun's Declination* alters near half a Degree

Degree every Day just about the *Equinoxes*; but it scarce alters so much in 10 or 12 Days on each Side of the *Solstices*: And this shews the Reason why the Length of Days and Nights changes so fast in *March* and *September*, and so exceeding slowly in *June* and *December*: For according to the Increase of the Sun's Declination in Summer, its Semidiurnal Arc * will be larger, and consequently it must be so much longer before it comes to its full *Height* at Noon, and it stays so much longer above the *Horizon* before it sets. *fig. 3.*

Thus while the *Sun's Declination* increases or decreases by slow Degrees, the *Length of the Days* must increase and decrease but very slowly; and when the *Sun's Declination* increases and decreases swiftly, so also must the *Length of the Days*: All which are very naturally and easily represented by the Globe.

S E C T. VII.

Of Longitude and Latitude on the Heavenly Globe, and of the Nodes and Eclipses of the Planets.

TH E *Longitude* and *Latitude* in Astronomy are quite different Things from

* The *Diurnal Arc* is that Part of the Circle or Parallel of Declination which is above the *Horizon*; and the Half of that Part is called the *Semidiurnal Arc*.

Longitude and *Latitude* in Geography, which is ready to create some Confusion to Learners.

The *Longitude* of the Sun or any Star is its *Distance from the Point Aries eastward, measured in the Ecliptick*. This is a short Way of describing it, and agrees perfectly to the Sun: But in Truth a Star's *Longitude is its Distance eastward from a great Arch drawn perpendicular to the Ecliptick through the Point Aries, and measured on the Ecliptick*.

We do not so usually talk of the Sun's *Longitude*, because we call it *his Place in the Ecliptick*, reckoning it no farther backward than from the Beginning of the Sign in which he is. So the 25th Day of *June*⁰⁵, we say the Sun is in the 14th Degree of *Cancer*, and not in the 104th Degree of *Longitude*.

The *Latitude* of a Star or Planet is its *Distance from the Ecliptick, measured by an Arch, drawn through that Star perpendicular to the Ecliptick*.

Longitude and *Latitude* on the Heavenly Globe bear exactly the same Relation to the *Ecliptick* as they do on the Earthly Globe to the *Equator*. As the *Equator* is the Line from which the *Latitude* is counted, and on which the *Longitude* is counted on the Earthly Globe, so the *Ecliptick* is the Line from which the *Latitude*, and on which the *Longitude* are counted on the Heavenly Globe.

And

And thus the *Lines of Latitude* in the Heavenly Globe are all supposed *Parallels* to the *Ecliptick*, and the *Lines of Longitude* cut the *Ecliptick* at right Angles, and all meet in the *Poles* of the *Ecliptick*, bearing the same Relation to it as on the Earthly Globe they do to the *Equator*.

The *Latitude* of a Star or Planet is called *Northern* or *Southern* as it lies on the *North* or *South* Side of the *Ecliptick*.

The Sun has no *Latitude*, because it is always in the *Ecliptick*. This Relation of *Latitude* therefore chiefly concerns the *Planets* and *Stars*.

The *Fixed Stars* as well as the *Planets* have their various *Longitudes* and *Latitudes*; and their particular *Place* in the Heavens may be assigned and determined thereby, as well as by their *Right Ascension* and *Declination* which I mentioned before; and *Astronomers* use this Method to fix exactly the *Place* of a *Star* *. But I think it is easier for a Learner to find a *Star's Place* by its *Declination*, and *Right Ascension*; and the common *Astrono-*

* *Astronomers* know that not only the 12 *Constellations* of the *Zodiac*, but also all the *Fixed Stars* seem to move from the West toward the East about 50" in a Year, or one Degree in 72 Years, in Circles parallel to the *Ecliptick*. Therefore their *Declination* is a little altered in 72 Years Time, that being measured from the *Equator*: But their *Latitude* never alters, that being measured from the *Ecliptick*: And upon this Account *Astronomers* use the *Latitude* rather than the *Declination* in their Measures, because it abides the same for ever.

mical Problems seem to be solved more naturally and easily by this Method.

It may be here mentioned, though it is before its proper Place, that the several Planets, *viz.* *Saturn, Jupiter, Mars, Venus, Mercury,* and the *Moon*, make their Revolutions at very different Distances from the Earth, from the Sun, and from one another; each having its distinct *Orbit* or Path nearer or farther from us. And as each of their *Orbits* is at vastly different Distances, so neither are they perfectly parallel to one another, nor to the *Ecliptick* or yearly Path of the Sun.

Thence it follows that these Planets have some more, some less *Latitude*, because their Orbits or Paths differ some few Degrees from the Sun's Path, and intersect or cross the *Ecliptick*, at two opposite Points in certain small Angles of two, three, four or five Degrees, which Points are called the *Nodes*.

The *Node* where any Planet crosses the *Ecliptick* ascending to the Northward is called the *Dragon's Head*, and marked thus Ω . Where the Planet crosses the *Ecliptick* descending to the Southward, it is called the *Dragon's Tail*, and marked thus γ .

It is very difficult to represent the *Latitude of the Planets* in their different Orbits either upon a Globe, or upon a flat or plain Surface; the best Way that I know is, to take two small Hoops of different Sizes, as in Figure

Figure XI. and thrust a strait Wire $c o$ through them both in the two opposite Parts of their Circumference: Then turn the innermost Hoop (which may represent the *Path* of the *Moon*) so far aside or obliquely as to make an Angle of $5\frac{1}{4}$ Degrees with the outermost Hoop, (which represents the *Sun's Path*.) Thus the two Points c and o or Ω and \mathcal{V} where the Wire joins the Hoops, are the two *Nodes* or the Points of Intersection.

This Difference of *Orbits* of the Planets and their *Intersections* or *Nodes*, may be represented also by two circular Pieces of Past-board as in Figure XII. When the less (whose Edge represents the *Moon's Orbit*,) is put half Way through a Slit $A B$, that is made in the Diameter of the larger (or the *Sun's Orbit*,) and then brought up near to a Parallel or level with the Larger within $5\frac{1}{4}$ Degrees. Thus the two *Nodes* will be represented by A and B .

If the *Moon's Path* and the *Sun's* were precisely the same, or parallel Circles in the same Plane, then at every *New Moon* the *Sun* would be eclipsed by the *Moon's* coming between the Earth and the *Sun*: And at every *Full Moon* the *Moon* would be eclipsed by the Earth's coming between the *Sun* and the *Moon*. But since the Planes of their *Orbits* or *Paths* are different, and make Angles with each other, there cannot be *Eclipses* but in or near the Place where the

38 *The first Principles of* Sect. 8.
Planes of their Orbits or Paths intersect or cross each other.

In or very near these *Nodes*, therefore, is the only Place where the Earth or Moon can hide the Sun or any Part of it from each other, and cause an *Eclipse* either *total* or *partial*: And for these Reasons the Orbit or Path of the Sun is called the *Ecliptick*.

The Eclipses of other Planets, or of any part of the Sun by their Interposition, are so very inconsiderable as deserve not our present Notice.

S E C T VIII.

Of Altitude, Azimuth, Amplitude, and various Risings and Settings of the Sun and Stars.

THE *Altitude* of the Sun or Star is its *Height* above the *Horizon*, measured by the *Degrees* on the *Quadrant of Altitudes*.

As the Height of the Sun at Noon is called its *Meridian Altitude*, or its *Culminating*, so the Height of the Sun in the East or West is sometimes called its *Vertical Altitude*.

The *Quadrant of Altitudes* is a thin Label of Brass, with a Nut and Skrew at the End of it, whereby it is fastened to the *Meridian* at the *Zenith* of any Place; now by bending this down to the *Horizon*, you find the
the

the Altitude of any Star or Point in the Heavens, because the Label is divided into 90 Degrees counting from the Horizon upward.

Circles parallel to the Horizon, supposed to be drawn round the Globe, through every Degree of the *Quadrant of Altitudes* less and less till they come to a Point in the Zenith, are called *Parallels of Altitude*, or sometimes in the old *Arabick* Name *Almicantars*. But these can never be actually drawn on the Globe, because the *Horizon* and *Zenith* are infinitely variable, according to the different Latitudes of Places. In the viith Figure, suppose *z* to be the Zenith, *N* the Nadir, *HR* the Horizon, and the straight Lines *a b*, *f g*, *k m*, will represent the *Parallels of Altitude*.

Note, The Sun being always highest on the *Meridian*, or at *Noon*, it descends in an Arch towards the Horizon in order to *set*, by the same Degrees by which it ascended from the Horizon after its *rising*. Stars and Planets *rise* and *set*, and come to the *Meridian* at *all different Hours* of the Day or Night according to the various Seasons of the Year, or according to the Signs in which the Planets are.

As the Word *Altitude* is used to signify the Height of the Sun or Star above the Horizon, so the *Depression* of the Sun or Star is its Distance from or below the Horizon.

The *Azimuth* of the Sun or Star is its *Distance from any of the four Cardinal Points, East, West, North and South, measured by the Degrees of the Horizon.*

Note, When we speak of the *Sun's Azimuth* in general, we usually mean his *Distance from the South*: But when his *Distance from the North, East, or West*, is intended, we say, his *Azimuth from the North, the East, or the West.*

Great Circles cutting every Degree of the *Horizon* at Right Angles, and meeting in the *Zenith* and *Nadir* are called *Azimuthal* or *Vertical Circles*. They direct the Eye to the Point of the Sun or Star's *Azimuth on the Horizon*, though the Sun or Star may be far above, or below the *Horizon*.

Note, *Vertical Circles* are the same with Regard to the *Zenith*, *Nadir*, and the *Horizon*, as *Meridians* or *Hour Circles* are with Regard to the two Poles of the World and the *Equator*. But these *Vertical Circles* can never be actually drawn on a *Globe*, because the *Zenith*, *Nadir*, and *Horizon* are ever variable. See them represented Figure vi. by the Lines $z H N$, $z a N$, $e N$, $z \&c.$ supposing $H R$ to be the *Horizon*.

Note, The *Quadrant of Altitudes* being moveable when one End of it is fastened at the *Zenith*, the graduated Edge of it may be laid over the Place of the Sun or Star, and

and brought down to the Horizon; then it represents any *Azimuth* or *Vertical Circle*, in which the Sun or Star is; and thus it shews the Degree of its *Azimuth* on the Horizon.

Note, The *Azimuth* of the Sun or Star from the *East* or *West* Points of the Horizon at its rising or setting, is called its *Amplitude*.

Note, The Sun is always in the South at Noon, or 12 a-Clock, and in the North at *Midnight*, viz. in *Europe* and all Places on this Side of the Equator. But it is not at the East or West at *six* a-Clock any other Day in the Year besides the two *Equinoctial* Days, as will easily appear in an *oblique Position of the Sphere*, (of which see the next Section) and especially in the last Section where the *Analemma* shall be more fully described.

Yet the Relation which the *Parallels of Altitude* bear to the *Vertical Circles*, and which these *Vertical* or *Azimuthal* Circles bear to the *Meridians* or *Hour Circles*, may be represented to the Eye in Figure VI. and VII.

In Figure VI. Suppose the outermost Circle be the Meridian, HR the Horizon, z the Zenith, N the Nadir; then db , fg , km , will be *Parallels of Altitude*: And $z a N$, $z e N$, $z o N$, $z c N$, &c. will be *Vertical Circles*, or Circles of *Azimuth* crossing the others at Right Angles.

Thus $z c N$ is the vertical Circle of East or West. And in this Scheme sa or fH

will be the Arch of the Altitude of the Star s , and $h a$ will be its *Azimuth* from the Meridian; and $c a$ will be its Azimuth from the East to West.

But if the Line $h r$ be supposed to represent the Equator, then z and n will be the two Poles of the World, and then $d b$, $f g$, &c. will be *Parallels of Latitude* on Earth, or *Parallels of Declination* in the Heavens. Then also the Arches $z h n$, $z a n$, $z e n$, $z o n$, $z c n$, will be *Meridians*, or *Lines of Longitude* on Earth, and *Hour Circles* in the Heavens.

In Figure VII. Let the utmost Circle be the Meridian, $h r$ the Horizon, z the Zenith, n the Nadir, $e q$ the Equator, $p l$ the Axis of the World, or rather the two Poles, North and South; then $z h n$, $z a n$, $z e n$, $z c n$ will be *Circles of Azimuth*: $p e l$, $p o l$, $p u l$, $p c l$, &c. will be *Hour Circles*.

And in this Position the Star s will have $t s$, *i. e.* equal to $E o$ for its *Hour* from Noon or the Meridian; but its Azimuth from Noon or the South or Meridian will be $h e$. Or if you reckon its Azimuth from the East or West Vertical (which is $z c n$) it will be found to be $c e$, while its Hour reckoned from $p o c l$ (which is the Six a-Clock Hour-Line) will be found to be $o s$ or $c o$.

Thus

Thus it will appear how the *Hour* of the Sun differs from its *Azimuth*, and that both of them are numbered, or counted from the Meridian P Z E H L N; yet they do not by any Means keep equal Pace with one another, one being numbered along the *Equator* E Q, the other numbered along the *Horizon* H R.

Thus you see most evidently that if you suppose the Sun s^* to be in the *Tropic of Cancer* represented by the Line τ^{ss} , the Difference between the *Hour* and *Azimuth* will appear to be very great; and that the Sun's *Azimuth* from Noon H e increases a great deal faster than his *Hour* τs doth in the Middle of Summer. And if another Line κ^{ss} were drawn to represent the *Tropic of Capricorn*, the Sun's *Azimuth* from Noon will appear to increase a great Deal slower than his Hours do in the Middle of Winter. at s^* *Azimuth* is 60° , & *Hour* near 90° .

I think it should not utterly be omitted here what is mentioned in almost all Writings of this Kind, (*viz.*) that a Star is said to *rise* or *set* *Cosmically* when it rises or sets at *Sun-rising*.

It is said to *rise* or *set* *Achronically* if it rise or set at *Sun-setting*.

A Star is said to *rise Heliacally* when it is just come to such a Distance from the Sun as that it is no longer hid by the Sun-Beams. And it is said to *set Heliacally* when the Sun approaches

approaches so near to it as that it begins to disappear from our Sight being hid by the Beams of the Sun.

The Fixed Stars and the three Superior Planets, *Mars, Jupiter, and Saturn*, rise *Heliacally* in the Morning, but the *Moon* in the Evening; for it is in the Evening the *New Moon* first appears, coming from her Conjunction with the Sun.

Note, This Sort of Rising and Setting of the Stars is also called *Poetical*; because the ancient *Poets* frequently mention it.

S E C T. IX.

Of the Inhabitants of the Earth according to the Positions of the Sphere, the Zones, &c.

IN order to make the *Doctrine of the Sphere* or *Globe* yet more plain and intelligible, let us consider the *Inhabitants* of the several Parts of the World, who may be distinguished three Ways, (1.) According to the various *Positions of the Globe*. (2.) According to the *five Zones*. (3.) In *Relation to one another*.

First, Let us consider them according to the *various Positions of the Globe* or *Sphere*, which are either *Direct, Parallel, or Oblique*.

These three Positions of the Sphere are represented in Figure VIII, IX, X, in each of which the utmost Circle is the *Meridian*

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H R is the *Horizon*, E Q the *Equator*, ∞ ∞ the *Ecliptick*, s N the *Axis* of the World, N the *North Pole*, s the *South*, z D the *Vertical Circle* of *East* and *West*, z the *Zenith*, D the *Nadir*, ∞ A the *Tropic of Cancer*, c ∞ the *Tropic of Capricorn*. The various Position of these Lines or Circles will appear by the following Descriptions.

I. A *Direct* or *Right Sphere* Figure VIII. is when the *Poles* of the World are in the *Horizon*, and the *Equator* passes through the *Zenith*: This is the Case of those who live directly under the *Line* or *Equator*.

Here the Inhabitants have no *Latitude*, no *Elevation* of the Pole: The *North* or *South Poles* being in the *Horizon* they may very nearly see them both.

All the Stars do once in twenty four Hours rise and set with them, and all at right Angles with the *Horizon*.

The Sun also, in whatsoever Parallel of *Declination* he is, rises and sets at right Angles with the *Horizon*; their Days and Nights therefore are always equal, because the *Horizon* exactly cuts the Sun's Diurnal Circles in Halves.

They have two Summers every Year, (*viz.*) when the Sun is in or near the two *Equinoctial Points*, for then he is just over their Heads at Noon, and darts his strongest Beams. And they have two Winters. (*viz.*) when
the

the Sun is in or near the *Tropics of Cancer* and *Capricorn* ; for then the Sun is farthest distant from them, though even then it is nearer than it is to us in *England* at Midsummer.

II. A *Parallel Sphere*, Figure IX. is where the *Poles* of the World are in the *Zenith* and *Nadir* : And the *Equator* is in the *Horizon*.

Now if there were any Inhabitants thus directly under the *North* and *South* Poles, they would have only one Day of six Months long, and one Night of six Months, in a whole Year, according as the Sun is on this or the other Side of the *Equator* ; for the Sun moving slowly in the *Ecliptick* on the *North* Side of the *Equator* half a Year, would be all that Time above the *Horizon* to the Inhabitants at the *North Pole*, though it went round them daily : And the Sun moving in the *Ecliptick* on the *South* Side of the *Equator* half a Year, would be below their *Horizon* all that Time. The same might be said concerning the Inhabitants of the *South Pole*.

The two Equinoctial Days, or when the Sun is in the Points *Aries*, or *Libra*, the Day and Night are equal all the World over ; and this is true in a Sense to those who live under the *Poles* ; for the Centre of the Sun is in their *Horizon*. Thus half the Sun is above their *Horizon*, and half below it for 24 Hours together.

Thus,

Thus, though the Polar Inhabitants begin to lose the Sun at the *Autumnal Equinox*, they are not in utter Darkness all the Time of the Sun's Absence: For the *Twilight* lasts till the Sun is 18 Degrees below their *Horizon*, and that is till he has 18 Degrees of *Declination*. The Inhabitants of the North Pole are therefore without the Twilight only from the 2d of *November* till the 18th of *January*.

Let it be noted also that the *Refraction* of the Rays through the thick Air or *Atmosphere* makes the *Sun* appear above their *Horizon* several Days sooner, and disappear several Days later, than otherwise it would do. It may be added in Favour of their Habitations too, that the Moon when she is brightest, (*viz.*) from the first Quarter to the last, does not set during their Middle of Winter: For in that Part of her Month she is most opposite to the Sun, and is therefore in that Part of the Heavens which is most distant from the Sun while he never rises.

The Parallels of the Sun's *Declination* in this Position of the Sphere are all parallel to the *Horizon*; and are the same with the Parallels of his *Altitude*, and therefore his *highest Altitude* with them can never exceed $23\frac{1}{2}$ Degrees.

The Stars that they could see would be always the same, making perpetual Revolutions

lutions round them, and never set nor rise, nor be higher or lower. And the Planets during half their Periods will be above their *Horizon*, as *Saturn* 15 Years, *Jupiter* 6, *Mars* 1, &c.

III. An *Oblique Sphere*, Figure x. is where the *Latitude* or *Elevation* of the Pole is at any Number of Degrees less than 90. Therefore all the Inhabitants of the Earth (except under the *Equator* and the *Poles*) have an *Oblique Sphere*.

Here the *Equator* and all the *Parallels* of *Declination* cut the *Horizon* obliquely, therefore the Sun and Stars always rise and set at oblique Angles with the *Horizon*.

As one Pole of the World is always in their View, and the other is never seen, so there are some Stars which never set, and others which never rise in their *Horizon*.

Their Days and Nights are of very different Lengths according to the different *Declination* of the Sun in the several Seasons of the Year.

In this *Oblique Position* of the Sphere, Astronomers sometimes talk of the *Oblique Ascension* of the Sun or Stars; and in order to obtain a clearer Idea of it, let us again consider the *Right Ascension*, which is the Sun or Star's *Distance from that Meridian, which passes through the Point Aries, measured on the Equator*.

Or

Or it may be expressed thus: The *Right Ascension* is that Degree of the *Equator* which comes to the *Meridian* together with the Sun or Star, considered in its Distance from the Point *Aries*.

But the *Oblique Ascension* is that Degree of the *Equator* which in an oblique Sphere rises together with the Sun or Star considered in its Distance from the Point *Aries*.

Note, That in a *Right* or *Direct Sphere* all the heavenly Bodies can only have *Right Ascension*, and no *Oblique Ascension*; because the same Point or Degree of the *Equator* that rises with them comes also to the *Meridian* with them: But in an *Oblique Sphere* there is sometimes a great deal of Difference between the Point that rises with them and the Point that comes with them to the *Meridian*.

Now the Difference between the *Right Ascension* of the Sun or Star, and its *Oblique Ascension* is called the *Ascensional Difference*.

Note, Concerning the Stars in the *Equator*, that their *Right* and *Oblique Ascension* are equal: Therefore the Sun in the *Equinoxes* rising at Six and setting at Six has no *Ascensional Difference*: But as he goes onward from the *Equator* toward the *Winter Solstice*, he rises after Six; and as he goes toward the *Summer* he rises before Six; and the

50 *The first Principles of* Sect. 9.
the *Distance of his rising or setting from Six a-Clock* is called the *Ascensional Difference*.

And perhaps it is sufficient as well as much easier for a Learner to remember that the Time of the Sun or Star's rising or setting before or after Six a-Clock is called by Astronomers the *Ascensional Difference* without taking any Notice at all of the *Oblique Ascension*, which is neither so easy to be apprehended or remembered.

The *Second* Distinction of the Inhabitants of the Earth may be made according to the *five Zones*, which they inhabit; this was an ancient Division of the Globe.

The *Zones* are broad Circles, five of which cover or fill up the Globe. There are two *Temperate*, two *Frigid* or cold, and one *Torrid* or hot.

The *Torrid* or *burning Zone* is all the Space that lies between the two *Tropics*; it was once counted uninhabitable, because of excessive Heat, being so near the Sun; but later Discoveries have found many and great Nations inhabiting those Parts which contain the greatest Part of *Africa* and of *South America*.

The two *Frigid* or cold *Zones* are those Spaces which are included within the two *Polar Circles*, with the Pole in the Centre, at great Distance from the Sun, scarcely habitable by Reason of the Cold. There lies
Greenland

Greenland and *Lapland* toward the *North Pole*. The *South Pole* and *Polar Regions* are undiscovered.

The two *temperate Zones* are those Spaces that lie on either Side of the Globe between the *Tropics* and the *Polar Circles*, where the Sun gives a moderate Heat, and makes those Parts most convenient for the Habitation of Men. All *Europe*, and the greatest Part of *Asia*, and *North America*, lie in the North temperate Zone.

Note, That the *Torrid Zone* lying between the two *Tropics*, every Place in it has the Sun in the *Zenith*, or exactly over their Heads once or twice in every Year.

Those who live under the *Tropic of Cancer* have their Winter when the Sun is in *Capricorn*. Those who live under the *Tropic of Capricorn* have their Winter when the Sun is in *Cancer*. Those who live under the Equator have (as I said before) two Winters in the Year; though indeed there is scarce any Season can be called *Winter* within the Limits of the *Torrid Zone*.

Those who live just within the Borders of the two *Frigid Zones*, lose the Sun for twenty four Hours together at Midwinter when the Sun is in the *contrary Tropic*: And those Places that are nearer and nearer to the Poles lose the Sun for two, three, four, five, six Days, for whole Weeks or Months together

at their Winter, or when the Sun is near the *contrary Tropic*.

What is said concerning the Loss of Light a whole Day or Week or Month at *Winter* in either of the *frozen Zones*, must be also said concerning the gaining a whole Day or Week or Month of Daylight at their *Summer*; and those Parts of the Year are all Darkness in the *Northern frigid Zone*, which are all Daylight in the *Southern*.

Thus as you go farther *Northward* or *Southward* the Continuance of the Sun above the *Horizon* grows longer in their *Summer*; and the utter Absence of it below the *Horizon* grows longer in their *Winter*; till you come to those Inhabitants (if any such there be) who live *under the Pole*, for these have half the Year Night, and half the Year Day, as I said before concerning the *Parallel Sphere*.

In the two *Temperate Zones* (as also in the *Torrid Zone*) there are never quite 24 Hours either of Day or of Night together; but when the Sun is in the *Equator*, all Days and Nights are equal: Afterwards their Days gradually increase till their longest Day in Summer, and gradually decrease till their shortest Day in Winter: Though those who live on the Borders of the *Polar Circles* or the *Frigid Zones* have their 22d of *June* or longest Day in Summer near 24 Hours; and their

their 22d of *December* or shortest Day in Winter, but just allows the Sun to peep a Moment above the *Horizon*, so that their Night is very near 24 Hours long.

Thirdly, The Inhabitants of the Earth may also be divided into three Sorts in respect of their *Geographical Relation* to one another, and they are called the *Periæci*, the *Antæci* and *Antipodes*.

I. The *Periæci* live under the *same Parallel of Latitude* on the same Side of the Globe, but differ in *Longitude* from East to West 180 Degrees, or just half the Globe. These have their *Summer* and *Winter* at the *same Times* with one another, but *Day* and *Night* just at contrary Times. *Note*, Those who live under the Poles have no *Periæci*.

II. The *Antæci* live under the *same Meridian* or *Line of Longitude*, and have the *same Degree of Latitude* too, but on *contrary Sides* of the *Equator*, one to the North, the other to the South. These have *Day* and *Night* exactly at the *same Time*, but *Summer* and *Winter* *contrary* to each other. *Note*, Those who live under the *Equator* have no *Antæci*.

III. The *Antipodes* have (if I may so express it) the Properties of the *Antæci* and *Periæci* joined together, for they live on *contrary Sides* of the *Equator*, though in the *same Latitude* or *Distance* from it; and their

Meridian or *Line of Longitude* is 180 Degrees or half the Globe different. A Line passing through the Centre of the Earth from the Feet of the one would reach the Feet of the other. They dwell at the full Distance of half the Globe, and have *Day* and *Night*, *Summer* and *Winter* at contrary Times.

In each of the three last Figures, (*viz.*) VIII, IX and X. you may see these Distinctions of the Earth's Inhabitants exactly represented. ∞ A are *Periæci*, so are c ∞ . But ∞ c or A ∞ are *Antæci*. ∞ ∞ , or A C, or N S or H R, or E Q, are all Antipodes to each other.

The *Amphiscii*, *Heteroscii* and *Ascii*, which are only *Greek* Names invented to tell how the Sun casts the Shadows of the several Inhabitants of the World, are not worth our present Notice.

S E C T. X.

The Natural Description of the Earth and Waters on the Terrestrial Globe.

THE *Earth* may be divided into its *Natural* or its *Political* Parts. The one Distinction is made by the God of Nature who created it : The other by Men who inhabit it.

The Globe or Surface of *Earth* on which we dwell is made up *naturally* of two Parts,
Land

Land and Water; and therefore it is called the *Terraqueous Globe*. Each of these Elements have their various Parts and Subdivisions, which are as variously described on *artificial Globes* or *Maps*.

The Land is called either an *Island*, a *Continent*, a *Peninsula*, an *Isthmus*, a *Promontory*, or a *Coast*. See the plain Description of all these Figure XIII.

An *Island* is a *Country* or *Portion* of Land, compassed about with *Sea* or ~~other~~ *Water*, as *Great Britain*, *Ireland* in the *British Seas*; *Sicily*, *Crete*, *Cyprus*, &c. in the *Mediterranean Sea*; the *Isles* of *Wight*, of *Anglesey*, of *Man* near *England*: There are also *Islands* in *Rivers*.

A *Continent*, properly so called, is a large *Quantity* of Land in which many great *Countries* are joined together, and not separated from each other by the *Sea*, such are *Europe*, *Asia*, *Africa*. This is sometimes called the *Main-Land*.

A *Peninsula* is a *Part* of Land almost incompassed with *Water*, or which is almost an *Island*: Such is the *Morea* which joins to *Greece*, such is *Denmark* as joining to *Germany*, and *Taurica Chersonesus* joining to *Little Tartary* near *Muscovy*; and indeed *Africa* is but a large *Peninsula* joining to *Asia*.

An *Isthmus* is a narrow *Neck* of Land between two *Seas*, joining a *Peninsula* to

the Continent, as the Isthmus of *Darien* or *Panama* which joins *North* and *South America*: The Isthmus of *Corinth* which joins the *Mærea* to *Greece*: The Isthmus of *Sues* which joins *Africa* to *Asia*.

A *Promontory* is a Hill or Point of Land stretching out into the Sea: It is often called a *Cape*, such is the *Cape of Good Hope* in the South of *Africa*; the *Land's End* and the *Lizard Point* are two Capes at the West of *England*; *Cape Finisterre* on the West of *Spain*, &c.

A *Coast* or *Shore* is all that Land that borders upon the Sea, whether it be in Islands or Continents: Whence it comes to pass that sailing near the Shore is called *Coasting*.

That Part of the Land which is far distant from the Sea is called the *Inland Country*: These are the Divisions of the Land.

The *Water* is divided into *Rivers* or *Seas*.

A *River* is a Stream of Water which has usually its Beginning from a small *Spring* or *Fountain* whence it flows continually without Intermiſſion, and empties itself into some *Sea*. But the Word *Sea* implies a larger Quantity of Water, and is distinguished into *Lakes*, *Gulfs*, *Bays*, *Creeks*, *Straits*, or the *Ocean*.

The *Ocean* or the *Main-Sea* is a vast spreading Collection of Water, which is not divided or separated by Lands running between:

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tween: Such is the *Atlantick* or *Western Ocean* between *Europe* and *America*: The *Eastern* or the *Indian Ocean* in the *East-Indies*: The *Pacifick Ocean* or *South Sea*, on the West Side of *America*, &c.

Note, The various Parts of this *Ocean* or *Main-Sea* that border upon the Land are called by the Names of the Lands which lie next to it: So the *British Sea*, the *Irish Sea*, the *Ethiopian Sea*, the *French* and *Spanish Seas*.

A *Lake* is a large Place of Water inclosed all round with Land, and having not any visible and open Communication with the Sea: Such are the *Caspian Sea* or *Lake* in *Asia*; the *Lake Zaire* in *Africa*, (as some Maps describe) and many others there are in *Europe* and *America*, and especially in *Sweden* and *Finland*, and on the West of *New England*: Such also is the *Lake* or *Sea* of *Tiberias* in the Land of *Canaan*, and the *Dead Sea* there, which we read of in Scripture.

A *Gulf* is a Part of the Sea that is almost incompassed with Land, or that runs up a great Way into the Land,

If this be very large it is rather called an *Inland Sea*: Such is the *Baltick Sea* in *Sweden*, and the *Euxine Sea* between *Europe* and *Asia*; the *Ægean Sea* between *Greece* and *Lesser Asia*; and the *Mediterranean Sea* be-

tween *Europe* and *Africa*, which is often in the old Testament called the *Great Sea*.

If it be a less Part of the Sea thus almost inclosed between Land, then it is more usually called a *Gulf* or *Bay*: Such is the *Gulf of Venice* between *Italy* and *Dalmatia*: The *Arabian Gulf* or the *Red Sea* between *Asia* and *Africa*: The *Persian Gulf* between *Arabia* and *Persia*: The Gulf or Bay of *Finland* in the *Baltick Sea*; and the Bay of *Biscay* between *France* and *Spain*.

If it be but a very small Part, or as it were an *Arm of the Sea* that runs but a few Miles between the Land, it is called a *Creek*, a *Haven*, a *Station*, or a *Road* for Ships; as *Milford Haven* in *Wales*; *Southampton Haven* in *Hampshire*, and many more in every Maritime Country.

A *Strait* is a narrow Part of the Ocean lying between two Shores, whereby two Seas are joined together, as the *Sound* which is the Passage into the *Baltick Sea* between *Denmark* and *Sweden*: The *Hellepont* and *Bosphorus*, which are two Passages into the *Euxine Sea* between *Romania* and the *Lesser Asia*: The *Straits of Dover* between the *British Channel* and the *German Sea*; and the *Straits of Gibraltar* between the *Atlantick* and the *Mediterranean*, though the whole *Mediterranean Sea* is sometimes called the *Straits*.

If

If we compare the various Parts of the *Land* with those of the *Water*, there is a pretty Analogy or Resemblance of one to the other. The Description of a *Continent* resembles that of the *Ocean*, the one is a vast Tract of Land as the other is of Water. An *Island* incompass'd with Water resembles a *Lake* incompass'd with Land. A *Peninsula* of Land is like a *Gulf* or *Inland Sea*. A *Promontory* or *Cape* at Land is like a *Bay* or *Creek* at Sea; and an *Isthmus*, whereby two Lands are joined, has the same Relation to other Parts of the *Earth* as a *Strait* has to the *Sea* or *Ocean*.

Let us now take Notice by what *Figures* the various Parts of *Land* or *Water* are described in a *Globe* or *Map*, and in what Manner they are represented. See Figure XIII.

Sea is generally left as an empty Space, except where there are *Rocks*, *Sands*, or *Shelves*, *Currents of Water* or *Wind*, described.

Rocks are sometimes made like little pointed Things sticking up sharp in the Sea. *Sands* or *Shelves* are denoted by a great Heap of little Points placed in the Shape of those Sands, as they have been found to lie in the Ocean by sounding or fathoming the Depths. *Currents of Water* are described by several long crooked parallel Strokes imitating a Current. The *Course of Winds* is represented by the Heads of Arrows pointing

ing to that Coast toward which the Wind blows.

The *Land* is divided or distinguished from the Sea by a thick Shadow made of short small Strokes to represent the *Shores* or *Coasts*, whether of Islands or Continents, &c. and it is usually filled with Names of Kingdoms, Provinces, Cities, Towns, Mountains, Forests, Rivers, &c. which are described in this Manner, (*viz.*)

Kingdoms or *Provinces* are divided from one another by a Row of single Points, and they are often painted or stained with distinct Colours. *Cities* or *great Towns* are made like little Houses with a small Circle in the Middle of them. *Lesser Towns* or *Villages* are marked only by such a small Circle. *Mountains* are imitated in the Form of little rising Hillocks. *Forests* are represented by a Collection of little *Trees*. *Small Rivers* are described by a single, crooked, waving Line; and *larger Rivers* by such a weaving or curling double Line made strong and black. The Mouths of large Rivers, where they empty themselves into the Sea, are represented sometimes as Currents of Water, by several parallel crooked Lines.

I should add this also, That in Terrestrial Globes you find the *Mariner's Compass* figured in several Parts, and the Lines of it are drawn out to a great Length toward all
Parts

Parts of the World on Purpose to shew how any Part of the Earth or Sea stands situated with regard to any other Part; and this is called its *Bearing*, by which you may know what Places bear East, West, North or South from the Place where you are, or at what other immediate Points of the Compass they lie. The *North* is generally described by a *Flower de Luce*, and the *East* frequently by a *Cross*.

Globes are generally so formed as to have the *North Pole* just standing before the Face: Then the *East* is at the right Hand, and the *West* at the Left: And thus usually the Names and Words are written to be read from the *West* to the *East*. This is also observed in large Maps, and it should be the same in small ones; for when a *Map of a Country* is drawn in any other Form, so that the *North* does not lie just before us, and the *East* to our right Hand, it gives great Confusion to the Learner, and sometimes confounds the Eye and Imagination even of Persons skilled in Geography.

S E C T. XI.

Of Maps and Sea Charts.

THough nothing can represent the Heavens or the Earth in their natural Appearances so exactly as a Globe, yet the

two Hemispheres either of the Heavens or of the Earth may be represented upon a flat or plain Surface, which are generally called *Projections of the Sphere*.

If you suppose a Globe to be cut in Halves just at the Equator, and each Hemisphere represented on a Plane, it is called a *Projection of the Globe upon the Plane of the Equator*. Then the *Equinoctial Line* will be the Circumference, and the two *Poles* of the World will be the Centres of those two Projections, and all the *Meridian Lines* will be so many strait Lines or Semidiameters meeting in the Centre. This is the most common Method of representing the *Celestial Globe and the Stars*.

If the Globe be cut asunder at the Horizon of any particular Place and thus represented on a Plane, it is called the *Projection on the Plane of the Horizon*. Then the *Zenith* and *Nadir* will be the Centres of those Projections, and the *Horizon* is the Circumference. The two *Poles* will be placed at such a Distance from the Circumference as the *Pole* of the World is elevated above the *Horizon* of that Place; and the *Meridian* will be represented as curve Lines meeting in the *Pole Point*, excepting only that *Meridian* that passes through the *Zenith* which is always a right Line. This is a more uncommon Projection of the Sphere,

Sphere, though it is much used in *Dialling*.

The most usual Way of describing the Earthly Globe on a Plane, or a Map, is to suppose the Globe cut in Halves about the first *Meridian* at the Island *Fero* or *Teneriff*. This is a *Projection on the Plane of the Meridian*: Then the *first Meridian* will determine the Circumference: The *Pole Points* will stand in the upper and lower Parts of that Circle, and the other *Meridians* will be curve Lines meeting in the *Pole Points*, except that which passes through the Centre of the Projection, which is a right Line.

Here the *Equator* will be a strait Line or Diameter crossing all the *Meridians* at right Angles, and at equal Distances from the two *Poles*.

Here the two *Tropics* of *Cancer* and *Capricorn* are drawn at their proper Distances of $23\frac{1}{2}$ Degrees from the *Equator*; and the two *Polar Circles* at the same Distance from the *Poles*.

In this Projection the *Ecliptick* is sometimes a strait Line cutting the Middle of the *Equator* obliquely in each Hemisphere, and ending where the two *Tropics* meet the *Meridian*: But sometimes the *Ecliptick* is drawn as a curve Line or an Arch beginning where the *Equator* meets the *Meridian*, and carried upward just to touch the *Tropic* of
Can-

Cancer in one Hemisphere, and downward to touch the *Tropic of Capricorn* in the other.

It is in this Form the Maps of the World are generally drawn in two large Hemispheres.

Note here, That it is impossible to represent a spherical Body exactly in its due Proportion upon a Plane; and therefore the Artificial *Meridians* or *Lines of Longitude*, *Parallels of Latitude*, &c. are placed at such different Distances by certain Rules of Art, and the Degrees marked on them are often unequal; but so drawn as may most commodiously represent the Situation of the several Parts of the Earth with Regard to one another.

The *Meridian* or Circumference of these Circles is divided into four Quarters, and each marked with 90 Degrees beginning from the *Equator* and proceeding toward the *Poles*. These Figures or Numbers shew the *Latitude* of every Place in the Earth, or its Distance from the *Equator*; and at every 10 Degrees there is a *Parallel of Latitude* drawn on Purpose to guide and direct the Eye in seeking the Latitude of any Place.

The *Equator* of each Hemisphere is divided into 180 Parts, which makes 360 in the whole: And the several *Meridians* or *Lines of Longitude*, cutting the *Equator* at every 10 Degrees, guide and direct the Eye to find the Longitude of any Place required.

As

As the *Equator*, the several *Lines of Longitude*, of *Latitude*, &c. cannot be represented on a Plane exactly as they are on a Globe; so neither can the several Parts of the World, *Kingdoms*, *Provinces*, *Islands*, and *Seas* be represented in a Map exactly in the same Proportion as they stand on a Globe. But as the Divisions of Degrees in a Map are bigger or less, so the Parts of the Land and Sea are represented there bigger or less in a most exact Proportion to those *Lines of Longitude* and *Latitude* among which they are placed.

Therefore though the Length or Breadth, or Distance of Places on a *Map of the World* cannot be measured by a Pair of Compasses as they may be on a Globe, yet you may count the Number of Degrees to which such Lengths, Breadths or Distances correspond, and thereby you may compute their real Dimensions; though not always so well as on a Globe; of which hereafter.

Thus much shall suffice concerning *Maps* that represent the *Whole World*, or the *Globe of Earth and Water*. Let us next consider those *Maps* which represent particular Parts of the World, *Kingdoms* or *Provinces*, these are generally drawn in a large Square, and are to be considered as *Parts of a Projection on the Plane of the Meridian*.

From the Top to or toward the Bottom of
the

the Square are drawn *Meridians* or *Lines of Longitude*; and the Number of Degrees of Longitude are divided and marked on the upper and undermost Line of the Square.

From Side to Side are drawn *Parallels of Latitude*, and the Degrees of Latitude are marked on the two Side Lines.

Thus you may easily find on a *Map* what is the *Longitude* or *Latitude* of any Place given, or you may find the Point where any Town stands or should stand, when the true *Longitude* and *Latitude* of it are given.

Note, In such Maps of particular Countries the *Longitude* is not always reckoned from the *first Meridian*, as *Fero* or *Teneriff*, but oftentimes it is reckoned from the *Chief City* of that Kingdom, which is described in the Map, as I have intimated before.

Observe farther, That though in Globes and Maps of the whole World the *Longitude* is reckoned from the *West* toward the *East*, yet in smaller Maps it is often reckoned both Ways, as *Bristol* is $2\frac{1}{2}$ Degrees of Western Longitude from *London*, *Amsterdam* has near 5 Degrees of Eastern Longitude.

Note also, That when a small Country is represented in a large Map, the *Lines of Longitude* and *Parallels of Latitude* are drawn not merely at every 10 Degrees, as in the Globe, but sometimes at every 5 Degrees, and sometimes at every single Degree.

Let

Let it be observed also in *large Maps*, that describe any particular Country or Province, as a single or double crooked waving Line signifies a *River* when it is made strong and black; so a *Publick Road* is described by a single or a double Line drawn from Town to Town, not quite so curled nor so strong as a *River* is, but strait or winding as the Road itself happens. And where the *Roads* lie through a broad Plain or great Common without Houses or Hedges, they are sometimes described by a *double Row of Points*.

As *Villages* and *smaller Towns* are described by a little Circle or small round o in Maps of larger Countries, where the *Cities* are represented by the Figure of a House or two with a Spire or Steeple; so in Maps of smaller Countries or Provinces the *little Towns* and *Villages* are described by the Figure of a House or two, and *great Towns* or *Cities* are marked like several Buildings put together in Prospect, or else the naked Plan of those very Towns or Cities is drawn there and distinguished according to their Streets.

I proceed now to consider *Sea-Charts*.

As *Maps* are drawn to describe particular Countries by Land, so a Description of Coasts or Shores, and of the Seas for the Use of Mariners is called a *Sea-Chart*, and it differs from a *Map* chiefly in these Particulars.

I. A *Map of the Land* is full of Names and Marks describing all the Towns, Countries, Rivers, Mountains, &c. but in a *Sea-Chart* there are seldom any Parts of the Land marked or described, besides the Coasts or Shores and the Sea Ports, the Towns or Cities that border upon the Sea, and the Mouths of Rivers.

II. In a *Map* the Sea is left as an empty Space, except where the Lines of Longitude and Latitude, &c. are placed: But in *Sea-Charts* all the Shoals or Sands, and shallow Waters, are marked exactly according to their Shape, as they have been found to lie in the Sea by sounding the Depth in every Part of them.

III. In *Sea-Charts*, the Meridians are often drawn in strait and parallel Lines, and the Lines of Latitude are also strait Parallels crossing the Meridians at right Angles. This is called *Mercator's Projection*; and the Points of the Compass are frequently repeated and extended through the whole Chart in a Multitude of crossing Lines *, that where-soever the Mariner is upon the Sea he may know toward what Point of the Compass he must steer, or direct his Vessel to carry it toward any particular Port; and that we may be able to see with one Cast of an Eye the various *Bearings* of any Port, Coast, Island, Cape, &c. toward each other. IV.

* See Marginal Note, Probl. X. Sect. XIX.

IV. The Sea is also filled in *Sea-Charts* with various Numbers or Figures which denote the Depth of Water, and shew how many Fathom deep the Sea is in those Places where the Number stands. These are called *Soundings*.

V. In *Sea-Charts* there is not such Care taken to place the *North* Parts of the World always directly upright and before the Face of the Reader; but the Coasts and Countries are usually described in such a Position as may afford the fittest Room to bring in the greatest Variety of Shores and Seas within the Compass of the same *Chart*, whether the *East*, or *West*, or *North*, be placed directly before the Reader.

Here let it be noted that as *Geography* taken strictly and properly is a Description of Land, so a Description of Water or Sea is called *Hydrography*; and as those who describe the Land on Maps are properly called *Geographers*, so those who draw the *Sea-Charts* are often called *Hydrographers*.

S E C T. XII.

The Political Divisions of the Earth represented on the Globe.

THUS we have finished the *natural Divisions of the Surface of the Earth*; we come now to consider how it is divided *Politically* by Men who inhabit it.

In this Sense it is distinguished into four Quarters, into Empires, Kingdoms, States, Commonwealths, Principalities, Dukedoms, Provinces, Counties, Cities, Towns, Villages, &c.

The *Earth* is first divided into four chief Parts or Quarters, which are called *Europe*, *Asia*, *Africa*, and *America*.

Europe is divided from *Africa* and bounded on the South Side by the *Mediterranean Sea*. On its Eastern Side it is divided from *Asia* by a Line drawn on the East Side of *Candia* or *Crete* passing up the *Ægean Sea* and through the *Propontis* into the *Euxine* or *Black Sea*, and from thence through the Sea of *Zabaique* by the River *Don* or *Tanais*, and thence through *Muscovy*, (as some will have it) to the River *Oby* running into the Northern Ocean. ^{the Ocean} It is also bounded on the West Side by the *Western* or *Atlantick Ocean*.

Asia is also bounded on the *North* by the Northern frozen Seas: On the South by the *Indian Ocean*: On the East it includes *Cbina* and the *Oriental Islands*: But on the *North East* its bounds are unknown, for Travellers have not yet been able to determine whether those Eastern Parts of *Great Tartary* may not be joined to some unknown Parts of *North America*.

Africa

Africa is a large Peninsula joining to *Asia* by a little Neck of Land at *Egypt*, bounded on the North by the *Mediterranean Sea*: On the West by the *Atlantick* and *Ethiopick Oceans*: On the North East by the *Red Sea*; and on the South and East by the *Southern* and *Indian Oceans*.

America was unknown to the Ancients till found out by *Christopher Columbus*, a little above two hundred Years ago. It is called in general the *West-Indies*. It lies almost three thousand Leagues to the Westward from *Europe* and *Africa* on the other Side of the *Atlantick* and *Ethiopick Seas*: It is made up of two large Continents, divided by a narrow Neck of Land into two Parts; the one is called *North America* or *Mexicana*, the other *South America* or *Peruana*.

Let us treat briefly of each of these in their Order.

S E C T. XIII.

Of EUROPE and its several Countries and Kingdoms.

THE chief Countries of which EUROPE is composed may be distinguished into the *Northern*, the *Middle*, and the *Southern* Parts.

I. The *Northern* Parts are the *British Isles*, *Denmark*, *Norway*, *Sweden*, *Muscovy*, and *Lapland*.

The *British Isles* are *Great Britain* and *Ireland*, *Great Britain* contains the two Kingdoms of *England* and *Scotland*, which were lately united into one. The chief City of *England* is *London*, and *Edinburgh* is the chief in *Scotland*, as *Dublin* is in *Ireland*. Note, That *Wales* is reckoned a Part of *England*, though they speak a different Language.

Denmark is a small Kingdom on the North of *Germany* made up of one Peninsula, and several Islands in the *Baltick Sea*; its chief City is *Copenhagen*, which stands in the largest of those Islands.

The Kingdom of *Norway* (which lies all along bordering on the West of *Sweden*) has its chief Town *Drontheim*; this together with the Isle of *Iceland* far distant in the Northern Sea is under the Government of the King of *Denmark*.

Sweden is one of the Northern Kingdoms which almost incompasses the *Baltick Sea*: Its chief City is *Stockholm*. That Part of it that lies on the East Side of the *Baltick* is called *Finland*, *Livonia*, &c. and the Southern Part on the West Side next to *Denmark* is called *Gothland*.

All the North East Part of *Europe* is *Russia* and *Muscovy* under the Government of the *Czar*, whose Capital City is *Moscow*. His Conquests have lately joined *Livonia*

to

to his Dominion, which before belonged to *Sweden*, and there he has built the City *Petersburg*.

Lapland is a cold savage Country that lies on the North of *Sweden*, and belongs to three Princes, (*viz.*) the *Dane*, the *Swede*, and the *Muscovite*.

Note, That *Norway*, *Lapland*, and *Sweden*, were once all comprized under the general Name of *Scandinavia*.

II. The *Middle Parts* of *Europe* are *France*, *Germany*, *Poland*, *Hungary*, and *Little Tartary*.

France lies just Southward of *England*; its Northern Coast is washed by the *English Channel*; its Western Shores by the *Atlantic Sea*; and its Southern by the *Mediterranean*: Its chief City is *Paris*.

Before I proceed to *Germany*, it is proper to mention a long Row of distinct Governments which lie on the East of *France*, and divide it from *Germany* and *Italy*. These are the *Seven United Provinces*, the *Ten Spanish Provinces*, the *Dukedom of Lorraine*, the Countries of *Switzerland*, *Savoy*, and *Piedmont*.

The *Seven United Provinces* are called by the Name of *Holland*, because that is the biggest of them. They are a most considerable Commonwealth, and their chief Cities are *Amsterdam*, *Rotterdam*, *Leyden*, *Utrecht*, &c.

Southward of this lie the Ten *Spanish Provinces*, or the *Low Countries* or *Netherlands*, which are called by the Name of *Flanders*, because that is the largest of them: They have belonged to the Kingdom of *Spain* for some Ages; but they are now under the Emperor of *Germany*; their chief Cities are *Brussels*, *Antwerp*, *Louvain*, *Mons*, *Namur*, *Ghent*, &c.

Lorraine lies to the South of *Flanders*, and is governed by a Duke: Its chief Town is *Nancy*.

Switzerland is the next: It is a free Republick divided into thirteen Parts, commonly called the *Swiss-Cantons*, (viz.) *Zurich*, *Bern*, *Basil*, *Lucern*, &c. Their Allies are the *Grisons*, the *Valtoline*, &c. The Commonwealth of *Geneva* might also be mentioned here, which is a very small but free Sovereignty, and maintains its Rights, because none of its Neighbours will let the others seize and possess it.

The Dukedom of *Savoy* and *Piedmont* borders upon the South of *Switzerland*, and reaches to the *Mediterranean Sea*: Its chief City is *Turin*; its Duke is lately made King of *Sardinia*.

I proceed now to *Germany*, which stands in the very Heart of *Europe*; it is called an *Empire*, and its chief City where the Emperor dwells is *Vienna*: But there are in it
many

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many lesser Governments, such as Dukedoms, Marquisates, Bishopricks, and several free Towns or Cities that have some Dependence upon the Emperor, but yet are little Sovereignties within themselves.

The most considerable of these is the Dominion of the Arch-duke of *Austria*, who is King of *Bohemia* and *Hungary*, and is generally chosen *Emperor*. The nine Electorates are next in Honour, which are so called because their Governors are Electors by whom the Emperor of *Germany* is chosen. Their Names or Titles are these. (1.) The Archbishop of *Mentz*. (2.) The Archbishop of *Triers* or *Treves*. (3.) The Archbishop of *Cologne*. (4.) The King of *Bohemia*. (5.) The Duke of *Bavaria*. (6.) The Duke of *Saxony*. (7.) The Marquis of *Brandenburgh*, now King of *Prussia*. (8.) The Prince Palatine of the *Rhine*. (9.) The Duke of *Brunswick* and *Lunenburgh*, who is also King of *Great Britain*. Besides all these there are many small Principalities governed by Secular or Ecclesiastical Powers, which are too numerous to be reckoned up here.

Poland is a large Kingdom lying to the East of *Germany*: It comprehends also the large Province of *Lithuania*: The chief Cities of this Kingdom are *Warsaw* and *Cracow*. I might here mention the Country
of

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of *Prussia*, which some Years past has been dignified with the Name of a Kingdom: It is situate Northward between *Germany* and *Poland*. The King resides at *Berlin* in *Brandenburgh*.

Hungary is a Kingdom which lies just South of *Poland*, its chief Towns are *Presburg* and *Buda*: It has been in a great Measure under the Government of the *Turks*; but it now belongs to the Emperor of *Germany*.

Little Tartary, which is also called *Crim Tartary*, is a small Country lying to the East of *Poland*, and stretching along on the North Side of the *Euxine* or *Black Sea*.

III. We go on now to the *Southern Parts* of *Europe*; and these are *Spain*, *Italy*, and the *European Dominions* of the *Turk*.

Spain is the most Southern Kingdom of *Europe*, a large Country; its Capital City *Madrid* stands in the Midst of it: On the West Side of it lies the Kingdom of *Portugal* bordering all along upon it; it was once a Part of *Spain*, but now is subject to a distinct King: Its chief City is *Lisbon*.

Italy is a large Peninsula in the *Mediterranean Sea*, and contains various Governments in it, (*viz.*) *Mantua*, *Modena*, *Parma*, *Lucca*, *Genoa*, &c. but the most noted and remarkable are these five, *Venice*, *Milan*, *Florence* or *Tuscany*, *Naples*, and the *State of the Church*, which is the Dominion of the Pope, whose chief City is *Rome*. In

In the South East Part of *Europe* lies the famous Country of *Greece*, which contains the antient Provinces of *Macedonia*, *Thessalia*, *Achaia*, &c. with the Towns of *Thessalonica*, *Philippi*, *Athens*, *Corinth*, &c. and the Peninsula of *Peloponnesus*, now called the *Morea*; but all these together with the more Northern Provinces of *Transylvania*, *Walachia*, *Bulgaria*, *Romania*, &c. are now almost intirely under the Dominion of the *Turk*, whose chief City is *Constantinople*, situate at the Mouth of the *Euxine Sea*. All this is called *Turkey in Europe*.

Thus have we gone through the *Northern* and *Middle*, and *Southern* Countries of *Europe*: But it may be proper to mention also some of the chief *Islands* of this Part of the World, as well as the *Mountains* of *Europe* and its *Rivers*.

Near to *Italy*, *France* and *Spain*, lie several *Islands* in the *Mediterranean Sea*; such as *Majorca*, *Minorca*, *Ivica*, *Corfica*, *Sardinia*, *Sicily* and *Malta*, which belong to different Princes.

On the East Side of *Greece* is the *Ægean Sea*, or *Archipelago*, in which are many small *Islands*, and *Crete* a large one: On the West Side of *Greece* is the *Gulph of Venice*, or the *Adriatick Sea*, in which also there are several small *Islands*, as *Corfu*, *Cephalonia*, *Zant*, &c.

Divers

Divers other *Isles* there are which are included in *Europe*; as the *Isle of Man*, of *Anglesey*, of *Wight*, *Jersey*, *Guernsey*, &c. which belong to *England*: The *Hebrides* on the West of *Scotland*, the *Orcades*, and *Schetland Isles* on the North: Some in the *Baltick Sea*, which belong to *Sweden* and *Denmark*: The *Azores* or Western Islands in the *Atlantick Sea*, which are under the King of *Spain*. And several others of less Note.

Some of the most remarkable *Mountains* in *Europe* are, (1.) The *Alps* between *France* and *Italy*. (2.) The *Apennine Hills* in *Italy*. (3.) The *Pyrenean Hills* between *France* and *Spain*. (4.) The *Carpathian Mountains* in the South of *Poland*. (5.) The *Peak* in *Derbyshire* in *England*. (6.) *Plinlimmon* in *Wales*, &c. Besides several *Volcano's*, or Burning Mountains, as *Vesuvius* and *Stromboli* in *Naples*, *Mount Ætna*, now called *Mon-Gibel*, in the Island of *Sicily*, and *Mount Hecla* in the cold Isle of *Iceland*.

The principal *Rivers* of Note in *Europe* are the *Thames* and the *Severn* in *England*; the *Tay* in *Scotland*; the *Shannon* in *Ireland*; *Tagus* in *Portugal* and *Spain*; the *Po* and *Tiber* in *Italy*; the *Weisel* or *Vistula* in *Poland*. In *Germany* the *Elbe* and the *Oder*, the *Rhine* and the *Danube*. In *France* the *Seine* and the *Rhone*. In *Moscovy* the *Don* and the *Volga*.

The

The *Danube* and the *Volga* are the largest Rivers in *Europe*, the *Danube* running through all *Germany* and *Turkey* into the *Euxine* or *Black Sea*; and the *Volga*, (which some Writers attribute to *Asia*, because) though it runs through a great Part of *Moscovy*, yet it empties itself into the *Caspian Sea*.

S E C T. XIV.

Of ASIA, and its several Countries and Kingdoms.

ASIA may be divided into these five Parts, (*viz.*) *Turkey*, *Persia*, *India*, *China* and *Tartary*.

The Dominion of the *Turks* in *Asia* contains several Countries in it, (*viz.*) *Natolia*, *Palestine*, *Arabia*, *Georgia*, &c.

1. *Natolia*, or *Asia Minor*, which is a Peninsula between the *Euxine Sea* and the *Mediterranean*, where lay the antient Countries of *Galatia*, *Cappadocia*, *Pontus*, *Bythynia*, *Lycônia*, *Cilicia*, *Phrygia*, *Pamphylia*, &c. through which the Apostle *Paul* travelled and made many Converts there. Here were the seven famous Churches of *Asia*, to which the Epistles were written in the second and third Chapters of the *Revelations*, (*viz.*) *Ephesus*, *Smyrna*, *Sardis*, &c. Many of them are now called by different Names:

Names: But *Smyrna* is one of the chief Cities in the whole Country.

2. *Palestine*, or the *Holy Land*, and all the adjacent Countries of *Syria*, *Chaldea*, *Mesopotamia*, &c. The chief Towns in it now are *Aleppo*, *Scanderoon*, or *Alexandretta*, *Bagdat* or *Babylon*, *Damascus*, *Jerusalem*, &c.

3. *Arabia*, which antiently was divided into *Arabia the Happy*, *Arabia the Desert*, and *Arabia the Stony*, lying all between the *Persian Gulf*, and the *Red Sea*: The chief Towns of it are *Mecca*, *Medina*, &c.

4. *Georgia* and *Turkomania*, formerly called *Armenia Major*, are Northern Provinces belonging to the *Turks*, that lie between the *Euxine* and the *Caspian Sea*.

Persia, a large Empire, lies Eastward from *Turkey* between the *Caspian* and *Indian Seas*: Its capital City is *Ispahan*.

India is divided in two Parts by the River *Ganges*. *India*, on this Side the *Ganges*, contains the biggest Part of the Empire of the *Great Mogul*, whose chief City is *Agra*. In a Peninsula or large Promontory in this Part of *India*, are various Settlements of the *European Nations*, as at *Fort St. George*, *Tranquebar*, *Goa*, &c. Beyond the River *Ganges* lies another large Peninsula, which contains the Countries of *Pegu*, *Siam*, *Tunquin*, *Cochinchina*, &c.

East-

Eastward of all these lies the Empire of *China*, a large and a polite Nation, whose chief City is *Pekin*. These countries last named are called in general the *East-Indies*.

Great Tartary takes up all the Northern Part of *Asia*. That which borders upon *Moscovy* is often called *Moscovy in Asia*: The whole is a savage, unpolished and unknown Country as to the Parts as well as the Inhabitants of it; and how far it reaches to the *North-East*, no Man in this Part of the World can inform us.

There are Multitudes of *Islands* which belong to *Asia*, the chief of which are *Japan*, *Borneo*, *Celebes*, *Java*, *Sumatra*, *Ceylon*, the *Philippine Isles*, the *Maldivè Isles*, &c. all these in the *Eastern Ocean*, and *Cyprus* in the *Mediterranean*.

The most remarkable *Rivers* are *Tigris* and *Euphrates* in *Turkey*, *Ganges* and *Indus* in *India*, whence the whole Country took its first Name.

The chief Mountains are *Imaus*, *Caucasus*, *Ararat*, which are but different Parts of the long Ridge of Hills which runs through *Asia* from the West to the East, and is called by the antient general Name of *Mount Taurus*.

S E C T. XV.

Of AFRICA and its Divisions.

AFRICA is the third Quarter of the World: It may be divided into the following Territories, *Egypt, Barbary, Bildulgerid, Zaara, Nigritia, Guinea, Nubia, Abyssinia* and *Ethiopia*.

Egypt lies to the North East and joins to *Asia*; the chief Cities are *Grand Cairo* and *Alexandria*.

Barbary is a long Country, it comprehends most part of the antient *Mauritania*, or the Country of the *Moors*; it lies along the Coast of the *Mediterranean Sea*: Its chief Towns are *Fez, Morocco, Mechanefs, Sallee, Tangeir, Ceuta, Algier, Tunis, Tripoli* and *Barca*.

Bildulgerid, or the antient *Numidia*, has its chief Town *Dara*; it lies South and South-East of *Barbary*, unless it be reckoned a part of it.

Zaara comes next; it is a Desert Inland Country, and much unknown. So is *Nigritia*, or the Land of the Negroes, which lies to the South of *Zaara*; as *Guinea* is situated in the South of *Nigritia*. The *Tooth*, or *Ivory Coast*, and the *Quaque Coast*, and the *Gold Coast*, are several Divisions of *Guinea* well known to Mariners.

Nubia

Nubia lies Southward of *Egypt*, as *Abyssinia* does to the South of *Nubia*, both near the Coast of the *Red Sea*.

Ethiopia has been given as a general Name to all the Countries that compose the South-East and South Part of *Africa*, at least, all the Maritime Countries or Coasts from *Guinea*, on the Western Side to *Abyssinia*, or *Nubia* on the East, and sometimes it includes *Abyssinia* also, which is called the *Lesser* or *Inner Ethiopia*.

In the more Southern Part of *Ethiopia*, are the Inland Kingdoms of *Monomotapa*, *Monoemunga*, &c. On the Western Coast *Congo*, *Loango*, *Angola*: The Eastern Coast is *Zanguebar* and the *Mozambique*: The Southermost Coast is inhabited by the *Cafres* and the *Hottentots*, near the *Cape of Good Hope*, who are famous for their Stupidity, living in the most brutal and barbarous Manner, as though they had little of human Nature in them beside the Shape.

The chief *Islands* near *Africa* are the large Isle *Madagascar*, called the Isle of *St. Lawrence*, that lies toward the *Eastern Sea*; and on the West or North-West are the small Islands of *Cape Verd*, the *Canary Islands*, and the *Maderas* in the *Atlantick Sea*, with others of lesser Note in the *Ethiopick Sea*.

The most famous *Rivers* in *Africa* are the *Nile* and the *Niger*. The *Nile* runs through all the Eastern Part of the Country, and empties itself into the *Mediterranean Sea* by many Mouths at the Land of *Egypt*. The River *Senegal*, antiently called *Niger*, runs through *Negroland*, into the *Atlantick Ocean*.

The most remarkable *Mountains* are these, (1.) *Mount Atlas*, or the *Atlantick Hills* in the West of *Barbary*, which were supposed by the Antients to be the highest in the World; whence came the Fable of *Atlas* a Giant bearing the Heavens upon his Shoulders. (2.) The Mountains of the *Moon*, which lie much more Southward toward *Monomotapa*: And (3.) The exceeding high Hill of *Teneriff*, which is among the *Canary Islands*.

S E C T. XVI.

Of AMERICA and its Divisions.

*A*MERICA is the fourth and last Quarter of the World, it is divided into the *Northern* and *Southern* Parts by an Isthmus or Neck of Land at *Darien* or *Panama*.

Northern America includes *Canada*, the *English Empire*, *Old Mexico*, *New Mexico*, *Florida*, and the *Northern Land*.

The

The *Northern Land* contains some Islands and Settlements of *European Nations*, in *Hudson's-Bay* and other Coasts of *Greenland*, *Greenland*, near to the *Arctick Circle*, but few of them are much known, frequented or inhabited.

As for the North West Part of *North-America*, it is utterly unknown whether it be Island or Continent, whether it may not reach thousands of Miles farther and be joined to the North-East Part of *Great Tartary*.

Canada, or *New France*, lies on the North-East Side of the River of *St. Lawrence*, its chief Town is *Quebec*.

The *English Empire* in *America* lies along the Eastern Coast from about thirty to almost fifty Degrees of North Latitude.

New England is the chief Province, of which *Boston* is the principal Town or City. North of *New England* lies *Acadia*, sometimes called *New Scotland*: Its chief Town was *Port Royal*, which hath changed its Name to *Annapolis*. Southward of *New England* lie *New York*, *New Jersey*, *Pensilvania* and *Maryland*, *Virginia* and *Carolina*. On the West and North-West Side of these Plantations lie large Tracts of Land with many great Lakes in it, where various Nations of Savages inhabit.

Florida comes next in course to be mentioned, it borders East or North-Eastward

on *Carolina*, and Westward it reaches to the River *Mississippi* and beyond it: It is bounded by the Sea on the South, but there have been no very great or remarkable Towns or Settlements formed there by the *Spaniards*, who found and named it.

New Mexico, or *New Granada*, lies West of *Florida*, possessed also by the *Spaniards*; its chief Town is *St. Fe*, upon the River *Nort*.

Mexico, or *New Spain*, lies more South, it is a large and rich country, long and uneven, stretching from North-West to South-East; and contains many Provinces in it belonging to the *Spaniards*, who have destroyed Millions of the Natives there. It has several Towns, of which the chief has the Name of *Mexico* given it. *Florida* and *Mexico* together make a large Bay, which is called the *Gulf of Florida*, or the *Gulph of Mexico*. This country reaches down to the small Neck of Land whereby *South America* is joined to it. On this Neck of Land are *Panama* on the South Side, and *Porto-Bello* on the North.

The *Southern Part of America* is something like a large Triangle lying in the vast *Southern Ocean*, and almost encompassed by it: On the Western Side this Ocean is called the *Pacifick Sea*, because seldom vexed with Storms.

This

This *Southern Part of America* comprehends many great countries, viz. *Terra Firma, Peru, Amazonia, Guinãa, Brasil, Chili, Paraguay, Terra-Magellanica, &c.* The Inland Parts are very much unknown, but the greatest Part of the Coasts are possessed by the Inhabitants derived from *Spain* and *Portugal*, who have made various Settlements there.

The chief *Islands of America* in the North are *Newfoundland*, which is a Triangle near *Acadia*; then *Cuba, Hispaniola, and Jamaica*, all in the same Climate with *Mexico*. The lesser Isles are called *Lucayes*, or *Babama Islands*, South-East of *Florida*; and the *Caribbee Islands* Eastward of *Hispaniola*. On the West Side of *North America*, lies a very large and long Island, called *California*, with many little ones near it.

The chief Island in *South America* is *Terra-Delfuego*, which lies near the *Main Land*, and thus makes the *Straits of Magellan*. There are many others of less Extent and Note, both on the Coast, and in the vast *South-Sea*.

The most noted *Rivers of North America* are the great River of *St. Lawrence*, or *Canada*, that divides *New England* from *New France*; and the River *Mississippi* where the *French* have made large Settlements.

In *South America* the two great Rivers are the *Amazon* with all its Branches, and *Rio dela Plata* or the River of *Plate*.

The chief *Mountains* are the *Apalackin* Hills in *North America*, which divide *Florida* from the more Northern Countries; and the *Andes* in *South America*, which is a long Ridge of Mountains running from the South Part of *America* toward the North: Travellers suppose them to be the highest in the World.

Thus I have described the various Countries of the Earth in a very brief but imperfect manner, sufficient only to give the young and ignorant Reader a Taste of *Geography*, and to encourage him to pursue the Study farther in that excellent Manual *Gordon's Geographical Grammar*, or in Volumes of larger Size.

S E C T. XVII.

Of the fixed Stars on the Heavenly Globe.

AS the *Terrestrial Globe* has the various Countries, Cities, Mountains, Rivers and Seas drawn upon it: So on the *Celestial Globe* are placed the fixed Stars exactly according to their Situation in the Heavens.

Yet there is this Difference between the Representations made by the *Heavenly*
and

and those made by the *Earthly* Globe, (*viz.*) That the several Countries, Rivers and Seas, are represented on the *Convex* or outward Surface of the *Earthly* Globe, just as they lie naturally on the *Convex Surface* of the Earth: Whereas the Stars naturally appear to us in the *Concave*, or inward hollow Surface of the Heaven, but they are represented on the *Heavenly* Globe on the *Convex Surface* of it. Therefore we must suppose our Eye to be placed in the Centre of the Globe, in order to have the Stars and Heavens appear to us in their *Concavity* and proper Situation.

Planets and *Comets* are vulgarly called by the general Name of Stars; but the *fixed Stars* differ from the *Planets* and the *Comets* in this, that they always keep the same Place or Distance with regard to one another; whereas the *Planets* and *Comets* are perpetually changing their Places and Distances with Regard to *one another*, and with regard to the *fixed Stars*.

They differ also in this respect, that the *fixed Stars* generally twinkle, except when near the Zenith, or seen thro' a Telescope; and they shoot sprightly Beams like the Sun, which is usually given as a Proof, that like the Sun they shine with their own Light: The *Planets* have a more calm Aspect like the Moon, and never twinkle, which is

one Argument among many others that they derive their Light from the Sun, and shine only by Reflection.

For our better Acquaintance with the *fixed Stars*, Astronomers have reduced them to certain *Constellations*. This we have shewn already in the second Section, concerning those Stars that lie in the *Zodiack*, which are reduced to 12 Constellations, and called the *twelve Signs*, (viz.) *Aries* or the Ram, *Taurus* or the Bull, *Gemini* or the Twins, &c. the rest of the Stars are distinguished into the *Northern* and *Southern* Constellations, as lying North or South of the *Zodiack* or *Ecliptick*.

The *Northern Constellations* were thus framed by the Antients, *Urfa Minor* or the little Bear, in whose Tail is the Pole Star, *Urfa Major* or the great Bear, *Draco* or the Dragon, *Cepheus* whose Feet are just at the North Pole: *Cassiopeia* and her Chair, *Andromeda*, the Northern *Triangle* *Perseus* with *Medusa's* Head, *Auriga* or the Charioteer, *Bootes* or the Hunter, who is sometimes called *Arcturus* or the Bear-keeper, *Corona Borealis* or the Northern Crown, *Egonasi* or *Hercules* Kneeling, *Lyra* or the Harp, *Cygnus* or the Swan, *Pegasus* or the great flying Horse, *Equuleus* or *Equiculus* the little Horse's Head, *Delphinus* or the Dolphin, *Sagitta* or the Arrow,

Arrow, *Aquila* or the Eagle, which some call the Vultur, *Serpens* or the Serpent, and *Serpentarius* the Man who holds it.

To these 21 Northern Constellations were afterwards added *Antinous* at the Equator next to the Eagle, *Cor Caroli* or King Charles's Heart a single Star South of the *Great Bear's Tail*, and *Bernice's Hair*, a few small Stars South of *Charles's Heart*, &c.

The *Southern Constellations* known to the Antients are *Cetus* the Whale, and the River *Eridanus* *Lepus* the Hare, the glorious Constellation of *Orion* with his Girdle, Sword, and Shield, *Sirius* or the great Dog, *Canicula* or the little Dog, *Hydra* or a large Serpent, the Ship *Argo*, *Crater* or the two handed Cup, *Corvus* the Crow, or the Raven, *Centaurus* or the Half-Man Half-Horse, *Lupus* or the Wolf, *Ara* or the Altar, *Corona Australis* or Southern Crown, *Piscis Notius* or the Southern Fish.

To these 15 there have been added 12 other Constellations made up of the fixed Stars toward the South Pole which are never visible to us in *Britain*, and therefore I shall not mention them.

Astronomers have framed some lesser *Constellations* which are contained in the greater, as the *Pleiades* or the Seven Stars, and the *Hyades* in *Taurus* or the Bull: *Capella* or the Goat, **α** which is a very bright Star
so

so called, in the Arms of *Auriga* or the Charioteer: The *Manger* and *Asses* in the *Crab*, which indeed is nothing but a bright Spot composed of a Multitude of small Stars: *Charles's Wain* which are seven bright Stars in the Rump and Tail of the *Great Bear*, three of which in the Tail resemble the *Horses*, and the other four, *c, d, b, r*, a *Square Cart*: See Figure xxx. The two hindmost Stars in the *Cart*, (*viz.*) *b* and *r* are called the *Pointers*, because they point to the *North Pole p*.

Besides these there are several other smaller Stars scattered up and down in the Heavens, which are not reduced to any of the *Constellations*; though of late Years *Hewelius* a great Astronomer has made *Constellations* of them which are described upon some modern Globes.

The *fixed Stars* are of different Sizes, and are divided into those of the *first, second, third, fourth, fifth* and *sixth* Magnitudes.

There are but a few Stars of the *first* and *second* Magnitude, and many of them have remarkable Names given to them, as the *Ram's Head*, *Aldebaran* or the *Bull's Eye*, *Capella* or the *Goat*, the three Stars in *Orion's Girdle*, the *Lion's Heart*, *Deneb* or the *Lion's Tail*, *Regel* the Star in *Orion's* left Foot, *Spica Virginis*, which is an *Ear of Corn* in the *Virgin's Hand*, *Hydra's Heart*,
the

the *Scorpion's Heart*, the *Eagle* or *Vultur's Heart*, *Ala Pegasi* or the *Horse's Wing*, *Fomabant* a large Star in the Southern *Fishes Mouth* near *Aquarius*, the *Pole Star* in the *Little Bear's Tail*, &c. See more in the Table of fixed Stars at the End of this Book.

Some remarkable Stars are called by the Name of the Constellation in which they are, as the *Great Dog*, the *Little Dog*, *Lyra* or the *Harp*, *Arcturus* the *Bear-keeper*, *Capella* the *Goat*, &c.

As the Globe of the Earth with all the *Lands* and *Seas* described on a *Terrestrial Sphere* is represented on *Maps*, so the *Celestial Sphere* with all the *fixed Stars* is often represented on *two Tables* or *Planispheres*, projected, one on the Plane of the *Equator* with the two *Poles* of the *World* in their *Centres*; and the other on the Plane of the *Ecliptic* with the *Poles* of the *Ecliptic* in their *Centres* *.

Note, This Sort of *Projections* has sometimes been furnished with some little *Appendices* which are moveable, and makes an *Instrument* called a *Nocturnal* to take the *Hour* of the *Night*, and perform many other *Astronomical Problems* by the *Stars*.

It is hardly necessary to say, that the *Stars* are supposed to keep their constant
Revo-

* Mr. *Senex* at the *Globe* over-against *St. Dunstan's* in *Fleet-street*, has lately printed the best that ever were in *England*, or perhaps in any *Country*.

Revolution once in twenty four Hours by Day as well as by Night: But the Day Light conceals them from our Eyes.

The Sun in its Annual Course moving from West to East through all the *Signs* of the *Zodiack* hides all those Stars from our Sight which are near its own Light or Place in the Heavens; and therefore at several Seasons of the Year you see different Stars or Constellations rising or setting, or upon the Meridian at every Hour of the Night: And as the Sun goes onward daily and monthly toward the East, the *Eastern Constellations* come daily and monthly within the Reach of the Sun Beams and are concealed thereby, which is called their *Setting Heliacally*. And the *Western Constellations* hereby getting farther off from the Sun Beams, are made visible to us, which is called *Rising Heliacally*.

Thus, as I intimated before, we may easily find what Stars will be upon the Meridian every Midnight by considering in what Sign the Sun is, and in what Degree of that Sign; for the Sun with the Stars that are near it being upon the *Meridian* at *Noon*, the Stars that are directly opposite to them in the Heavens will be upon the *Meridian* that Day at *Midnight*. And by the same Means if you observe what Stars
are

are upon the *Meridian* at *Midnight*, you easily infer the Sun is in the opposite Point of the Heavens at *Midnoon*.

Here it should not be forgotten, that there is a broad uneven Path incompassing the Heavens, passing near the *North Pole*, which is brighter than the rest of the Sky, and may be best seen in the darkest Night; this is called the *Milky Way*, which later Philosophers have found by their Telescopes to be formed by the mingled Rays of innumerable small Stars. It is to the same Cause that some other bright Spots in the Sky (though not all) are ascribed which appear to us like whitish Clouds in Midnight Darkness.

S E C T. XVIII.

Of the Planets and Comets.

THOUGH the *Planets* and *Comets* are never painted upon the Globe because they have no certain Place, yet it is necessary here to make some Mention of them; since they are Stars much nearer to us than the *fixed Stars* are, and we know much more of them.

The *Planets* are in themselves huge dark Bodies which receive their Light from the Sun, and reflect it back to us. They are called *Planets* from a *Greek Word* which signifies

signifies *Wanderers*, because they are always changing their Places in the Heavens, both with regard to the fixed Stars and with regard to one another.

The *Planets* are placed at very different Distances from the Centre of our World, (whether that be the Earth or the Sun) and they make their various Revolutions through the twelve Signs of the *Zodiack* in different Periods of Time.

<i>Saturn</i>	in 29 Years and 167 Days, <i>i. e.</i> about 24 Weeks.
<i>Jupiter</i>	in 11 ———— 314 ———— 45 ————
<i>Mars</i>	in 1 ———— 321 ———— 46 ————
<i>Earth or Sun</i>	in 1 ———— 0 ———— 0 ————
<i>Venus</i>	in 0 ———— 224 ———— 32 ————
<i>Mercury</i>	in 0 ———— 87 ———— 12½ ————
<i>Moon</i>	in 0 ———— 27½ ———— 4 ————

As the *Ecliptick* Line is the Orbit or Annual Path of the *Earth* or *Sun*, so each *Planet* has its proper Orbit, whose Plane differs some few Degrees from the Plane of the Orbit of the Sun, and to a Spectator's Eye placed in the Centre would intersect or cut the Sun's Orbit at two opposite Points or *Nodes*. Now the Distance of a Planet from the *Ecliptick*, measured by an Arch perpendicular to the *Ecliptick*, is the *Latitude* of that Planet as before.

To represent this as in Figure XI. you may imagine as many *Hoops* as there are *Planets* thrust through with several strait *Wires*, and thereby joined in different Places to the
Hoop

Hoop that represents the Plane of the *Ecliptick*, i. e. the Sun's or Earth's Orbit; and then let these *Hoops* be turned more or less obliquely from the Plane of the *Ecliptick*: For all the several Orbits or Paths of the *Planets* do not cross or intersect the *Ecliptick* or *Sun's* Path in the same Point, nor at the same Angles: But their *Nodes* or Intersections of the *Ecliptick* are in different Parts of the *Ecliptick*, and also make different Angles with it.

Among the several Uses of observing the *Latitude* of a Planet, see one very necessary in *Problem XXXVII*.

The *Comets* were by *Aristotle* and his Followers supposed to be a Sort of *Meteors* or *Fires* formed in the Sky below the Moon, continuing for some Months, and then vanishing again. But by later Astronomers they have been found to be *dark Bodies* like the *Planets*, moving through the Heavens without any Regard to the *Ecliptick*, but in very different Orbits, which are supposed to be *Ellipses* or *Ovals* of prodigious Length, and returning at various Periods of several scores or hundreds of Years. Though it must be confessed, those Parts of their Orbits which are within the Reach of our Sight are so very inconsiderable Parts of the vast *Ovals* they are said to describe, that it has been much doubted, whether the Lines they describe

scribe in their Motion be not *Paraboli- cal*, or some other infinite Curve; and thus whether the *Comets* themselves are not *wandering Stars* that have lost all regular Revolution, and perhaps have no settled Periods at all and may never return again: But *Comets* appear so seldom that they have scarce given the nice Enquirers of these last Ages sufficient Opportunity to observe or calculate their Motions with such an absolute Certainty as could be wished.

Thus I have finished the speculative Part of this Discourse which contains the *Rudiments* or *first Principles of Astronomy*: It is called the *Spherical Part*, because it treats of the *Doctrine and Use of the Sphere*; and I have concluded therein the *general Part of Geography*, and given a slight Survey of the *particular Divisions of the Earth*.

It is indeed the *Second or special Part of Geography* that treats properly of these particular Divisions of the Earth which I have but slightly run over, and in a much larger Manner enumerates not only all the Kingdoms, States, and Governments of the World, but also gives some Account of their Manners, Temper, Religion, Traffick, Manufactures, Occupations, &c. It also describes the various Towns and Villages, the larger and lesser Mountains, Rivers, Forests, the several Products of every Country, the Birds,
Beasts,

Beasts, Insects, Fishes, Plants, Herbs, the Soil, Minerals, Metals, and all Rarities of Art and Nature: It relates also the various antient and modern Names of the Nations, Cities, Towns, Rivers, Islands, &c. What remarkable Occurrences of Battles, Victories, Famine, Desolations, Prodigies, &c. has happened in every Nation, and whatsoever has rendered it worthy of publick Notice in the World.

There are many Books extant in the World on this Subject; some of lesser Size, such as *Gordon's Geographical Grammar*, *Chamberlain's Geography*; and larger, (viz.) *Morden's Geography Rectified*, in Quarto, *Theſaurus Geographicus*, *Moll's Geography* in Folio, &c.

The *Second* or *Special Part of Astronomy* is called the *Theory of the Heavens*, or *the Sun and Planets*, which will lead us into the Knowledge of a thousand beautiful and entertaining Truths concerning the System of the World, the various Appearances of the Heavenly Bodies, and the Reasons of those Appearances, (viz.) a more particular and exact Account of the *Day and Night*, and of the several Seasons of the Year, *Spring, Summer, Autumn,* and *Winter*, of the *Length and Shortness* of the Days: Why in the Winter the Sun is nearer to us than it is in the Summer, and

why the Winter Half-Year is *seven* or *eight Days shorter* than the Summer Half-Year : Whence come the *Eclipses* of the Sun and Moon, both total and partial ; why the *Moon* is only eclipsed when she is *full*, and the *Sun* only when she is *New* : Whence proceed the different *Phases of the Moon*, as the *New* or *Horned Moon*, the *Half-Moon*, the *Full*, &c. Why the two lower Planets *Mercury* and *Venus* always keep near the Sun, and never move so far as two whole Signs from it : Why *Venus* is horned, halved and full as the Moon is : Why the three superior Planets *Mars*, *Jupiter* and *Saturn*, appear at all Distances from the Sun, and are sometimes quite opposite to it : Why both the *upper* and *lower Planets* sometimes appear swifter, sometimes slower : why they seem sometimes to move directly or forward, sometimes retrograde or backward, sometimes are stationary, or seem to stand still : Why they are sometimes nearer to the Earth, which is called their *Perigeum*, and sometimes farther from the Earth, which is called their *Apogeum*, and by this Means appear greater or less. Why they are nigher to or farther from the Sun, which is called their *Perihelion* and *Aphelion* ; and in what Part of their Orbits this Difference falls out : How it comes to pass that they seem higher in the Horizon than really

really they are by *Refraction*, and how again they seem lower than they really are by the *Parallax*.

In this Part of *Astronomy* it is proper also to shew the different *Schemes* or *Hypotheses* that have been invented to solve or explain all these Appearances of the Heavenly Bodies. Here the *Ptolemaick* or ancient System should have the first Place, to represent how the Antients placed the *Earth* in the *Centre* of the World, and supposed the Sun to move round it amongst the other Planets as it appears to the vulgar Eye; and what tedious and bungling Work they made by their Contrivance of *solid transparent Spheres* of different Thickness, placed in *Eccentric* Order and assisted by their little *Epicyles*: What infinite Embarrassments and Difficulties attend this rude and ill adjusted Contrivance, and how impossible it is to solve all the Appearances of Nature by this *Hypothesis*.

Then the Modern or *Copernican Scheme* should be represented, which makes the Heaven all void, or at least filled only with very fine Ethereal Matter; which places the *Sun* in the *Centre* of our World with all the *Planets* whirling round it; which makes the *Earth* a Planet, turning *daily* round its own Axis (which is the Axis of the Equator) to form Day and Night;

and also carried *yearly* round the Sun in the *Ecliptick* between the Orbits of *Venus* and *Mars* to form Summer and Winter. This Scheme also makes the *Moon* a *Secondary Planet* rolling *monthly* round the *Earth*, and carried with it in its *yearly Course* round the Sun, whereby all the Variety of Appearances of the Sun and Moon, and of all the Planets, as well as the Differences of Day and Night, Summer and Winter, are resolved and explained with the greatest Ease, and in the most natural and simple Manner.

Here also it should be shewn that as the *Moon* is but a *Secondary Planet*, because it moves round the *Earth* which is itself a *Planet*: So *Jupiter* which moves round the *Sun* has also *four secondary Planets* or *Moons* moving round it, which are sometimes called his *Satellites* or *Life-Guards*, *Saturn* also has *five such Moons*, all which keep their certain Periodical Revolutions: And beside these, *Saturn* is encompassed with a large *Flat Ring* 21000 Miles broad, whose Edges stand inward toward the *Globe of Saturn*, (like a wooden Horizon round a Globe) at about 21000 Miles Distance from it, which is the most amazing Appearance among all the heavenly Bodies: But these *Secondary Planets* which belong to *Jupiter* and *Saturn* together with this admirable *Ring* are visible only

only by the Assistance of Telescopes: And yet Mathematicians are arrived at so great an Exactness in adjusting the Periods and Distances of these *Secondary Planets*, that by the Motions and Eclipses of the *Moons* of *Jupiter* they find not only the true Swiftness of the Motion of Light or Sunbeams; but they find also the *Difference of Longitude* between two Places on the Earth.

It may be manifested here also that several of the *Planets* have their *Revolutions round their own Axis* in certain Periods of Time, as the *Earth* has in 24 Hours; and that they are vast bulky dark Bodies, some of them much bigger than our Earth, and consequently fitted for the Dwelling of some Creatures; so that it is probable they are all *Habitable Worlds* furnished with rich Variety of Inhabitants to the Praise of their great Creator. Nor is there wanting some Proof of this from the Scripture itself. For when the Prophet *Isaiab* tells us, that *God who formed the Earth, created it not in vain, because he formed it to be inhabited*, Isa. xlv. 18. He thereby insinuates, that had such a Globe as the Earth *never been inhabited*, it had been *created in vain*. Now the same Way of Reasoning may be applied to the other *Planetary Worlds*, some of which are so much bigger

ger than the Earth is, and their Situations and Motions seem to render them as convenient Dwellings for Creatures of some Animal and Intellectual Kind.

Many of these Things have been performed by ingenious Men with great Exactness, for the Use of Persons learned in the Mathematicks; but I know not any short, plain and intelligible Account of them fitted for the Use of the unlearned World, except among Dr. *Wells's* Volumes, intituled, *Mathematicks for a young Gentleman*: Yet I persuade myself, that some Parts of it might be performed with greater Ease and Clearness, in a more natural Method, and to much greater Perfection, if some Person of peculiar Skill in these Sciences and of equal Condescension would undertake the Work.

S E C T. XIX.

Problems relating to Geography and Astronomy to be performed by the Globe.

AS *Theorems* in Mathematick Science are certain Propositions declaring some *Mathematical Truth*: So a *Problem* is a *Mathematical Question* proposed to be resolved, or some *Practice* to be performed.

Because this *Problematick Part* will require the Recollection of a great many things

things in the former Sections, I think it may not be improper to give a short Summary of *Definitions* of the chief Subjects of Discourse in the *Doctrine of the Sphere*, and set them in one View.

DEFINITIONS.

The *Latitude of a Place* on the Earthly Globe, is the Distance of the Zenith of that Place from the Equator toward the North or South Pole measured by the Degrees of the Meridian.

The *Elevation of the Pole* is the Height of the Pole above the Horizon of that Place measured on the Meridian: And it is always the same Number of Degrees as the *Latitude*.

The *Longitude of a Place* is the Distance of it toward the East or West from some first Meridian, and it is measured on the Equator.

The *Declination of the Sun* or any *Star* or *Planet* is its Distance Northward or Southward from the Equator measured on the Meridian. It is the same Thing as *Latitude on the Earthly Globe*.

The *Right Ascension* of the Sun is its Distance from that Meridian that cuts the Point *Aries* measured Eastward on the Equator; it is much the same with *Longitude on the Earthly Globe*.

The *Hour of the Sun* is its Distance from Noon or the Meridian of the Place measured on the Equator by 15 Degrees, for every 15 Degrees on the Equator make an Hour. Or it may be reckoned from the opposite Meridian or Midnight.

Note, The *Right Ascension* is reckoned either in Degrees or in Hours.

The *Latitude of a Star or Planet* is its Distance Northward or Southward from the Ecliptick: *Note,* The Sun has no *Latitude* because it is always in the Ecliptick.

The *Longitude of the Sun or Star* is its Distance from the Point *Aries* Eastward measured on the Ecliptick. But with regard to the Sun or a Planet, this is usually called the *Place of the Sun or Planet* for any particular Day, *i. e.* its Place in the *Zodiack*, or the Degree of the Sign in which it is at that Time.

The *Altitude or Height* of the Sun or a Star is its Distance from and above the Horizon, measured on the Quadrant of Altitudes.

The *Depression* of the Sun or Star is its Distance from and below the Horizon.

The *Azimuth* of the Sun or a Star is its Distance from the Cardinal Points of East, West, North or South, measured on the Horizon.

The Sun or Stars *Meridian Altitude* is
its

its Altitude or Height when it is on the Meridian or at the South.

The *Vertical Altitude* of the Sun is used by some Writers for its Height above the Horizon when it is in the Azimuth or Vertical Circle of East or West. But the Sun is said *to be Vertical* at any Place when it is in the Zenith of that Place at Noon.

The *Amplitude* of the Sun or a Star is its Azimuth or Distance from East or West at rising or setting.

The *Ascensional Difference* is the Time of the Sun or Star's rising or setting before or after six a Clock: Or it is the Difference between the Sun or Star's semidiurnal Arc and a Quadrant or 90 Degrees, as some Persons express it, because 90 Degrees or a Quadrant reaches from 6 a Clock to 12.

P R O B L E M S.

Problem I. *To find the Longitude and Latitude of any Place on the Earthly Globe.*

Turn the Globe about till the Place come just under the Side of the brazen Meridian on which the Figures are, which is called its *Graduated Edge*, then the Degree marked on the Meridian just over the Place shews the *Latitude* either North or South: And the Globe so standing, that Degree of the Equator, which is cut by the Meridian shews the true *Longitude* of the Place.

Place. So *London* will appear to have $51\frac{1}{2}$ Degrees of North Latitude, and near 18 Degrees of Longitude, counting the first Meridian at *Teneriff*. So *Rome* has $41\frac{3}{4}$ Degrees of North Latitude, and about 13 Degrees of Longitude, Eastward from *London*, or almost 31 Degrees from *Teneriff*.

Problem II. *The Longitude or Latitude of any Place being given, how to find that Place on a Globe or Map.*

If only the *Latitude* of a Place be given, the Place itself may be easily found by casting your Eye Eastward and Westward along that Parallel of Latitude in that Part of the World where it lies, and the Place (if it be marked on the Globe) will soon appear.

If the *Longitude* only were given, guide your Eye along that Meridian Northward or Southward, and you will quickly see it.

But if both *Longitude* and *Latitude* be given then the Place is immediately found, for where the given *Line of Longitude* or Meridian cuts the given *Line of Latitude*, there is the Place required. These two Problems also may be practised on a Map as well as on a Globe.

Problem III. *To find the Distance of any two Places on the Earthly Globe, or two Stars on the Heavenly.* Here

Here let it be noted that a *Degree* of the Meridian or of the Equator, or of any great Circle on the Earthly Globe is found by Measure to be $69\frac{1}{2}$ or 70 *English Miles*: See Prob. XII. Sect. XX. Tho' Geographers many times count 60 *Geographical Miles* to a Degree, making them the same with the *Minutes* of a Degree for the greater Ease in Computation.

Let it be noted also, that all the *Degrees* on the Meridians or *Lines of Longitude* on the Globe are equal, because all those Lines are great Circles; but in the *Parallels of Latitude*, the farther you go from the Equator the Circle grows less and less, and consequently the *Degrees* of those Circles are less also: And therefore if two distant Places are either both *on the Equator* or have the *same Meridian*, the Number of the Degrees of their Distance on the Equator or on the Meridian being reduced to Miles shews you their true Distance: But if the two Places are not both *on the Equator* nor *on the same Meridian*, you must find their true Distance by the following Method.

To perform this *third Problem* lay the Quadrant of Altitude from one Place to the other, and that will shew the Number of Degrees of Distance, which being multiplied by 60 *Geographical Miles*, or by

110 *The first Principles of* Sect. 19.
70 *English Miles*, will give the Distance sought.

Or you may take the Distance between the two Places with a Pair of Compasses and measure it upon the Equator, which shews the Distance in *Degrees*, and then reduce them to *Miles*.

The Quadrant of Altitudes or a Pair of Compasses in the same Manner, will shew the Distance of any two Stars on the Heavenly Globe (*viz.*) in *Degrees*, but not in *Miles*.

Observe here, that though these Methods will find the true Distance of Places on the *Globe*, yet on a *Map* the same Methods are useless; because in Maps or plain Surfaces the *Degrees* of Longitude marked on the same Parallel of Latitude are unequal, and so the *Degrees* of Latitude marked on the same Meridian are often unequal. (See the *XI. Section* concerning *Maps*.) The only Way therefore of measuring Distances on a Map is to measure the Number of *Degrees* on the nearest *correspondent Line of Longitude* or *Latitude*, and apply that to the Distance required, which after all is but an uncertain Account.

Problem IV. *To find the Antœci, Periœci and Antipodes of any Place given, suppose of London.*

Bring

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Bring *London* to the Meridian, observe its Latitude Northward, then reckon so many Degrees on the Meridian from the Equator Southward, and it shews the Place of the *Antæci*.

Keep *London* under the Meridian, set the Hour Index or Pointer on the Dial at the Pole to the upper 12 which is 12 a Clock at Noon, turn the Globe about till the Index point to 12 at Midnight, and the Place that will be under the same Degree of the Meridian where *London* was, shews where the *Periæci* dwell.

The Globe so standing, count the same Degrees of Latitude from the Meridian Southward, and that will shew who are the *Antipodes* to *London*.

Problem V. *Any Place being given to find all those Places which have the same Hour of the Day with that in the given Place.*

All the Places that have the *same Longitude* have the *same Hour*. Bring the given Place therefore to the Brazen Meridian, and observe what Places are then exactly under the graduated Edge of the Meridian, for the People in those Places have the same Hour, and their Habitation has the same Longitude.

Problem VI.

Problem VI. *Any Place being given (suppose Paris) to find all those Places in the World which have the same Latitude, and consequently have their Days and Nights of the same Length.*

Bring *Paris* to the Meridian, and you find it near 49 Degrees North Latitude. Turn the Globe all round, and all those Places which pass under the 49th Degree of the Meridian have the same Latitude with *Paris*, and the Pole is just as much elevated above their Horizon, viz. 49 Degrees.

Problem VII. *To rectify the Globe according to the Latitude of any given Place.*

Elevate the proper Pole (whether it be North or South) so far above the Horizon as is the *Latitude of the Place* proposed; this is done by moving the Pole of the Globe upward from the Horizon, counting by the Degrees of the under Part of the Meridian, which begin to be numbered from the Pole; thus for *London* you must raise the Pole $51\frac{1}{2}$ Degrees above the Horizon.

Then while *London* stands under the Meridian, the true and real Situation of it is exactly represented on the Globe with its proper Horizon: For *London* is by this Means placed in the *Zenith*, or on the very Top of the Globe, at 90 Degrees Distance from the Horizon every Way; and thus the
Zenith

Zenith is as high above the *Equator* on the South side as the *Pole* is above the *Horizon* on the North side.

To render this Representation of the Situation of any Place yet more perfect, 'tis a useful thing to have a small *Mariner's Compass* at hand with a Needle touch'd with a Loadstone, to shew which are the *North* or *South* Points of the *real Horizon*, and then, as near as you can, set the Brazen Meridian of the Globe exactly *North* and *South*.

Thus the *Wooden Horizon* will be a perfect Parallel to the *real Horizon*, the *brazen Meridian* to the real *Meridian*, the *Equator*, the *Ecliptick* and all the *lesser Circles*, and the *Points* on the Globe will represent those Circles and Points on the Earth or in the Heavens, in their proper Position.

Problem VIII. *The Hour being given in any Place (as at London) to find what Hour, it is in any other part of the World.*

Rectify the Globe for *London*, bring the City *London* to the side of the Meridian where the Degrees are marked; then fix the Index of the Dial-plate to the *Hour* given, (suppose four a Clock in the Afternoon) this being done turn the Globe and bring any Places successively to the Meridian, then the Index or Hour Pointer will shew

shew the *true Hour* at the *Place* required. Thus when it is four a Clock in the Afternoon at *London* it is almost five at *Rome*, near six at *Constantinople*, 'tis almost half an Hour past nine at Night at *Fort St. George* in the *East-Indies*, 'tis near Midnight at *Pekin* in *China*, 'tis eleven a Clock in the Morning at *Jamaica*, and a little past Noon at *Barbadoes*.

Problem IX. *To rectify the Globe for the Zenith.*

After the former Rectification for the *Latitude* of the *Place*, fasten the Edge of the Nut of the Quadrant of Altitude on its graduated side at the proper Degree of Latitude on the graduated side of the brazen Meridian, and that will represent the *Zenith* of that *Place* in the Heavens.

The Quadrant of Altitude being thus fastened serves to measure the *Sun* or *Star's* *Altitude* above the *Horizon*, and the *Sun* or *Star's* *Azimuth*; and it has been sometimes (though erroneously) used to shew the *Bearing* of one *Place* to another, as in the following Problem.

Problem X. *Any two Places being given, to find the Bearing from one to the other, i. e. at what Point of the Compass the one lies in respect to the other.*

The

The common Way whereby several Writers have solved this Problem is this. Rectify the Globe both for the *Latitude* and for the *Zenith* of one of those Places, and bring that Place to the Zenith. Then bring down the Edge of the Quadrant of Altitude to the other Place, and the End of the Quadrant shall cut the Horizon in the true Point of the Compass, and shew how the one bears to the other. So if you rectify the Globe for the Latitude and Zenith of *Barbadoes*, you will find that *Cape Finisterre* in *Spain*, and *Azoff* in *Muscovy*, both lie in a direct Line *North-East* from *Barbadoes*, according to this Practice.

But here let it be noted, that though according to this Sort of measuring, they both lie *North-East* from *Barbadoes*, yet they do not lie *North-East* of one another; for if you rectify the Globe for the Latitude and Zenith of *Cape Finisterre*, you will find *Azoff* lies near *East-North-East* from *Cape Finisterre*, or more than two Points of the Compass, (*i. e.* more than $22\frac{1}{2}$ Degrees different from the *North-East*).

And if a Sailor or Traveller who is at *Barbadoes*, should every League or Mile of his Way, by observing the Compass, still make toward the *North-East*, he would come sooner to the *Hebrides* or *Western Scots Islands* than to *Azoff*, or even to *Cape Finisterre*. But the Course that he must

I

really

really steer to come to *Cape Finisterre* is near *North-East and by East*: And if he could sail all the Way clear to *Azoff* from *Barbadoes*, he must steer still much *more* to the *Eastward*: All which Things shew the Mistake of solving this Problem in this Manner.

Perhaps this may be made yet plainer to a Learner, if we name two Places which lie under the same Parallel of Latitude, (*viz.*) *Madrid* in *Spain*, and *Pekin* in *China*, Latitude 40. Now these must always bear directly East and West from each other. But if you bring *Madrid* to the Zenith, and having fixed there your Quadrant of Altitude, you bend it down to the Horizon, it will not follow the Course of the 40th Parallel of Latitude, and lead your Eye to *Pekin*, but to much more Southern Places very far distant from *Pekin*, and which have a very different *Bearing*, (*viz.*) to the Isle of *Ceylon*, &c.

Upon this Account, the best Writers call that the *Angle of Position* between two Places, which is found by the Quadrant of Altitude thus fixed at the Zenith of any Place, and drawn down to the Horizon: But they describe the *Rhumb* or *Course of Bearing* from one Place to the other in a different Manner, (*viz.*) It is that *Point of the Compass*, toward which any Person must constantly sail or travel, in order to arrive at the distant Place given. And without all doubt

doubt, this is the most just and exact Account of Things.

Now in order to find this, it is sufficient for a Learner to know, that if any one of the Lines drawn from the Points of the *Mariner's Compass* marked on the Globe, (which are called *Rhumb Lines*) passes through both Places, that Line shews *the Course or Bearing from one to the other*, as the Course from *Cape St. Vincent* in *Portugal*, to *Cat Island* among the *Bahama Islands*, is *West and by South*.

If no *Rhumb Lines* pass through those Places, then that *Rhumb Line* to which those two Places lie most parallel, shews their Bearing: Thus the Course from *Barbadoes* to *Cape Finisterre* is *North-East and by East*, or thereabouts.

If the Learner has a Mind to see the Reason, why there must be such a Difference betwixt the *Angle of Position* between two Places, and their *Course of Bearing* to each other, I know not how to represent it upon a flat Surface plainer than by Figure XXI.

Suppose the four Cardinal Points, *North*, *South*, *East*, and *West*, are represented on the Globe by the Letters N. S. W. E: Suppose three distant Places are B *Barbadoes*, C *Cape Finisterre*, and A *Azoff*. If the Surface of the Earth were not Spherical, but a Plane, and the *Meridians* of these Places were all parallel (as in that Representation

or Projection of the Globe, which is called *Mercator's Chart*) then their *Angle of Position* and their *Course of Bearing* would be the same: Then as ns is the Meridian of the Place B , so qu would be the Meridian of the Place c , (*viz.*) a strait Line and parallel to ns : Then the Line BCA would be the Line or Rhumb of *North-East*, (*viz.*) 45 Degrees distant from ns ; which would represent both the *Angle of Position* and the *Course of Bearing* between all the three Places B , c and A : For the Angle qca would be the same with the Angle nba ; and thus A would still bear *North-East* from c and from B *.

But the Earth being of a Spherical Figure and the Meridians meeting in the Poles, the Meridian of B on the Globe being brought to the Zenith is ns ; the Meridian of c is the Curve Line ncm ; and the Meridian of A is the Curve Line naz ; all which meet in n the North Pole. Now though the strait Line BCA shews the *Angle of Position* between the three Places B , c and A , (as B stands on the Globe at the Zenith) yet the Line BCA does by no

* And for this Reason in those Sea Charts where the Points of the Compass or Rhumbs are drawn in strait Lines quite through the Chart, the Meridians or Lines of Longitude are all made strait and parallel Lines: For if the Meridians were a little curved as they are commonly in Maps, the Rhumbs could not be drawn through the Chart in strait Lines. See *Sect. XI. Of Sea Charts*, pag. 68.

means make the *same Angles*, or has the *same Bearing* with the Curve Line $N C m$ (which is the Meridian of c) as it does with $N s$ (which is the Meridian of B :) and it still makes more different Angles with the Curve Line $N A z$ (which is the Meridian of A .)

Thence it follows, that all the *Rhumb Lines* must be a Sort of Spiral Lines on the Globe, except the *North* and *South*, which is the *Meridian*, and the *Equator* with its *Parallels of East* and *West*, which are *Circles* *.

The *North-East* Line in this Place must be $B P x$ still gradually inclining toward the several Meridians, that so it may make the *same Angles* with the Meridians $N C m$ and $N A z$, as it does with $N B s$.

But by this Means you see, that to steer or travel still to the *North-East* would bring you down to P and x , not to c and A .

You see also, that the Course you must steer or travel to come to A will be repre-

* All the other Lines of *East* and *West* besides the *Equator*, are *Parallels of Latitude*, and are lesser *Circles*. And though the Line of *East* and *West* in this Figure, be for the Ease of a young Learner represented in a straight Line, because it is a Parallel to the *Equator*, and if drawn round the Globe would be a perfect Circle and run into itself, yet it should more properly be so far curved, as to cut all the *Side-Meridians* $N m$ and $N z$ at right Angles, as well as the Meridian of the Place $N s$. And thus they are commonly drawn in Maps of the World, wherein there is no Line of *East* and *West* drawn straight besides the *Equator*.

sented by the Line *B r A*, which is much nearer the *East Point*.

But this is something too laborious and painful for every Reader to trouble his Thoughts with it.

Problem XI. *Having the Day of the Month given, to find the Sun's Place in the Ecliptick.*

Find the Day of the Month in the Calendar on the Horizon, (either Old Stile or New, which soever is required) lay a flat Rule on the Day of the Month, and over against it on the inner Edge of the Horizon, will appear both the Sign in which the Sun is, and the Degree of that Sign, as on the 10th of *May* Old Stile, the Sun is just entering into the *first Degree of Gemini*, which you may find in both the Globes on the Ecliptick Circle; and there you may also compute the Longitude of the Sun from the Point *Aries* if you please.

Problem XII. *The Day of the Month being given, to find those Places of the Globe where the Sun will be Vertical or in the Zenith that Day.*

Find out the Sun's Place in the *Ecliptick Circle*; bring it to the Meridian; mark the Degree over it; then turn the Globe round, and all those Places that pass under that Degree will have the Sun in their *Zenith* that Day.

Pro-

Problem XIII. *The Day and Hour of the Day at one Place, (viz.) London being given, to find at what other Place the Sun is Vertical at that Hour.*

The Sun's Place for that Day being brought to the Meridian, and the Degree over it, (*i. e.* the Declination) being observed, bring the first Place, *i. e.* London to the Meridian. Set the Hour Index to the given Hour; and turn the Globe till the Index come to the upper 12, (that is 12 at Noon) then the Place of the Earth that stands under the observed Degree of the Meridian, has the Sun at that Moment in the *Zenith*.

Problem XIV. *The Day and Hour at one Place, (viz.) London being given, to find all those Places of the Earth where the Sun is then rising, setting, or on the Meridian, (which is called culminating) also where it is Day-light, Twilight, or dark Night.*

By the foregoing Problem, find the Place where the Sun is Vertical at the Hour given: Rectify the Globe for the Latitude of that Place; bring that Place to the Meridian.

Then all those Places that are in the *West* Semi-Circle of the Horizon have the *Sun rising*, for it is 90 Degrees from their *Zenith*.

Those in the *East* Semi-Circle of the Horizon have it *setting*, for it is 90 Degrees past their *Zenith*.

To those who live under the same Line of Longitude or Upper-Meridian, it is *Noon*, if they have any Day at that Time.

To those who live under the opposite Line of Longitude or lower Meridian, it is *Midnight*, if they have any Night at that Time.

Those Places that are above the Horizon, have the *Sun above their Horizon* so many Degrees, as the Places themselves are.

Those Places that are under the Horizon, but within 18 Degrees, have *Twilight*.

And with those who are lower than 18 Degrees, it is *dark Night*.

Problem XV. *A Place being given in the Torrid Zone, to find those two Days in which the Sun shall be Vertical there.*

Bring the Place to the Meridian; mark the Degree over it, which is its *Latitude*; move the Globe round, and observe these two opposite Points of the Ecliptick, that pass through the aforesaid Degree; search on the Wooden Horizon on what two Days the Sun passes through those two Points of the Ecliptick, for then the Sun at Noon will be in the *Zenith of the Place* given.

Problem XVI. *A Place being given in one of the Frigid Zones, (suppose the North) to find when the Sun begins to depart from, or to appear on that Place, how long he is absent, and how long he shines constantly upon it.*

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Suppose the Place given be the North *Cape of Lapland* 71 Degrees of Latitude. Rectify the Globe for that Place, or elevate the Pole 71 Degrees; then turn the Globe till the descending Part of the Ecliptick, the Meridian and South Point of the Horizon meet together: Thus the Ecliptick will shew, that the Sun toward the *End of Scorpio* (that is, a little after the *Middle of November*,) goes below the Horizon intirely and leaves that Part of *Lapland*.

Then turn the Globe a little further, till the ascending Part of the Ecliptick meet the Meridian in the same South Point of the Horizon, and it will shew that about the ninth or tenth Degree of *Aquarius*, that is, about the *End of January*, the Sun begins to rise above their Horizon. Thus they are at least two Months without the Sun in *Winter*.

In like Manner bring the ascending Part of the Ecliptick to meet the Meridian in the North Point of the Horizon, there you will find that the Sun begins to be entirely above their Horizon toward the *End of Taurus*, or near the *Middle of May*; and if you turn the Globe a little farther, the descending Ecliptick will meet the Meridian and Horizon in the North at the 8th or 9th Degree of *Leo*, or about the *Beginning of August*: Thus it appears that those *Laplanders* will have the Sun at least two Months above
their

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 their Horizon in Summer, or two Months
 of compleat Day-light.

Problem XVII. *To find the Sun's Declination and Right Ascension any Day in the Year: Suppose the twenty-first of May.*

Find out the Sun's Place for that Day, or the beginning of the first Degree of *Gemini* on the Ecliptick; bring that Point of the Ecliptick to the Meridian, and the Degrees numbered on the Meridian will shew the *Sun's Declination*, (*viz.*) 20 Degrees Northward.

At the same Time the Place where the Meridian cuts the Equator will shew the *Right Ascension of the Sun*, or its Distance from the Point *Aries* on the Equator, (*viz.*) 58 Degrees. It is marked usually in Degrees on the Globe; if you would turn it into Hours, divide it by 15, and it amounts to three Hours $\frac{13}{15}$ which is 52 Minutes $\frac{4}{15} = \frac{2}{15}$ $\frac{1}{15} = 4'$

Note, That any *Star's Declination* and *Right Ascension* are found the same Way by bringing it to the Meridian. $\frac{2}{15} = 8'$

Remember the Sun's Declination is always *North* in our Summer Half-Year from the 21st of *March*, and *Southward* in our Winter Half-Year from the 23^d of *September*.

Problem XVIII. *To rectify the Globe for the Sun's Place, any Day in the Year, and thus to represent the Face of the Heavens for that Day.* Bring

Bring the Sun's Place found on the Ecliptick of the Globe to the Meridian ; and at the same time set the Hour-Index or Pointer of the Dial to the upper 12, that is, to *Noon*.

Note, When the Globe is thus rectified for the *Latitude* of the particular Town or City by Problem 7th, and for the *Zenith* of it by Problem 9th, and for the *Sun's Place in the Ecliptick* that Day by this Problem 18th, it is then fitted to resolve most of the following Problems, for then it most exactly represents the real Face and State of the Heavens for that Day.

Here let it be observed, that this Practice does really represent the Face of the Heavens only for that Day at *Noon*, (when the Astronomers Day begins) and not for all the following Hours of the Day ; because the Sun is every Moment changing his Place a little in the Ecliptick. But it is customary, and it is sufficient for Learners, to make this go for a Representation of the Heavens for all that Day, to perform any common Operations.

Problem XIX. *The Place and Day being given, (viz. May 10th at London) to find at what Hour the Sun rises or sets, his ascensional Difference, his Amplitude, the Length of Day and Night.*

Rectify

Rectify for the *Latitude*, and for the *Sun's Place*, then bring the Sun's Place down to the *Eastern Part* of the Horizon, and the Index will shew the Time of *Sun rise* on the Dial, (*viz.*) five Minutes after four in the Morning. Bring the Sun's Place to the *Western Side* of the Horizon, and the Dial will shew the Hour of *Sun setting*, (*viz.*) five Minutes before eight at Night.

Thus his *Ascensional Difference* will appear, that is, how long he rises or sets before or after six a Clock, which is one Hour and 55 Minutes.

Thus also his *Amplitude* will appear in the Horizon to be almost 34 Degrees to the *North of the East*.

The Hour of the *Sun's rising* doubled gives the *Length of the Night*, (*viz.*) eight Hours and 10 Minutes; and the Hour of the *Sun's setting* doubled gives the *Length of the Day*, which will be 16 Hours wanting 10 Minutes, *i. e.* 15 Hours 50 Minutes.

Problem XX. *The Place and Day being given, to find the Altitude of the Sun at any given Hour.*

Rectify for the *Latitude*, for the *Zenith* and for the *Sun's Place*: Bring the *Quadrant of Altitude* under the Meridian, and it will meet the Sun's Place in the Meridian Altitude of the Sun that Day, and thus shew how high it is at *Noon*. Turn

Turn the Globe till the Index point to any other given Hour on the Dial, then observe where the Sun's Place is, bring the Quadrant of Altitude to it, and it will shew the Sun's Altitude at *that Hour*: Thus *May 10th*^{0.4} at *London*, the Sun's Meridian Altitude will be a little above $58 \frac{1}{2}$ Degrees, and at 9 a Clock in the Morning will be $43 \frac{1}{4}$.

Problem XXI. *The Place and Day being given, to find the Azimuth of the Sun at any given Hour.*

Rectify the Globe for the *Latitude*, the *Zenith* and the *Sun's Place*: Then turn the Globe till the Index point to the Hour given; then observe the Sun's Place; bring the Edge of the Quadrant of Altitude down upon it, and it will cut the Horizon in the *Azimuth of the Sun*, or shew what Point of the Compass the Sun is in. Thus *May 10th*^{0.5} at 20 Minutes past 9 in the Morning, the Sun's *Azimuth* will be about 60 Degrees from the *South toward the East*, that is, near *South-East and by East*.

Problem XXII. *The Sun's Altitude being given at any certain Place and Day, to find the Hour of the Day, and also his Azimuth.*

Rectify as before for the *Latitude*, the *Zenith* and the *Sun's Place*: Turn the Globe, and move the Quadrant of Altitudes so that
the

the Sun's Place may meet the Degree of Altitude given on the Quadrant, then the *Index* will shew the *Hour* on the Dial; and the Quadrant of Altitude will cut the *Azimuth* on the *Horizon*. Thus *May* 10th in the Morning, if the *Altitude* be near 46 Degrees the *Azimuth* from the South will be 60, and the *Hour* 26 Minutes past 9.

Here *Note*, That to find the *Sun's Hour* or *Azimuth* by his *Altitude*, you should never seek it too near Noon, because then the *Altitude* alters so very little for two Hours together.

Problem XXIII. *When the Sun is due East or West in Summer, how to find the Hour, and his Altitude.*

Rectify as before; then bring the Quadrant to cut the *East* or *West* Point of the *Horizon*, and turn the *Globe* till the *Sun's Place* in the *Ecliptick* meet the Edge of the Quadrant. Thus the Quadrant will shew the *Altitude*, and the *Index* will point to the *Hour*: Thus *May* 10th⁰⁵ in the Afternoon, the *Sun* will be *due West* at about 56 Minutes past 4; and its *Altitude* will be near 26 Degrees. This is called the *Vertical Altitude* by some Writers.

Thus if the *Place* and *Day* be known, and either the *Hour*, the *Azimuth*, or the *Altitude* be given, you may easily find the other two.

Pro-

Problem XXIV. *To find the Degree of the Depression of the Sun below the Horizon, or its Azimuth at any given Hour of the Night.*

Observe the Place of the Sun, suppose *May* 21st in the first Degree of *Gemini*, then seek his opposite Place in the *Ecliptick* at half a Year's Distance, (*viz.*) the first Degree of *Sagittary* on the 23d of *November*; this being done, seek the *Altitudes*, the *Azimuths*, and the *Hours* just as you please for that Day, and they will shew you what are the Sun's *Depressions*, *Azimuths*, and *Hours*, on the 21st of *May* at Night*.

Problem XXV. *To find how long the Twilight continues in any given Place and given Day, suppose the 21st of May at London, both at Morning and Evening.*

The Way to answer this Question is to seek how many Hours or Minutes it will be after Sun set, before the Sun be deprest 18 Degrees below the Horizon in that Place on the 21st of *May*: And so before Sun rise for the Morning Twilight. This

* *Note*, The Reason why we use the opposite Part of the *Globe*, to find the Degrees of *Depression* of the Sun, is because the *Wooden Horizon* is so thick, that we cannot conveniently see, observe, or compute the Distances of Depression from the upper Edge of it, which Edge is the true Representative of the real *Horizon*.

is best performed by seeking how long it will be after *Sun rise* or before *Sun set* on the 23d of *November*, that the Sun will have 18 Degrees of Altitude, which is done by the foregoing Problem.

Note, That from the 26th of *May* to the 18th of *July* at *London*, there is no *dark Night*, but constant *Twilight*: For during this Space the Sun is never deprest above 18 Degrees below the *Horizon*.

Problem XXVI. *To know by the Globe the Length of the longest and shortest Days and Nights in any Place of the World.*

Remember that the Sun enters the first Degree of *Cancer* on the longest Day, at all Places on the *North* Side of the *Equator*, and the first Degree of *Capricorn* on the *South* Side: Also remember that he enters the first Degree of *Capricorn*, the shortest Day in all Places of the *Northern* Hemisphere, and the first Degree of *Cancer* in the *Southern*: Then rectify the Globe for the *Latitude* and *Sun's Place*, and find the Hour of *Sun rising*, which doubled shews the Length of the *Night*: And the Hour of the *Sun setting* doubled, shews the Length of the *Day*, as in Problem XIX.

Problem XXVII. *The Declination and Meridian Altitude of the Sun, or of any Star,*

Star being given, to find the Latitude of the Place.

Mark the Point of *Declination* on the Meridian, as it is either *North* or *South* from the *Equator*; then slide the Meridian up and down in the Notches, till the Point of Declination be so far distant from the *Horizon* as is the given *Meridian Altitude*. Then is the Pole elevated to the Latitude sought.

Thus where the Sun or any Star's *Meridian Altitude* is $58\frac{1}{2}$ Degrees, and its *Declination* 20 Degrees *Northward*, the *Latitude* of that Place will be $51\frac{1}{2}$ Degrees North. See more *Problem VII, VIII, IX. Sect. XX.*

Note, There are some few *Problems* which relate to the Sun and to the Hour, which may be performed on the Globe when the Sun shines, though not with any great Exactness, yet sufficient for Demonstration of the Reason of them as follows.

Problem XXVIII. The Latitude of a Place being given, to find the Hour of the Day in the Summer when the Sun shines.

Set the Frame of the Globe upon a Plane perfectly Level or Horizontal, and set the Meridian due North and South; both which are difficult to be done exactly; even though you have a *Mariner's Compass* by you:

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Then

Then rectify the Globe for the Latitude, and the iron Pin of the Pole will cast a Shadow on the Dial and shew the *true Hour*. For when the Globe is thus placed, the Dial Plate with the Pole in the Centre of it, is a true *Equinoctial Dial* for our *Summer Half-Year*, when the Sun is on the North Side of the Equator.

The same may be also done in the *Winter Half-Year*, by depressing the North Pole as much below the South Part of the Horizon as is equal to the Latitude of the Place; for then the *Dial Plate* is a proper *Equinoctial Dial* for the *Winter Half-Year*: But this is not so commodiously performed, though the Reason of it is the same as the former.

Problem XXIX. *To find the Sun's Altitude, when it shines, by the Globe.*

Set the Frame of the Globe truly Horizontal or Level; turn the North Pole to the Sun; move the Meridian up and down in the Notches till the Axis cast no Shadow; for then it points exactly to the Sun, and then the Arch of the Meridian between the Pole and the Horizon shews the *Sun's Altitude*.

Problem XXX. *The Latitude and Day of the Month being given, to find the Hour of the Day when the Sun shines.*

Let

Let the Globe stand on a Level, and the Meridian due North and South; rectify the Globe for the *Latitude* and for the *Sun's Place*; stick a Needle perpendicular to the Sun's Place on the Globe; turn the Globe about till the Needle point directly toward the Sun, and cast no Shadow; then will the *Index* shew the Hour of the Day.

I proceed now to shew some *Problems to be performed by the Stars* upon the Heavenly Globe.

Problem XXXI. *The Place being given, to find what Stars never rise or never set in that Place.*

Rectify the Globe for the *Latitude*; turn it round, and observe that such Stars as do not go under the Horizon during its whole Revolution, do never set in the Place given; and such Stars as rise not above the Horizon of the Globe during its whole Revolution, they never rise in the Place given, nor are ever seen by the Inhabitants thereof: So the *little Bear*, the *Dragon*, *Cepheus*, *Cassiopea* and the *great Bear* never set at *London*, and many of the *Southern Constellations* never rise.

Problem XXXII. *The Place and Day of the Month being given, to represent the Face or Appearance of the Heavens and shew the*
K 2 *Situation*

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*Situation of all the fixed Stars at any Hour
of the Night.*

Set the Globe exactly North and South : Rectify it for the *Latitude*, and for the *Sun's Place* ; then turn the Globe till the Index points to the given Hour. Thus every Star on the Globe will exactly answer the Appearance of the Stars in the Heavens ; and you may see what Stars are near or on the Meridian, which are rising or setting, which are on the East or West Side of the Heavens. Thus *October 24th* at 10 a Clock at Night, the glorious Constellation *Orion* will appear on the East Side at *London*, the Star *Regel* in the left Knee (or Foot) of *Orion* just above the Horizon, the *three Stars* in his *Girdle* a little higher, &c. This represents the Face of the Heavens at Night, as *Problem XVIII* does in the Day.

Note, This Problem is of excellent Use to find out and know the several Constellations, and the more remarkable Stars in each Constellation.

Here follow several *Problems* to find the *Hour of the Night* by the Stars.

Problem XXXIII. Any Star on the Meridian being given, to find the Hour of the Night.

In order to find what Stars are upon the Meridian at any Time, it is good to have
a Me-

a *Meridian Line* drawn both in a North and in a South Window; that is, a *Line pointing exactly to the North and South*: Then set up a broad smooth Board of 20 or 24 Inches high, and 8 or 10 Inches broad; place it perpendicular on the Window with its lower Edge on, or parallel to the Meridian Line; and fixing your Eye at the upright nearest Edge of the Board, and glancing along the plain Face of it, you will easily observe what Stars are on the Meridian, either North or South at that Time*.

Having found what Star is on the Meridian, rectify the Globe for the *Latitude*, and for the *Sun's Place* that Day; then bring the Centre of the Star which is on the Meridian in the Heavens to the Edge of the brazen Meridian of the Globe; and the Index will shew *the Time of Night* on the North Side of the Dial among the Evening, or Midnight, or early Morning Hours.

Note, How to draw a Meridian Line, see *Sect. XX. Problem XXII, &c.*

K 3

Problem

* *Note*, To set the Board perpendicular and convenient, it is fit to have a Foot made to it behind, that it may stand firm. And let a strait Line be drawn from the Top to the Bottom of the Board, through the Middle of it, parallel to the Sides: Fix also a Pin in the upper Part of this Line, near the Top of this upright Board, on which hang a Thread and Plummet, to play loose in a Hole near the Bottom, to keep it perpendicular. Then the Thread hanging almost close to the Board will direct your Eye to the Stars on the Meridian.

Problem XXXIV. *The Azimuth of any known Star being given, to find the Time of Night.*

The Method I just before proposed, will easily find the *Azimuth* of any Star. Set this tall flat Board perpendicular on the Window, with one End of it upon the *Meridian Line* drawn there, so as that your Eye may just see the Star in the very Edge of the Plane of this Board; then a Line drawn on the Window by the Foot of the Board will cross the Meridian Line in the *true Angle of its Azimuth*, or its Distance from North to South.

Having found the Azimuth of the Star, rectify the Globe for the *Latitude*, and for the *Sun's Place* as before; rectify it also for the *Zenith*, and bring the Quadrant of Altitude to the Azimuth of the Star in the Horizon; then turn the Globe till the graduated Edge of the Quadrant of Altitude cut the Centre of that Star, and the Index will shew the *Hour of the Night* upon the Dial Plate.

Note, That if you have a Meridian Line drawn on a Window, you may find by such Methods as these when the Sun is in the Meridian, and what is its Azimuth at any Time.

Problem XXXV. *The Altitude of a Star being given, to find the Hour of the Night.*

Note,

Note, That the Altitude of the Star must be found by a Quadrant or some such Instrument: But remember that if you would find the Hour by the Altitude of a Star, you must never choose a Star that is too near the Meridian; because for almost two Hours together, the Altitude varies very little when it is near the Meridian.

Rectify the Globe as before for *Latitude, Zenith* and *Sun's Place*; move the Globe and the Quadrant of Altitude backward or forward, till the Centre of that Star meet the Quadrant of Altitude in the Degree of Altitude which is given, then the Index will point to the *true Hour*.

Note, These three last Problems being well understood, will shew you how to find at what Hour any Star will rise or set any Day of the Year; what Stars are or will be upon the North or South Meridian at any Hour given; what Stars are in the East or the West, or on any Points of Azimuth at any Time of the Night; and what Altitude they have at that Hour, or at that Azimuth.

Problem XXXVI. *To find the Latitude and Longitude of any Star: Also its Right Ascension and Declination.*

Put the Centre of the Quadrant of Altitude on the proper Pole of the Ecliptick,

whether it be North or South; bring its graduated Edge to the given Star; then that Degree on the Quadrant is the *Star's Latitude*; and the Degree cut by the Quadrant on the Ecliptick is the *Star's Longitude*. Thus the Latitude of *Arcturus* is 31 Degrees North: Its Longitude is 200 Degrees from the Point *Aries*, or 20 Degrees from *Libra*. The Latitude of *Sirius* or the *Dog Star* is near 40 Degrees of South Latitude, and its Longitude is about 100 Degrees from *Aries*, or 10 Degrees from *Cancer*.

To find a *Star's Right Ascension* and *Declination*, see Problem XVII. for it is done the same Way as that of the *Sun*; only observe this Difference, that the *Sun* changes both his Right Ascension and his Declination every Day, whereas the *fixt Stars* have the same Right Ascension and Declination all the Days in the Year.

Remember also, that the *fixt Stars* every Day in the same Year, keep the *same Longitude and Latitude*, as well as the *same Right Ascension and Declination**; but the Planets are ever changing all these, and the
Learner

* The insensible Change of the Longitude, Right Ascension, and Declination of the *fixt Stars*, made by their slow Motion parallel to the Ecliptick is not worth Notice in this Place.

Learner can know none of them but by some Almanacks which are called *Ephemerides*, or Tables which are calculated on Purpose to shew the Longitude and Latitude, or the Place of the several Planets among the twelve Signs of the *Zodiack* every Day in the Year.

Problem XXXVII. *To find the Place of any Planet on the Globe: Also to find at what Hour any Planet, (suppose Jupiter) will rise or set, or will be upon the Meridian any given Day of the Year.*

You must first find out by some *Ephemeris*, what Degree of what Sign *Jupiter* possesses that Day of that Year: Mark that Point on the *Ecliptick* either with Chalk or with a Pencil, or by sticking on a little black Patch; and then for that Day and that Night you may perform any Problem by *that Planet* in the same Manner as you did by a *fixed Star*.

But if you would be very exact you must not only seek the *Planet's Place* in the Sign for that Day, which is its *Longitude*, but you must seek its *Latitude* also in the *Ephemeris* (which indeed in the superior Planets *Jupiter*, *Saturn*, *Mars*, alters but very little for whole Months together) and thus set your Mark in that Point of Latitude, or Distance from its supposed Place
in

140 *The first Principles of* Sect. 19.
in the Ecliptick, whether Northward or Southward, and then go to work your Problem by this Mark.

I shall give but one Instance, which will sufficiently direct to solve all others of the same Kind that relate to the Planets. On the 3d of *April* 1723, I find by an *Ephemeris* that the Sun is about the End of the 23d Degree of *Aries*, *Jupiter* enters the 8th Degree of *Capricorn*, and (if I would be very exact,) I observe also that the *Latitude of Jupiter* that Day is 15 Minutes or a Quarter of a Degree to the North: There I make a Mark or put on a small black Patch on the Globe to stand for *Jupiter*. Then having rectified the Globe for the *Latitude v. c.* of *London*, and for the *Sun's Place*, *April* the 3d, I turn the Mark which I made for *Jupiter* to the Eastern Edge of the Horizon, and I find *Jupiter* will rise near the *South-East* at a little past One in the Morning: He will come to the *Meridian* at a very little past Five: He will set near the *South-West*, about Nine in the Morning.

Then if I rectify the Globe for the *Zenith*, the Quadrant of Altitude being brought down to the Horizon, will tell you what is his *Altitude*, and what his *Azimuth*, at any given Hour of the Morning, by the Help of the Dial and Index.

Or

Or his *Altitude* or *Azimuth* being given you may find what it is a Clock.

By this Means you may find the Hour when the *Moon* will rise and set, together with her *Southing*, or the Time of her coming to the Meridian. But let it be noted, that the *Moon* changes her Place in the *Zodiack* so swiftly, that she moves through 13 Degrees of one Sign every Day, or thereabout; and therefore you cannot find the precise Hour and Minute of her *rising*, *setting*, *southing*, &c. upon the Globe without much more Trouble than most of the other Planets will give you, which change their Places in the *Zodiack* much more slowly.

Problem XXXVIII. *The Day and Hour of a solar Eclipse being known, to find all those Places in which that Eclipse will be visible.*

By the 13th *Problem* find out at what Place the *Sun* is vertical at that Hour of the Day. Bring that Place to the Pole or vertical Point of the Wooden Horizon, that is, *rectify the Globe for the Latitude of that Place*; then the Globe being in that Situation, observe what Places are in the upper Hemisphere; for if it be a large Eclipse the *Sun* will be visibly eclipsed in most of them.

Problem XXXIX. *The Day and Hour of a Lunar Eclipse being known, to find by the Globe*

Globe all those Places in which the same will be visible.

By *Problem XIII.* find as before at what Place the *Sun is vertical at that Hour*; then by *Problem IV.* find the *Antipodes* of that Place: Rectify the Globe for the Latitude of those *Antipodes*; thus they will be in the *Zenith*, or in the Pole of the *Horizon*; then observe as before what Places are in the upper Hemisphere of the Globe, for in the most of those Places the Moon will be visibly eclipsed.

The Reason of rectifying the Globe for the *Antipodes* in this Problem, is because the Moon must be directly opposite to the Sun whensoever she is eclipsed.

S E C T. XX.

Problems relating to Geography and Astronomy, to be performed by the Use of the plain Scale and Compasses.

IT is supposed that the Reader is already acquainted with some of the first and easiest Principles of *Geometry*, before he can read with Understanding this or any other Treatise of *Astronomy* or *Geography*; and it is presumed also that he knows what is a *Chord*, a *Tangent* and a *Sine*, and how to make and to measure an Angle either by a
Line

Line or Scale of Chords, or Sines or Tangents; in order to practise the Problems of this last Section; though a very slight Knowledge of these Things is sufficient for this Purpose.

Because several of the following *Problems* will depend upon the *Altitude, or Azimuth* of the Sun, and in order to obtain these, we sometimes use a *Pin or Needle* fixed perpendicularly, on an upright or Horizontal Plane; therefore the *first Problem* I propose shall be this, (*viz.*)

Problem I. How to fix a Needle perpendicular on a Plane, or to raise a perpendicular Style or Pointer in order to make Observations of a Shadow.

Note, Any Thing fixed or set up to cast a Shadow is called a Style.

One Way to perform this, is by having at Hand a *Joyner's Square*, and while one Edge of it is laid flat to the Plane, the other Edge of it standing up will shew when a *Needle or Style* is fixed on that Plane perpendicularly, if it be applied to the Side of the Needle.

Note, If you have a little Square made of Box or any hard Wood, one Leg being six, or the other eight or nine Inches long, one Inch or $1\frac{1}{2}$ broad, and an Inch thick, with a Thread and Plummet hanging from the End
of

of one Leg, down toward the Place where the other Leg is joined, as in Fig. XIV. and a large Hole for the Plummet to play in: It will be of Use not only to shew you how to erect a *Needle* truly *perpendicular*; but it will also discover whether any *Plane* be truly smooth, and be *Horizontal* or *Level*, as well as whether any *upright Plane* be exactly perpendicular to the Horizon.

Such a *Square* will also be very useful in the Practice of any *Geometrical Problems*, by drawing one Line *perpendicular* to another with the greatest Ease.

Another Way to fix a *Needle* perpendicular to any *Plane*, is this; describe a Circle as *a, o, d, b*, in Fig. XV. Fix a *Needle* *sp* in the Centre *p*, then measure from several opposite Parts of it, as *a, o, d, b*, to the Tip of the *Needle*, *s*, and fasten the *Needle* so as that the Tip *s*, shall be at equal Distance from all those Points, then it is truly *perpendicular*.

Note here, That in most of these Practices where a *perpendicular Needle* is required, the same End may be attained by a *Needle* or *Wire* strait or crooked, which may be called a *Style*, set up sloping at Random, as in Figure XVI. without the Trouble of fixing it *perpendicular*, if you do but find the Point *p* on the *Plane*, which lies perpendicularly under the Tip of the
Style

Style *s*, and this may be found by applying the Edge of the Square, described Fig. xiv. to the Tip of the Style: Though there are other Ways to find this *perpendicular Point* for nice Practices in *Dialling by Shadows*, which require great Exactness.

But *take Notice* here, that if you use this Method of a *Style* set up sloping at random as in Figure xvi. then with your *Compasses* you must measure the Distance from the Tip of the Style *s* to the Point *p*, and that Distance must be counted and used as the Length of the perpendicular Style *sp* in Fig. xv. wheresoever you have Occasion to know or use the Length of it.

Observe also, that if the Tip of your *Style* (whether *strait* or *crooked*) be more than three or four Inches high from the Plane, you will scarce be able to mark the Point of Shadow exactly, because of the *Penumbra* or faint Shadow which leaves the Point or Edge of a Shadow undetermined.

On a *Horizontal* or *Level Plane* you must use a much *shorter* *Style* when the Sun is *low*, or in *Winter*, because the Shadow is long; but in the longest Days in *Summer* a four Inch *Style* is sufficient, though the Shadow at that Season be very short all the middle Hours of the Day. From the Tip of the *Style* to the Tip of the Shadow should never be above six Inches distance.

After

After all, If you have frequent Occasion for a *perpendicular Style* to observe a Shadow by it, I know nothing easier than to get a *small Prism* of Wood, or Ivory, or rather of Brass, such as is described Fig. xvii. Let the *Base* be a right angled Triangle ABC : The *Line* BC an Inch: AB two Inches: And let the *Height* of the Prism, (*viz.*) AD or CE be three Inches (or near four Inches if you please.) By this means you obtain three perpendicular Styles of different Lengths, according as you want the Shadow to be either longer or shorter in Summer or in Winter.

If you set it upon the *Square Side* $ABDO$, your perpendicular Style will be BC or OE : If it be BC , then C is the Tip of the Style, and B marks the Point on the Plane. If you set it on the *Square Side* $BCOE$ as it stands in the Figure, then AB , or DO is your perpendicular Style. Or if you set it on its *Triangular Base* ABC , then either AD , or BO or CE will be your perpendicular Style.

This little plain *Prism* has these great Advantages in it, (*viz.*) That you can set it up in a Moment on a perfectly smooth Plane, and you are sure it is perpendicular to the Plane; and then if you require it to stand there any Time, and it should happen to be moved, if you have but fixed and marked
its

its place by the lower Edges on the Plane, and remember which Edge you design'd for the Style, you may set it exactly in the same Position again.

Problem II. *How to take the Altitude of the Sun by a Needle fix'd on an Horizontal Plane, or by any perpendicular Style.*

In all these Practices be sure that your Plane be truly *Level* or *Horizontal*, which you cannot well know without some such Instrument as I have described before, Fig. XIV. which serves instead of a *Level*.

You must apply this Instrument or Square not only to one Part, but to every Part of the Plane, wheresoever you can imagine the Shadow will fall, to see if it be precisely *Horizontal* or *Level*: For a very small Variation from the Level will cause a great Difference in the Length and in the Point of Shadow; and upon this Account there are few Window-Stools, or any Boards or Posts fix'd by the common Work of Carpenters sufficiently Level for a Just Observation in *Astronomy* or *Dialling*.

Fix your perpendicular Style ps , as in Fig. XVIII. observe the Point of Shadow cast from the tip of the Style s : Draw pc : Then take the Height of the Style ps in your Compasses; set it perpendicularly on pc ; draw the Line sc on the Plane,
L and

and the Angle c is the *Sun's Altitude* (*viz.*) 35 Degrees.

Here it is evident that if you suppose c the Centre and $c p$ to be the Radius, then $p s$ is the *Tangent of the Altitude* 35 Degrees; for it measures the Angle c or the Arch $p a$. But if you make s the Centre, and suppose $s p$ to be the Radius of a Circle, $c p$ is the *Tangent of the Coaltitude* of the Sun, (*viz.*) 55 Degrees; for it is that Tangent which measures the Angle s or the Arch $p e$.

Hence it will follow that if you fix a *perpendicular Needle, Pointer or Style*, on any Horizontal Plane, and divide a Line, as $p c$, according to the Scale of Tangents, whose Radius shall be $p s$, beginning at p towards c , and make this Line of Tangents moveable round the Centre p , the Shadow of the Style will shew you the *Coaltitude of the Sun* at any time on that moveable Scale of Tangents.

Or if the Scale of Tangents $p c$ be divided on the immoveable Horizontal Plane it self, and you describe concentric Circles on the Centre p thro' every Degree of that Scale, the Shadow of the tip of the Style will shew the *Coaltitude* among those Circles; for they will exactly represent the Parallels of Altitude in the Heavens.

Note,

Note, This is described thus particularly rather for *Demonstration* than *Use*, because when the Sun is low the Shadow $p c$ will be extended many Feet or Yards.

Problem III. *To take the Altitude of the Sun by a Style on a perpendicular or upright Plane.*

Fix your Style $A B$ perpendicular to a flat Board as Fig. XIX. Raise your Board exactly upright, and turn ^{Facing} it to the Sun, so that the Shadow of the Style $A D$ may be cast downward directly perpendicular from the Center A in the Line $A Q$. Then take the Length of the Style $A B$ in your Compasses, and set it on the Board at right Angles to the Line of Shadow, from A to B : Draw the Line $B D$; and the Angle $A D B$ shall be the *Sun's Coaltitude*, (or *Zenith Distance* as it is sometimes called) (*viz.*) 55 Degrees: The Tangent of which is $A B$ to the Radius $D A$, and the Angle $A B D$ (which is the Complement of it) or 35^d . shall be the *Sun's Altitude*; the Tangent of which is $A D$ to the Radius $B A$.

Or to make this more evident, draw the obscure Line $D O$ parallel to $A B$, *i. e.* Horizontal, and the Angle $B D O$ will plainly appear to be the Angle of the *Sun's Altitude* 35 Degrees.

Hence it will follow, that if the Line $A D$ be prolonged to Q and divided according

to the Degrees of a *Scale of Tangents*, this Board or Instrument will be always ready to shew the Sun's Altitude on that Scale, by the Shadow of the Style *A B* turn'd directly to the Sun, when the Board is held up and made to stand perpendicular to the Horizon.

N. B. This is the Foundation of those Dials which are made on *Moveable Columns*, or on *Walking Canes*, which shew the Hour of the Day by the different Altitudes of the Sun in the various Seasons of the Year.

Note, There are several other ways to find the *Altitude of the Sun* by a moveable or immoveable *upright Plane*, and a *perpendicular Style* fixed on it. But none of those Ways of taking an Altitude by the Point or End of the Shadow are the most commodious and exact for common Use; I have chiefly mentioned them to lead the Learner into a more familiar and perfect Acquaintance with the Nature and Reason of these Operations.

If no regular Instrument be at Hand to take the *Sun's Altitude*, I prefer the following Method above any others.

Problem IV. To find the Sun's or any Star's Altitude by a plain Board, Thread and Plummet.

Take a smooth flat Board as *n o p q* which is at least 8 or 9 Inches broad every
Way,

Way, See Fig. xx. Mark two Points on it as a c at least at seven or eight Inches distance, and draw that Line. Fix a very short Pin at c perpendicular which may be done sufficiently true by guess. Hang a Thread and Plummet on it. Hold up the Edge of the Board to the Sun till the Shadow of the Pin be cast all a along the Line a c . Observe where the Thread falls; mark a Point in it as at d ; draw the Line d c , and the Angle a c d is the *Complement of the Sun's Altitude*: Or you may draw the whole Quadrant a c e , and then the Angle d c e is the *Sun's Altitude*. Now if the Arch d e be measured by a Line of Chords you find the Number of Degrees.

Note, That the Degrees of Altitude must always be reckoned from that side of the Quadrant which is held next to the Sun, (*viz.*) c e . The Coaltitude from the side c a .

Note farther, That the *Sun's Altitude* should scarce ever be taken within half an Hour of Noon for any other Purposes beside the finding of the *Meridian Altitude*; because for an Hour together the Altitude then increases or decreases so very little, the Sun being then near the Middle of its diurnal Arch.

Take Notice also, That when the Sun is near the Horizon it appears higher than really it is by Reason of the *Refraction* or

breaking of its Rays in passing through a larger Space of *Atmosphere* or thicker Air. When the Sun is one Degree high its *Refraction* causes it to appear near half a Degree higher than it is. At two Degrees high the *Refraction* is 20 Minutes, at three Degrees the *Refraction* is 15 Minutes, at five Degrees the *Refraction* is 10 Minutes, at 10 Degrees the *Refraction* is five Minutes. You must therefore allow proportionably by deducting so much from the *apparent Altitude* when you make an Observation near Sun-rise or Sun-set.

Nota again, That the heavier your Plumbet is, the more steady it will hang, and make the Observation more exact.

If you please you may draw the whole Quadrant on the Board, and stick in the Pin at the Centre before you make your Observation, which indeed is the most proper way.

You may find the *Altitude of the Moon* the same way. And the *Altitude of any Star* may be found by the same Board, if you stick in another very short Pin perpendicular at *a*, and fixing your Eye at *s* bring both the Pins *a* and *c* just over the Star; then the Thread will hang (suppose) on the Point *d* in the Arch, and shew the Degree or Angle of Altitude to be *d c e*,

Problem V. *To observe the Meridian Altitude of the Sun or its Height at Noon : And by the same Method to find any Star's Meridian Altitude.*

If you know exactly when it is *Noon*, take the *Altitude of the Sun* by any Instrument within a Minute or two of that time, and that is the *Meridian Altitude* ; for two or three Minutes at *Noon* make no sensible Difference in the *Altitude*.

But if you have no Clock or Dial or any thing of that kind whose truth you can rely on, then a little *before Noon* observe and set down the *Altitude* every four or five Minutes till you find it begins to grow a little less, then review your Observations, and the greatest Height was the true *Meridian Altitude*.

You may, by the same Method, find the *Meridian Altitude of any Star* above the *Horizon*, if you make several Observations, when the *Star* is coming near to the *North* or *South Part* of the *Meridian*.

Problem VI. *How to find out the Declination of the Sun, or of any large or known Star.*

If you know the *Latitude of the Place* where you are, with the *Meridian Altitude of the Sun* any *Day* in the *Year*, or if you know the *Sun's Place in the Ecliptick*, you

may find the *Declination of the Sun* thereby *Geometrically*, as shall be shewn afterward: But if these are not known, then in order to other Astronomical Operations, you must seek the *Declination of the Sun* for that Day, either by the *Globe* on the brazen Meridian; or in a *Scale of the Sun's Declination*, which is drawn on artificial Quadrants, or other Mathematical Instruments; or it may be found in *Tables of the Sun's Declination* calculated exactly to every Minute of a Degree for every Day in the Year, which is the best way where it may be had.

There are also *Tables of Declination of several of the most noted Stars*. These are all the Year at the same Distance from the Equator, and their *Declination* does not vary, as the *Sun's* does.

These Tables of the Sun's and Stars Declination are found at the End of this Book, Sect. XXI.

But let it be noted here, that the *Declination of the Sun* not only changes every Day in the Year, but it differs also some few Minutes in the next Year from the Year foregoing, even on the same Day of the Month: Whence this Difference arises, and how to act with respect to it, see Problem XX. following, and more in Sect. XXI.

Problem VII. *To find the Latitude of any Place by the Meridian Altitude and Declination of the Sun any Day in the Year.*

The Way to find the *Latitude* of any Place (*i. e.* the Distance of the Zenith of that Place from the Equator) by the Meridian Altitude of the Sun, is first to seek its *Colatitude*, *i. e.* the Complement of its Latitude, or (which is all one) the Elevation of the Equator above the Horizon of that Place. Suppose the Day given be the 21st of June, or the Summer Solstice.

This may be done by looking back to Figure III. First, Draw the Line HO for the Horizon, and from the Centre c raise a Perpendicular cz to represent the Zenith. Make the Semicircle HzO for the Meridian: Then suppose the *Meridian Altitude of the Sun* at the Summer Solstice be 62 Degrees, by the Use of your Compasses and a Scale of Chords set up 62 from H to s : Also the *Declination of the Sun* that Day being $23\frac{1}{2}$ Degrees Northward, set $23\frac{1}{2}$ from s downward, and it will find the Point E , and the Arch HE is the *Altitude of the Equator* above the Horizon, or the *Colatitude* of the Place, (*viz.*) $38\frac{1}{2}$ Degrees; Thence you find the *Latitude* is Ez or $51\frac{1}{2}$ Degrees which compleats a Quadrant. Then if you draw the Line Ec it will represent the *Equator* in that Scheme.

Sup-

Suppose you take the *Meridian Altitude of the Sun* on either of the Equinoctial Days, (*viz.*) in *March* or *September*, and you find it to be $38\frac{1}{2}$ Degrees: Set up $38\frac{1}{2}$ from H to E, then the Sun having no Declination the *Meridian Altitude* it self shews you the *Height of the Equator* above the Horizon, which is the *Complement of the Latitude*.

Suppose the *Meridian Altitude* of the Sun at the shortest Day be 15 Degrees, set up 15 from H to v: Then the *Sun's Declination* is $23\frac{1}{2}$ Degrees Southward; therefore set $23\frac{1}{2}$ from v upward, and it finds the Point E: And the Arch HE is the *Complement of the Latitude* as before, (*viz.*) $38\frac{1}{2}$ Degrees.

For all these Practices the chief Rule is this. In the Summer Half-Year set your Declination *downward* from the Point of the Meridian Altitude, and it will find the *Equator's Height* above the Horizon. In Winter set your Declination *upward* from the Point of the Meridian Altitude, and it will shew you the *Height of the Equator*. The Reason of it is most evident in the third and fourth *Figures*.

It may be proper in this Place to recollect what I have already demonstrated in *Section V. Figure iv.* that the Latitude of any Place (that is the Distance of its Zenith

nith from the Equator) $z E$ is equal to the Elevation of the Pole $P O$ above the Horizon. Thereby it appears that the *Elevation of the Equator* above the Horizon of that Place on one Side as $E H$ (which is the Complement of the Latitude) is equal to the Complement of the *Pole's Elevation* on the other side as $z P$. If therefore the *Latitude* (suppose of *London*) be $E Z$ or $P O$ $51^{\frac{1}{2}}$ the *Colatitude* $P Z$ or $H E$ will be $38^{\frac{1}{2}}$ for it must compleat a Quadrant or 90 Degrees; and therefore if you set the Point P $51^{\frac{1}{2}}$ Degrees above O on the other side of the Horizon, and draw the Line $P C$, you have the *Axis of the World* represented, or the *North Pole* in its proper Elevation for *London*, and standing (as it ought) at right Angles with the Equator $E C$.

I have represented the Solution of this sixth Problem in a *Geometrical manner* to shew the Reason of this Practice; but this Problem of *finding the Latitude by the Meridian Altitude* is much easier performed *Arithmetically* thus.

In the Winter Half-Year add the *Declination* to the *Meridian Altitude*, and it gives you the *Colatitude*.

In the Summer Half-Year subtract the *Sun's Declination* from the *Meridian Altitude*, and it gives the *Colatitude*.

Example,

Example *June 21th*

<i>Merid. Alt.</i>	HS	62	}	Subtract
<i>Sun's Declin.</i>	ES	$23 \frac{1}{2}$		
<i>Colatitude</i>			$38 \frac{1}{2}$	

December 21th

<i>Merid. Alt.</i>	HV	15	}	Add
<i>Sun's Declin.</i>	EV	$23 \frac{1}{2}$		
<i>Colatitude</i>			$38 \frac{1}{2}$	

Then if you subtract the Colatitude from the Zenith or 90, you find the Latitude, as,

<i>Zenith</i>	HZ	90	}	Subtract
<i>Colatitude</i>	HE	$38 \frac{1}{2}$		
<i>Latitude</i>			$51 \frac{1}{2}$	

After all it must be observed here, that all these Problems of finding the Latitude of the Place by the Sun's or Star's Meridian Altitude, &c. belong chiefly to those Places which lie within the *Temperate Zones*. If the Place lie in the *Torrid* or *Frigid Zones*, these Methods of Solution are good, when the Meridian Sun is on the same Side of the *Zenith* with the *Equator*, whether North
or

or South. But if not, then there must be some little Difference of Operation at some times of the Year. Yet if you project a Scheme for the Solution of such an Enquiry like Fig. III. the very Reason of things will shew you when you must Add or Subtract.

Problem VIII. *To find the Meridian Altitude of the Sun any Day of the Year, the Latitude of the Place being given.*

This is but the Converse of the former Problem, and therefore is to be performed the contrary Way, (*viz.*) in Winter subtract the Declination $v E$ from the Equinoctial Altitude or Colatitude $H E$, and the Remainder is $H v$ the Meridian Altitude.

In Summer add the Declination $E S$ to the Equinoctial Altitude, or Colatitude $H E$, and it gives the Meridian Altitude $H S$.

The Meridian Altitude at the Equinoxes is the same with the Colatitude as before.

Problem IX. *To find the Declination of the Sun, its Meridian Altitude and the Latitude of the Place being given.*

It is hardly necessary to describe this Practice to those who have perfectly learn'd the two foregoing Problems.

Subtract the Colatitude $H E$ from the Meridian Altitude in Summer $H S$, and the Remainder is the Sun's Summer Declination $E S$.

Sub-

Subtract the Meridian Altitude in *Winter* $H V$ from the Colatitude $H E$, and the Remainder is the *Sun's Winter Declination* $E V$.

Or in short, if the Meridian Altitude and Colatitude be given, *subtract the less from the greater*, and the Remainder is the *Sun's Declination*.

Problem X. *To find the Latitude of a Place by the Meridian Altitude of a Star, when it is on the South Meridian.*

Find the Declination of that Star in some Table or Scale of the Star's Declination. If it has *Declination Northward*, (as the Sun has in Summer) *subtract* the Declination from the Meridian Altitude, and it gives you the *Colatitude*.

If the Star's *Declination* be *Southward* (as the Sun's is in Winter) add its Declination to its Meridian Altitude, and it gives you the *Colatitude*.

Note, When I speak of North and Southward in relation to Winter and Summer, in many of these Problems, I mean in *Northern Latitude* such as ours is in *Britain*.

When the Star is on the *North Meridian* see how to find the Latitude by it in *Problem XXXII*.

Problem XI. *By what Methods is the Longitude of Places to be found.*

Though

Though the *Latitude* (which lies *Northward* and *Southward*) may be determined with the utmost Certainty by the Methods before proposed, yet the *Longitude* of a Place (which is the *Distance of any two Places* from each other *Eastward* or *Westward*) is very hard to be determined by the Sun or Stars, because they always appear moving round from *East to West*. The *Longitude* therefore of Places is usually found by measuring the Distance on Earth or Sea from *West* or *East*.

The *Map-Makers* who describe Countries, Provinces or Kingdoms, measure the Distances on the Earth by an Instrument made on Purpose, with a *Wheel* so contrived, that a certain Number of its Revolutions is equal to a Pole, a Furlong, or a Mile; it hath also a *Mariner's Compass* and Needle touch'd with a Loadstone fastned to it, to shew how much their course varies from the *North* or *South*.

In this last Age they have also invented a Way to find the *Difference of Longitude* between two Towns that are some thousands of Miles asunder in distant Nations; and that is by a nice and exact Observation of the Moment when the *Eclipses of the Moon* begin or end, made by Mathematicians at those distant Places: And thus by the Difference of Time in those Eclipses they compute the Distance of Place. This

- This Invention is still further improved by Observations of the *Eclipses of the four Moons* or little secondary Planets, which roll round the Planet *Jupiter* as our Moon does round our Earth: By these Means the supposed Distances of some Places in the *East* and *West-Indies* have been altered, and the Mistakes of several hundred Miles corrected.

The *Sailors* measure it at Sea by the *Log*, which is a piece of Board fastened to a long Line which they cast out of the Ship while a Minute or Half-Minute Glass begins to run: Then drawing in the *Log*, they see how far the Ship has sailed *in a Minute*; and supposing the Circumstances of the Wind and Water to be the same, they compute thereby how far they have sail'd in *some Hours*. But this being a very uncertain Way of reckoning because of the continual Changes either of the Strength or the Point of the Wind, or current of the Water, they are often liable to Mistakes. Therefore it has been the famous and solicitous Enquiry of these last Ages how to find out and ascertain *Longitude* at Sea; and there is so vast a Reward as twenty thousand Pounds offered by the Parliament of *Great-Britain* to any Man who shall invent a Method for it, which shall be plain, easy and practicable at Sea.

Problem

Problem XII. *To find the Value of the Degree of a greater Circle upon the Earth, or how much it contains in English Measure.*

Here let it be noted, that one Degree of a greater Circle on the *Earth* answers to one Degree of a greater Circle in the *Heavens*. It is true the heavenly Circles are incomparably larger than the Circumference of the Earth; and they are also larger than each other according to the different Distances of the Planets and Stars; yet every Circle (whether greater or lesser) is divided into 360 Degrees, and therefore though Circles differ never so much in Magnitude, yet, when they are supposed to be *concentrical*, (*i. e.* to have the same Centre) every single Degree of each Circle is correspondent to a single Degree of all other Circles.

Now that a Degree of the *Heavens* thus answers to a Degree on the *Earth* is very evident; for if we travel on *Earth*, or sail one Degree *Northward* or *Southward* on the same *Meridian*, we shall find by the Sun or the fixed Stars in *Heaven* that our *Zenith* is just a Degree altered, our *Latitude* is changed one Degree, and our *Pole* is one Degree more or less elevated, (*viz.*) more elevated if we go from *London* toward the *North*, and less elevated if we go toward the *South*, till we come to the *Equator*: Afterward the contrary *Pole* is elevated gradually. By such Experiments

as these Philosophers infer also that the *Earth is a Globe* and not a plane Surface.

Wherefore to find the Value of a Degree on a greater Circle of the Earth, you must travel directly in the same Meridian, measuring your Miles all the Way, till your Latitude be alter'd one Degree; and then (if you have been exact in your Measure) you will find that you have travelled about 70 *English Miles*; though Geographers often reckon 60 *Geographical Miles* to a Degree for greater Ease in Computation, as I have said before.

Problem XIII. *To find the Circumference, the Diameter, the Surface and solid Contents of the Earth.*

Having found the Value of one Degree to be 70 *Miles*, multiply that by 360, and it produces 25200 *Miles* for the *Circumference*.

The *Diameter* is in proportion to the *Circumference* as 113 to 355, or as 50 to 157, or in more brief and vulgar Account as 7 is to 22, which will make the *Diameter* of the Earth to be about 8000 *Miles*.

Multiply the *Circumference* by the *Diameter*, and that Product shall be the *Square Feet, Furlongs, Miles, &c.* of the *Surface*.

Multiply the *Surface* by the sixth part of the *Diameter*, and that will give the *solid Content*.

Note, That Geographers differ a little in the Computation of these Measures, because they

they differ in the Measure of a single Degree: And that is because of the Crookedness and Inequality of any Road that you can travel for 70 Miles together: The justest Measures have made $69\frac{1}{2}$ Miles go to a Degree, or the round Number of 70 Miles.

Problem XIV. *To find the Value of a Degree of a lesser Circle on the Earth, i. e. the Value of a Degree of Longitude on the lesser Parallels of Latitude.*

I have mentioned it before under the III^d Prob. of the 19th Sect. that all the Degrees marked on the Equator, or on any of the Meridians are 70 Miles, because all those Lines are *Great Circles*; yet in the *Parallels of Latitude*, the further you go from the Equator, the *Circle* grows less and less, and consequently each *Degree* of it must be less also; and for this Reason the whole Circle of 360 *Degrees* near the Pole will not make above 360 *Miles*; and as you approach still nearer to the Pole, it will not make so many *Furlongs* or *Feet*.

To find therefore the *true Value of a Degree* suppose in the *Parallel of Latitude of London* $51\frac{1}{2}$ Degrees, use this Method, Fig. XXII. Make a straight Line A B to represent one Degree in the Equator, divide it into 60 *Geographical Miles*, or into 70 *English Miles*, all equal: Set the Foot of your

Compasses in A, describe an Arch from B to C of $51\frac{1}{2}$ Degrees, then from the Point C let fall a Perpendicular to D, and A D is the Measure of a *Degree of Longitude in the Parallel of London*, (*viz.*) about $43\frac{1}{2}$ Miles.

The Demonstration of it may thus be explained. Prolong the Arch B C and complete the Quadrant E A B. Then E shall represent the North Pole: E A the Northern Half of the Axis of the World, A B the Semi-diameter at the Equator, and N C the Semi-diameter of the Parallel of Latitude for London. Then *Arithmetically*, if the Line A B (suppose 1000 equal Parts) allow 70 Miles for a Degree, what will N C (*i. e.* about 622 equal Parts) allow? *Ans.* $43\frac{1}{2}$

Or *Trigonometrically* thus. A B is the whole Sine of 90^d , or Radius. N C is the Sine of the Colatitude $38^d\frac{1}{2}$. Then say, As A B or the Sine 90^d is to 70 Miles, so is N C or A D the Sine of $38^d\frac{1}{2}$ to $43\frac{1}{2}$ Miles.

Note, this Diagram or Figure will shew the value of a Degree of Longitude in any Parallel of Latitude, if from every Degree in the Arch E C B a Perpendicular were drawn to the Line A B.

Therefore a whole Line of Sines if number'd backward, and applied to a Scale of 70 equal Parts, will shew the Miles contain'd in one Degree of Longitude under any Parallel of Latitude whatsoever.

Having

Having shewn in former Problems how to take the *Meridian Altitude of the Sun*, and thereby to find the *Latitude of any Place* on the Earth, I think it may be proper now to shew how to *project the Sphere* for any Latitude upon the Plane of the Meridian, and represent it in straight Lines, which is called the *Analemma*: Because the Erection of this Scheme (and sometimes of a little Part of it) will solve a variety of *Astronomical Problems*, as will appear hereafter.

Problem XV. *To erect the Analemma, or represent the Sphere in straight Lines for the Latitude of London $51\frac{1}{2}$ Degrees.*

First, It is supposed you have a *Scale of Chords* at hand, or a *Quadrant* ready divided into 90 Degrees. Take the Extent of 60 Degrees of the Line of Chords in your Compasses, (or which is all one) the Radius of your Quadrant, and describe the Circle *N Z E H S Q* for a Meridian both North and South as in *Figure XXIII.* (*viz.*) *N E S*, which represents 12 o'clock at Noon; and *N Q S*, which represents the Hour of Midnight.

Through *c* the Centre draw the Line *h o* for the *Horizon*. At 90 Degrees distance from *h* and *o* mark the Point *z* and *d* for the *Zenith* and *Nadir*; then draw the Line *z d* which will cross *h o* at Right
M 3 Angles.

Angles, and will represent the *Azimuth of East and West*; as the Semicircle $z o d$ represents the *North Azimuth*, and $z h d$ the *South*.

Above the *Horizon* o mark n for the *North Pole* elevated $51\frac{1}{2}$ Degrees: Through the Centre c draw the Line $n s$ for the *Axis of the World*; which Line will also represent the *Hour Circle of six o'clock*, being at 90 Degrees distance from *Noon* and *Midnight*. s will stand for the *South Pole*, depress'd as much below h the *South* side of the *Horizon*, as n the *North Pole* is raised above o on the *North* side of it.

At 90 Degrees from n mark e and q on each side; then cross the *Axis of the World* $n s$ with the Line $e q$ at right Angles, which represents the *Equator*. Thus e will be 90 Degrees from n the *North Pole*, $51\frac{1}{2}$ Degrees from z the *Zenith*, which is the *Latitude*, and it will be $38\frac{1}{2}$ Degrees above h the *Horizon* which is the *Complement of the Latitude*.

At $23\frac{1}{2}$ Degrees from e on each side mark the Points m and w ; then parallel to the *Equator* or $e q$ draw the Line $m \varpi$ for the *Tropick of Cancer*, and the $w \varpi$ for the *Tropick of Capricorn*. After that, through the Centre c draw $m \varpi$ which is the *Ecliptick*: It cuts the *Equator* $e q$ in c , and makes an Angle with it of $23\frac{1}{2}$ Degrees.

From

From the Points N & mark p and x on each side at the Distance of $23\frac{1}{2}$ Degrees, pp are the *Poles of the Ecliptick*, and the Line px and xp being drawn are the two *Polar Circles*, (*viz.*) the *Arctic* and *Antartic*.

Thus *Analemma* is completed for all general Purposes or Problems.

The further Observables in it are these, *viz.*

M is the *Sun's Place* in the Ecliptick when it enters *Cancer* at the Summer Solstice: And the Arch EM is its *North Declination* $23\frac{1}{2}$ Degrees.

c is the *Sun's Place* in the Ecliptick entering *Aries* or *Libra* at the Equinoxes: And then it has no *Declination*.

w is the *Sun's Place* in the Ecliptick entering *Capricorn* at the Winter Solstice: And the Arch wQ or (which is all one) EW is its *South Declination* $23\frac{1}{2}$ Degrees.

The Line $M\sigma$ is the *Sun's Path* the *Longest Day*, or at the *Summer Solstice*; it is at σ at Midnight; it rises at R ; it is at six o'clock at δ ; it is in the East Azimuth at v ; it is on the Meridian at M that Day, and the Arch MH is its *Meridian Altitude*, (*viz.*) 62 Degrees.

The Line EQ is the *Sun's Path* on the *two Equinoctial Days* at *Aries* and *Libra*; it is at Midnight at Q ; it rises at c , and it is in the same Moment at the East, and six o'clock; for on the Equinoctial Days

M 4

ZD

z D the Azimuth of East and West, and NS the six o'clock Hour Line both meet at c in the Horizon HO, which never happens any other Day in the Year: Then the Sun goes up to E at Noon; and EH is the Arch of its Meridian Altitude at the Equinoxes, (*viz.*) $38\frac{1}{2}$ Degrees.

w ν is the Sun's Path the Shortest Day, or at the *Winter Solstice*; it is Midnight at ν ; it is in the East at κ long before it rises; it is six o'clock at G before it rises also; then at I it rises or gets above the Horizon; it is Noon at w, and its Meridian Altitude is wH or 15 Degrees.

The Sun's *Ascensional Difference* (that is, its Distance from six o'clock at its Rising or Setting) in the *Summer Solstice* is the Line R6, and at the *Winter Solstice* 'tis the Line IG.

Its *Amplitude* (or Distance from East or West at its Rising or Setting) in *Summer* is R C; in *Winter* 'tis I C.

Here you must suppose that the Sun goes down again from the Meridian in the Afternoon on t'other side of the Scheme or Globe in the same manner in which its Ascent toward the Meridian is represented on this Side: So that the Line MR represents the Sun's *Semidiurnal Arch at Midsummer*, EC at the *Equinoxes*, and wI at *Mid-winter*. The *Semidiurnal Arch* is half the Arch it makes above the Horizon. *Note,*

Note, That as we have described the various Places of the Sun's Appearance *above the Horizon* HO at the several Seasons of the Year, so the various Places of its Depression *below the Horizon* HO may be easily found out and described by any Learner.

Problem XVI. *How to represent any Parallel of Declination on the Analemma, or to describe the Path of the Sun any Day in the Year.*

Find out what is the *Sun's Declination* that Day by some Scale or Table: Observe whether it be the *Winter* or the *Summer* Half-year; and consequently whether the Declination be *North* or *South*: Then for the North side of the Equator, if it be Summer, set the Degrees of *North Declination* upward from E toward Z ; if it be Winter set the *South Declination* downward from E toward H : And from the Point of Declination (suppose it be M or w) draw a Line parallel to $E Q$ the Equator, as $M \infty$ or $w \infty$, and it represents the *Parallel of Declination*, or the *Path of the Sun* for that Day.

Problem XVII. *How to represent any Parallel of Altitude, either of the Sun or Star on the Analemma.*

As the Lines of *Declination* are parallel to the *Equator*; so the Lines of *Altitude* are
parallel

parallel to the *Horizon*: Suppose therefore the Altitude of the Sun be about 42 Degrees; set up 42 Degrees on the Meridian from H to A, draw the Line A L parallel to H O, and it describes the *Sun's Parallel of Altitude* that Moment.

Here *Note*, that where the Sun's *Parallel of Declination* for any Day and his *Parallel of Altitude* for any Moment cross each other, that is an exact Representation of the *Sun's Place in the Heavens* at that Time: Thus the Point Sol \odot is the precise Place where the Sun is when he is 42 Degrees high on the longest Day of the Year: for M ∞ represents his *Path or Parallel of Declination* that Day, and A L represents his *Parallel of Altitude* that Moment.

I might add here also, that the prick'd Arch N \odot S represents the *Hour Circle* in which the Sun is at that Moment; and z \odot D represents its *Azimuth* or *vertical Circle* at that Time. *Note*, These Arches are troublesome to draw aright, and are not at all necessary to solve common Problems by the Scale and Compasses on the *Analemma*.

Month

Problem XVIII. *The Day of the*
and the Sun's Altitude being given, how to
find the Hour or Azimuth of the Sun by the
Analemma.

The

The two foregoing Problems acquaint you how to fix the precise *Point* of the *Sun's Place* any Minute of any Day in the Year by the *Parallel of Declination* and *Parallel of Altitude* crossing each other.

Now suppose the Day of the Month be the 6th of *May*, and the *Sun's Altitude* 34 Degrees in the Morning. Describe the Semicircle Hzo in Figure $xxiv$. for the Meridian. Make hc the Horizon. Draw ec making with hc an Angle of the Colatitude $38\frac{1}{2}$ Degrees to represent the Equator. Seek the *Declination of the Sun*, and in the Tables or Scales you will find it near $16\frac{1}{2}$ Degrees Northward: Set $16\frac{1}{2}$ from e to d ; draw dr for the Path of the Sun that Day, parallel to ec the Equator. Then set the Altitude 34^d . from h to a . draw al parallel to ho the Horizon, Thus the Point o shews the Place of the Sun as before.

Now if you would find the *Hour*, you must draw the Line cn at right Angles with the Equator ec , which represents the fix a Clock Hour Line; and the Distance $6o$ is the *Sun's Hour from six*; that is, his Hour after six in the Morning, or before six in the Afternoon.

If you are to seek the *Azimuth*, then you must draw the Line cz perpendicular to ho , which is the vertical Circle of East or West;

West; then the Extent $F\theta$ is the *Sun's Azimuth from East* in the Morning, or *from West* in the Afternoon.

Thus you see that in order to solve those two difficult Problems of the *Hour* or *Azimuth*, you need but a very few Lines to perform the whole Operation; for if you want only the *Hour*, $c z$ may be omitted; if you want only the *Azimuth*, $c n$ may be omitted.

Yet in the Winter Half-year, suppose the 13th of *November*, when the *Declination* is near 18 Degrees South, it must be set downward as $E W$ from E toward H ; then you cannot so well find the *Hour* without producing the fix a Clock Line $n c$ below the Horizon down to s , that you may measure the *Hour* from s or fix .

Observe also that this little Diagram in Figure *xxiv.* will solve a great Variety of Problems besides the *Hour* and *Azimuth* on the 6th of *May*: It shews the *Length of the Day* by the Semidiurnal Arch $D R$. The *Sun's Ascensional Difference* is $6 R$. His *Amplitude* is $c R$. His *Azimuth* from East or West at fix is $\tau 6$. His *Altitude* at East and West is $v c$. His *Meridian Altitude* is the Arch $D H$: And his *Azimuth* from East or West at *rising* or *setting* is the Line $c R$.

Problem XIX. *How to measure the Number of Degrees on any of the straight Lines in the Analemma.* I

I think there is no need to inform the Reader that any Part of the outward Circle or *Meridian* may be measured upon that Scale of Chords or Quadrant, according to whose Radius the whole *Analemma* is drawn.

As for the *straight Lines* they are all to be considered as *Sines*; those Semidiameters which are drawn from the Centre *c* to the Circumference are so many *whole Lines of Sines* or 90 Degrees to the common Radius of the Semicircle. But if you consider any *whole Diameter* which passeth through the Centre *c*, it is a Line of *versed Sines*, i. e. two Lines of right Sines joined at their Beginning to the same common Radius of the Semicircle.

If therefore you have a *Scale* or *Line of Sines* at hand to the same Radius of the Circle, you may measure any Part of those straight Lines, setting one Foot of the Compasses in the Centre *c*, and extending the other to the Point proposed, then applying that Extent to the beginning of the Line of Sines, and observing how far it reaches.

But if you have no *Scale* or *Line of Sines* at hand, you may find a Quantity of any Part of the Semidiameter by the outward Limb or Semicircle, and by the Scale of Chords, according to whose Radius the Semicircle is drawn. The Method of performing it see in Figure xxv, where the
 Quadrant

Quadrant $y x b$ is drawn by the same Radius as the Semicircle in Figure xxiv. But I chose to make it a distinct Figure, lest the Lines should interfere with one another and breed Confusion; and therefore in Figure xxiv. I have used capital Letters, in Figure xxv. all the Letters are small.

Suppose I would find how many Degrees are contained in $v c$ which is the *Sun's Altitude at East or West*. This is a Part of the Semidiameter $c z$: Suppose therefore $c z$ to be a whole Line of Sines, beginning to be number'd at c . Take the Extent $v c$ in your Compasses, and carry one Leg up in the Arch $y x$ till the other Leg will but just touch the Diameter $y b$, and the Leg of the Compasses will rest at n ; wherefore it appears that $c v$ in Fig. xxiv. is the Sine of the Arch $y n$ in Figure xxv. or 21 Degrees.

Another Way to perform it is this. Take the Extent $v c$, set one Leg of the Compasses in y , and with that Extent make a blind or obscure Arch at e , and by the Edge of that Arch lay a Rule from the Centre b ; and it will find the Point n in the Limb (*viz.*) 21 Degrees.

By the same Practice you may find the Number of Degrees contained in any Part of those Lines which are drawn from the
Centre

Centre c , (*viz.*) CH , CE , CM , CZ , CN , CO , all which are whole Lines of Sines to the common Radius of the Quadrant.

But as for those *Lines* in the *Analemma* which are not drawn from the Centre c , but are drawn across some other Diameter and produced to the Limb, such as the Line $6D$, the Line sw , the Line FA , and the Line FL , each of these are to be esteemed as a *whole Line of Sines* also, but to a *less Radius*.

So $6\odot$ Figure xxiv. is the *Sine of the Sun's Hour* from 6 ; but the Radius is $6D$, and the Number of Degrees in $6\odot$ is to be found in this manner. Take the Extent $6D$, or this whole lesser Radius in your Compasses, and set it from b to q in Figure xxv. then take the Extent $6\odot$, and setting one Foot of the Compasses in q . make an obscure Arch at o , and a Ruler laid from b the Centre by the Edge of that Arch o will find the Point d in the Limb, and shew that dy is $34\frac{1}{4}$ Degrees, which (turned into Hours) is *two Hours 17 Minutes* from six, (*viz.*) 17 Minutes past eight in the Morning, to 43 Minutes past three in the Afternoon.

Again $F\odot$ in Figure xxiv. is the *Sine of the Azimuth from East to West* to the Radius FA ; take therefore FA in your
Compasses

Compasses and set it from b to p in Figure xxv. then take the Extent $F \odot$ and with one Foot in p make the obscure Arch a ; by the Edge of that Arch lay a Ruler from b the Centre, and you will find the Point s in the Limb; therefore ys is the *Azimuth from East to West*, that is, about 17 Degrees.

Note, If you have the Instrument called a *Seſtor* at hand and know how to use it, you may with great Eafe and Exactneſs find the value of any Sine in the *Analemma*, whether it be to a greater or a leſſer Radius, without theſe Geometrical Operations.

Problem XX. To find the Sun's Place in the Ecliptick any Day in the Year.

It is well known that the 12 Signs of the *Zodiack*, each of which has 30 Degrees, contain in all 360 Degrees: And the Sun is ſaid to go thro' them all once in twelve Months or a Year. Therefore in a vulgar Account, and for the Uſe of Learners, we generally ſay, the Sun goes through one Degree in a little more than a Day, and thereby finiſhes the 360 Degrees in 365 Days. But this is not the juſteſt and moſt accurate Account of Things: Let us therefore now toward the End of this Book, with a little more Exactneſs obſerve,

1. That

1. That the annual Course which the *Sun* appears to take through the *Ecliptick* round the Earth, is much more properly and truly ascribed to the *Earth's* moving or taking its Course round the *Sun*; tho' the common Appearances to our Eye are much the same as if the *Sun* moved.

2. This annual Course or Path of the Earth is not properly a *Circle*, but an *Ellipsis* or oval: And as the *Sun* is fixed in one of the *Focus's* of the *Ellipsis*, so the fixed Stars, (and among them the 12 Signs) surround and encompass it. See Fig. xxxi. where the black Point *t* is the *Earth* in its Orbit moving round, and \odot the *Sun* near the Middle, and the outward Circle of Points is the *starry Heaven*.

3. That Part of this Ellipsis or Oval, which the Earth traces in our *Winter* Half-year, (*i. e.* from Autumn to Spring) is nearer to the Sun than the other Part of it which the Earth traces in our *Summer* Half-year, (*i. e.* from Spring to Autumn.) And as it is nearer to the Sun, so consequently it is the shorter or lesser half, if I may so express it. The very Figure shews it plainly.

Note, By our *Winter* and our *Summer* I mean those Seasons as they respect us in *Europe*, and in these *Northern* Parts of the Globe.

4. Thence it follows that the Sun appears to finish its Winter Half-year from *September 23d* to *March 20th*, *i. e.* from \sphericalangle by \wp to φ sooner by 7 or 8 Days than it does the Summer Half-year, *i. e.* from φ by \sphericalangle to \sphericalangle , or from *March 20th* to *September 23d*, which is proved thus: When the Earth is at *t*, the Sun appears at \sphericalangle and it is *Midsummer*. When the Earth is at *e* the Sun appears at \sphericalangle and it is *Autumn*. When the Earth is at *o* the Sun appears at \wp and it is *Midwinter*. And when the Earth is at *a* the Sun appears at φ and it is *Spring*. Thus the Sun appears to pass through those Signs which are just opposite to those which the Earth passes. Now as the Earth is longer in going through the Arch *ate*, from \sphericalangle to φ , than it is in going through the Arch *eo a*, from φ to \sphericalangle , so consequently the Sun appears to pass through the opposite Signs from *Aries* to *Libra*, slower than he does from *Libra* to *Aries*.

This is proved also plainly by the Computation of Days.

After the Sun enters *Aries* on *March 20th*, that Month hath 11 Days, and after the Sun enters *Libra* on *September 23d*, that Month hath 8 Days. Now let us compute.

March

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<i>March</i> — 11	☾	} Days	<i>September</i> - 8	☽	} Days
<i>April</i> — 30	}		<i>October</i> — 31	}	
<i>May</i> — 31			<i>November</i> 30		
<i>June</i> — 30	}		<i>December</i> 31	}	
<i>July</i> — 31			<i>January</i> - 31		
<i>August</i> — 31	}		<i>February</i> 28	}	
<i>September</i> 22			☽		
<hr/>			<hr/>		
<i>Summer</i>	186 Days		<i>Winter</i>	- 179 Days	

5. Agreeably hereto it is found that in the Winter Months (chiefly from the latter end of *October* to the middle of *March*) the Sun appears to move something more than one Degree in a Day : But in the Summer Months (chiefly from the middle of *March* to the latter end of *October*) the Sun appears to move something less than one Degree in a Day. This is one Reason why a good Pendulum Clock measures Time more justly than the Sun : And it is this Irregularity of the Sun's measuring Time that makes the Tables of Equation of Time necessary.

6. And thence arises a sensible Inequality between the Times of the Sun's apparent Continuance in different Signs of the *Zodiack* : He seems to tarry longer in those of the Summer, and shorter in those of the Winter : So that he does not leave one Sign, and enter another just in the same Proportions or Distances of Time every Month.

7. This occasions a little Variation of the *Declination* of the Sun, and his *Right Ascension* from the Regularity that we might expect; for they are both derived from his apparent Place in the *Ecliptick*: And therefore none of them can be found by Learners with utmost Exactness, but in an *Ephemeris* or Tables which shew the *Sun's Place*, &c. every Day in the Year.

8. Let it be noted also, that the *Leap-year* with its additional Day the 29th of *February*, returning every four Years, forbids the Sun's Place in the *Ecliptick* to be exactly the same at the same Day and Hour of the following Year, as it was in the foregoing; so that though you knew the *Sun's Place*, his *Right Ascension* and *Declination* for one whole Year, that would not serve exactly for the next Year, for the nicest Purposes of Astronomy.

9. Yet as in four Years Time the Sun appears very nearly at the same Place in the Heavens again at the same Day and Hour and Minute as before, so a Table that contains the Round of four Years is a sufficient Direction for 20 Years to find the *Sun's Place* for any common Purposes: Provided always that we seek the *Sun's Place*, *Declination* or *Right Ascension*, for any Year and Day in that Year in the Table that is equally distant from Leap-year, whether it happens to be the
first,

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first, the second, or the third after Leap-year, or whether it be the Leap-year, it self. See more of this Matter *Seēt. XXI.* of the *Tables of Declination.*

10. If we would make one single Table or Scale of the Sun's *Entrance* into the Signs of the *Zodiack*, or of his *Declination* or *Right Ascension* to serve for every Year, we must chuse the second after the Leap-year, because that comes nearest to the *mean* or *middle Course and Place* of the Sun, and will occasion the least Error in any Opperations.

I have therefore here set down a short *Table* of the Sun's Entrance into the several Signs, for the Year 1754, which is the second after Leap-year; and for Geometrical Operations with a plain Scale and Compass, it is sufficiently exact for 20 Years to come.

Anno 1754, the second after Leap-year.

Day	d.	m.	Day	d.	m.
<i>March</i>	20	--	<i>Sept.</i>	23	--
	ϛ	--		⚊	--
	0	: 09		0	: 21
<i>April</i>	20	--	<i>Oct.</i>	23	--
	8	--		Ⓜ	--
	0	: 19		0	: 3
<i>May</i>	21	--	<i>Nov.</i>	22	--
	Ⓜ	--		†	--
	0	: 16		0	: 14
<i>June</i>	22	--	<i>Dec.</i>	22	--
	⚍	--		⚍	--
	0	: 51		0	: 44
<i>July</i>	23	--	<i>Jan.</i>	21	--
	♏	--		Ⓜ	--
	0	: 25		0	: 33
<i>August</i>	23	--	<i>Feb.</i>	20	--
	♑	--		Ⓧ	--
	0	: 11		0	: 55

It is not possible to form all this irregular Variety of Times when the Sun enters the several Signs into any Memorial Lines or

Rhymes with any Exactness and Perspicuity; and therefore I have omitted the Attempt. Such a short *Table* as this may be always carry'd about by any Person who deals frequently in such Operations and Inquiries.

But to give an Example of the Practice. Suppose it be inquired, what is the Sun's Place, *April* 25th, I find the Sun just entered into *Taurus* 8 *April* the 20th, then I reckon it is in the 5th Degree of 8 *April* 25th, which added to the whole 30 Degrees of *Aries*, shews the Sun to be 35 Degrees from the Equinoctial Point γ on the 25th of *April*.

If the 29th of *November* we enquire the Sun's Place, we must consider the Sun is just entered \ddagger the 22d of *November*: Therefore on the 29th it is about 7 Degrees in \ddagger , which added to 30 Degrees of \mathfrak{m} and 30 Degrees of $\acute{\alpha}$, shews the Sun on the 29th of *November*, to be about 67 Degrees from the Autumnal Equinox or $\acute{\alpha}$.

Thus by adding or subtracting as the Case requires, you may find the *Sun's Place* any Day in the Year: And thence you may compute its Distance from the nearest *Equinoctial Point*, which is of chief Use in Operations by the *Analemma*.

Problem XXI. *The Day of the Month being given, to draw the Parallel of Declination for that*

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that Day without any Tables or Scales of the Sun's Declination.

This may be done two Ways. The *first* Way is by considering the *Sun's Place in the Ecliptick*, as *May* the 6th, it is $46\frac{1}{2}$ Degrees from the Equinox Northward. Therefore in *Figure xxiv.* after you have drawn Hzo the Meridian, Ec the Equator, set up $23\frac{1}{2}$ Degrees the Sun's greatest Declination from E to M ; draw Mc to represent the *Ecliptick*; then take $46\frac{1}{2}$ Degrees from a Line or Scale of Sines and set it from c the Equinoctial Point to K in the *Ecliptick*; through the Point K , draw DR parallel to Ec the Equator. Thus DR represents the *Sun's Path* that Day, and shews the *Declination* to be ED or $16\frac{1}{2}$.

Note, If you have ne'er a *Scale of Sines* at hand, then take the *Chord* or the *Arch* of $46\frac{1}{2}$ Degrees, set it up in the Limb from H to G , set one Foot of the Compasses in G , and take the nearest Distance to the Line Ho or Diameter, and that Extent is the *Sine* of $46\frac{1}{2}$ Degrees.

The *other* Way of drawing a *Parallel of Declination*, is by seeking what is the *Meridian Altitude* for the 6th of *May*, and you will find it to be 55 Degrees. Set up therefore the Arch of 55 Degrees from H to D ; and from the Point D draw DR a Parallel to Ec , which shews the *Declination* and *Sun's Path* as before.

N 4

Thus

Thus though you have no *Scales* or *Tables* of the *Sun's Declination* at hand, you see it is possible to find the *Hour* and *Azimuth*, and many other Astronomical Problems by the *Analemma* for any Day in the Year. But this Method which I proposed of performing them by finding the *Sun's Place in the Ecliptick* by any short general Scale or Table, is liable to the Mistake of near Half a Degree sometimes.

Observe here, if you have by any Means obtained and drawn the *Sun's Path*, (*viz.*) DR for any given Day, you may find both the *Sun's Place in the Ecliptick* and its *Right Ascension* by drawing c m the *Ecliptick*. For then c κ will be the Sine of the *Sun's Place* or *Longitude* to the common Radius c m: And 6 κ will be the Sine of the Sun's Distance on the *Equator* from the nearest *Equinoctial* Point, but the Radius is 6 D: From hence you may easily compute its *Right Ascension*.

Note, Though the little Schemes and Diagrams which belong to this Book, are sufficient for a Demonstration of the Truth and Reason of these Operations, yet if you have Occasion to perform them in order to find the *Hour* or *Azimuth* with great Exactness, you must have a large flat Board, or very stiff Pastebord with white Paper pasted on it, that you may draw a Semi-circle

circle upon it of 9 or 10, or rather 12 Inches *Radius*; and the Lines must not be drawn with Ink, nor with a Pencil; for they cannot be drawn fine enough: But draw them only with the Point of the Compass; and you must observe every Part of the Operation with the greatest Accuracy, and take the Sun's Place or Declination out of good Tables: For a little Error in some Places will make a foul and large Mistake in the final Answer to the Problem.

Yet if the Sun be within seven or eight Days of either Side of either Solstice, you may make the *Tropic of Cancer* or *Capricorn* serve for the Path of the Sun, without any sensible Error; for in 16 Days together at the Solstices, its Declination does not alter above 12 or 15 Minutes: But near the *Equinox* you must be very exact; for the Declination alters greatly every Day at that Time of the Year.

There might be also various *Geographical* Practices or Problems, that relate to the Earthly Globe performed by the Assistance of the *Analemma*, and several other *Astronomical* Problems relating to the Sun and to the fixed Stars; but some of them are more troublesome to perform; and what I have already written on this Subject is abundantly sufficient to give the Learner an Acquaintance with the Nature and Reason of

of these Lines, and the Operations that are performed by them. And for my own Part I must confess, there is nothing has contributed to establish all the Ideas of the Doctrine of the Sphere in my Mind, more than a perfect Acquaintance with the *Analemma*.

Problem XXII. *How to draw a Meridian Line, or a Line directly pointing to North and South on a Horizontal Plane by the Altitude or Azimuth of the Sun being given.*

At the same Time while one Person takes the *Altitude of the Sun* in order to find the *Azimuth* from Noon by it, let another hold up a Thread and Plummet in the *Sun-Beams* and mark any two distant Points in the *Shadow* as A B, Figure xxvi. and then draw the Line A B: Suppose the *Azimuth* at that Moment be found to be 35 Degrees, draw the Line A E at the Angle of 35 Degrees from A B, and that will be a true *Meridian Line*.

You must observe to set off the Angle on the proper Side of the Line of Shadow *Eastward* or *Westward*, according as you make your Observation in the Morning or in the Afternoon.

Note, Where you use a *Thread* and *Plummet*, remember that the larger and heavier your Plummet is, the steadier will
your

your Shadow be, and you will draw it with greater Ease and Exactness.

In this and the following Operations to draw a *Meridian Line*, you must be sure that your Plane be truly *Level* and *Horizontal*, or else your Performances will not be true.

Problem XXIII. *To draw a Meridian Line on a Horizontal Plane, by a perpendicular Style.*

Note, That when I speak of a *perpendicular Style*, I mean either of those three Sorts of *Styles* before-mentioned in *Problem I.* (*viz.*) A *straight Needle stuck into the Board perpendicularly*, as *Figure xv.* A *straight or crooked Wyre stuck in sloping at Random with the perpendicular Point found under the Tip of it*, as *Figure xvi*; or the *Brass Prism*, as *Figure xvii.* For what I call a *perpendicular Style* may be applied and ascribed to either of these.

Make several parallel *Circles* or *Arches*, as *Figure xxvii*: In the *Centre* of them fix your *perpendicular Style* *nc.* Mark in the *Morning* what *Point* in any *Circle* the *End* of the *Shadow* touches, as *A.* In the *Afternoon* mark where the *End* of the *Shadow* touches the same *Circle*, as *o*: Divide the *Arch* *A o* just in halves by a *Line* drawn from the *Centre*, and that *Line* *cm* will be a true *Meridian Line.*

The

The Reason of this Practice is derived hence, (*viz.*) that the Sun's Altitude in the *Afternoon* is equal to the Sun's Altitude in the *Morning*, when it casts a Shadow of the same Length: And at those two Moments it is equally distant from the *Point of Noon* or the *South*, which is its highest Altitude: therefore a Line drawn exactly in the Middle between these two Points of Shadow, must be a *Meridian Line* or Point to the *North* and *South*.

This Problem may be performed by fixing your perpendicular Style first, and observing the Shadow A before you make the Circles, (especially if you use the *Brass Prism*, or the sloping Style with the perpendicular Point under it) then set one Foot of your Compasses in the perpendicular Point c, extend the other to A, and so make the Circle.

If you use the *Prism* for a Style, you may mark a *Line* or *Angle* at the Foot of it where you first fix it, and place it right again, though you move it never so often.

It is very convenient to mark three or four Points of Shadow in the Morning, and accordingly draw three or four Arches or Circles, lest the Sun should not happen to shine, or you should not happen to attend just at that Moment in the Afternoon when the Shadow touches that Circle on which

which you marked your first Point of Shadow in the Morning.

If you would be very exact in this Operation, you should tarry till the Sun be gone one Minute further *Westward* in the Afternoon, *i. e.* till *one Minute* after the Shadow touches the same Circle, and then mark the Shadow; because the Sun in six Hours Time (which is one Quarter of a Day) is gone *Eastward* on the Ecliptick in his Annual Course *one Minute* of Time, which is 15 Minutes (or one Quarter) of a Degree.

Problem XXIV. *To draw a Meridian Line on a Horizontal Plane by a Style or Needle set up at Random.*

Another Method near a-kin to the former is this: Set up a Needle or sharp-pointed Style at Random, as *N D*, in Figure *XXVIII*. Fix it very fast in the Board, and observe a Point of Shadow in the Morning as *A*. Then with a Pin stuck on the Tip of the Style *N* (without moving the Style) draw the Arch *A s o*: Mark the Point of Shadow *o*, in the Afternoon when it touches that Arch (or rather when it is one Minute past it.) Then draw the Line *A o* and bisect it, or cut it in Halves by a perpendicular Line *M E*, which is a true *Meridian*.

Note, In this Method you have no Trouble of fixing a Style perpendicular,
nor

But in general, it may be advised that the Summer Half-year is far the best for Observation of Shadows in order to any Operations of this Kind.

Problem XXV. *To draw a Meridian Line on an Equinoctial Day.*

On an *Equinoctial Day* or very near it, as the ¹⁸th, ²⁰th, or ²¹th of *March*; or the ²²th, ²³th, or ²⁴th of *September*, you may make a pretty true *Meridian Line* very easily thus by *Figure XXIX*.

Mark any two Points of Shadow as A B from a Needle c D set up at Random, (no Matter whether it be either upright or straight.) Let those two Shadows be at least at the Distance of three or four Hours from each other, and it is best they should be observed one in the Morning and the other about the same Distance from 12 in the Afternoon; and then draw the Line A B which represents the *Equinoctial Line*, and is the Path of the Sun that Day: Cross it any where at right Angles. and M N, or O P, are *Meridian Lines*.

Note, It is best to mark several Shadows that Day, as S, S, S, and draw a right Line A S S B by those which lie nearest in a right Line, that you may be the more exact.

Problem XXVI. *To draw a Meridian Line by a Point of a Shadow at Noon.*

If

If you have an exact Dial to whose Truth you can trust, or a good Watch or Clock set exactly true by the Sun that Morning, then watch the Moment of 12 a Clock or Noon, and hold up a Thread and Plummet against the Sun, and mark the Line of Shadow on a Horizontal Plane, and that will be a true *Meridian Line*.

Or you may mark the Point or Edge of Shadow, by any Thing that stands truly perpendicular, at the Moment of 12 a Clock, and draw a *Meridian Line* by it.

Problem XXVII. *To draw a Meridian Line by a Horizontal Dial.*

If you have a Horizontal Dial which is not fastened, and if it be made very true, then find the exact Hour and Minute by a Quadrant, or any other Dial, &c. at any Time of the Day, Morning or Afternoon; set the Horizontal Dial in the Place you design, to the true Hour and Minute; and the Hour Line of 12 will direct you to draw a *Meridian*.

Or if your Dial be square, or have any Side exactly parallel to the Hour Line of 12, you may draw your *Meridian Line* by that Side or Edge of the Dial.

Problem XXVIII. *How to transfer a Meridian Line from one Place to another.*

There

There are several Ways of doing this.

Ist *Way*. If it be on the same Plane, make a parallel Line to it, and that is a *true Meridian*.

IId *Way*. If it be required on a different Plane, set some good Horizontal Dial at the true Hour and Minute by your *Meridian Line* on the first Plane, then remove it and set it to the same Minute on the second Plane, and by the 12 o'Clock Line mark your new *Meridian*.

Note, If the Sides or Edges of your Horizontal Dial are cut truly parallel to the 12 o'Clock Line, you may draw a *Meridian* by them as before.

IIIId *Way*. Hold up a Thread and Plumbet in the Sun, or set up a perpendicular Style near your *Meridian Line* any Time of the Day, and mark what Angle the Line of Shadow makes with that *Meridian Line* on your first Plane; then at the same Moment, as near as possible, project a Line of Shadow by the Thread, or another perpendicular Style on the new Plane, and set off the same Angle from it which will be a true *Meridian*.

Note, Two Persons may perform this better than one.

Problem XXIX. *How to draw a Line of East and West on a Horizontal Plane.*

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Where

Where a *Meridian Line* can be drawn, make a *Meridian Line* first, and then cross it at right Angles, which will be a true *Line of East and West*.

But there are some Windows in a House on which the Sun cannot shine at Noon; in such a Case you may draw a *Line of East and West* several Ways.

Ist *Way*. You may use the same Practice which Problem XXII. directs, with this Difference, (*viz.*) instead of seeking the *Sun's Azimuth from the South*, seek its *Azimuth from East and West*, and by a *Line of Shadow* from a *Thread and Plummets* marked at the same Time, set off the Angle of the *Sun's Azimuth from the East in the Morning*, or the *West in the Afternoon*. A common Observation of the Course of the Sun will sufficiently inform you on which Side of the *Line of Shadow* to set your Angle.

IId *Way*. You may use the second Method of transferring a *Meridian Line* by a *Horizontal Dial* with this Difference, (*viz.*) instead of using the *12 o'Clock Hour Line*, by which a *Meridian* was to be drawn, use the *6 o'Clock Line*, which will be *East and West*; for in a *Horizontal Dial* it stands always at right Angles with the *Meridian*.

IIIId *Way*. The third Method of transferring a *Meridian Line* will serve here also; but with this Difference, (*viz.*) set off the
Comple-

Complement of the Angle, which the Line of Shadow makes with your Meridian Line on the first Plane, instead of setting off the same *Angle*, and observe also to set it off on the contrary Side, that so it might make a right Angle with a Meridian Line if that could have come on the Plane.

Problem XXX. *How to use a Meridian Line.*

The various Uses of a Meridian Line are these.

Ist Use. A Meridian Line is necessary in order to draw an Horizontal Dial on the same Plane, or to fix an Horizontal Dial true if it be made before.

IId Use. A brass Horizontal Dial may be removed from one Place to another in several Rooms of the same House: and shew the Hour wheresoever the Sun comes, if either a *Meridian Line* or *Line of East and West* be drawn in every Window, by which to set an Horizontal Dial true.

IIIrd Use. By a Thread and Plummet, or any perpendicular Pin, or Post casting a Shadow precisely along the Meridian Line, we find the Hour of 12, or the Point of Noon, and may set a Watch or Clock exactly true any Day in the Year, if we have no Dial at Hand.

IVth *Use*. It is necessary also to have some Meridian Line in order to find how a House or Wall stands with regard to the four Quarters of the Heavens, *East, West, North, or South*, which is called the *Bearing of a House or Wall*, that we may determine what sort of upright Dials may be fixed there, or what sort of Fruit-Trees may be planted, or which Part of a House or Garden is most exposed to the Sun, or to the sharp Winds.

Vth *Use*. By observing the Motion of the Clouds, or the Smoke, or a Vane or Weather-Cock, you cannot determine which Way the Wind blows, but by comparing it with a Meridian Line, or with a Line of *East and West*.

When once you have got a true Meridian Line, and know which is the *South*, then the opposite Point must be *North*; and when your Face is to the *North*, the *East* is at your Right Hand, and the *West* at your Left.

VIth *Use*. A Meridian Line will shew the Azimuth of the Sun at any time by holding up a Thread and Plummēt in the Sun, and observing where the Line of Shadow crosses it. Or the sharp smooth Edge of an upright Style or Post will cast a Shadow across a Meridian Line, and shew the Sun's *Azimuth*.

VIIth *Use.* If you have a Meridian Line on a Horizontal Plane, you may draw a Circle on that as a Diameter, and divide it into 360 Degrees: Then set up a fixed or moveable perpendicular Style, and it will shew the Azimuth of the Sun at all Hours.

VIIIth *Use.* A perpendicular Style on a Meridian Line will shew the Sun's Meridian Altitude by the Tip of the Shadow according to *Problem II.* And thereby you may find the Latitude of any Place by *Problem VII.*

IXth *Use.* If you have a broad smooth Board with a Foot behind at the Bottom, to make it stand, such as is described in *Prob. XXIII.* of the *XIXth Sect.* and if it be made to stand perpendicular on a Horizontal Plane by a Line and Plummets in the middle of it, you may set the Bottom or lower Edge of this Board in the *Meridian Line*, and by your Eye fixed at the Edge of the Board and projected along the flat Side, you may determine at Night, *what Stars are on the Meridian*; and then by the *Globe* (as in *Problem XXXIII.* and *XXXIV. Sect. XIX.*) or by an Instrument called a *Nocturnal*, you may find the Hour of the Night, or by an easy Calculation as in the *XXXIIIrd. Problem* of this *XXth Section.*

Problem XXXI. How to know the Chief Stars, and to find the North Pole.

If you know any one Star you may find out all the rest by considering first some of the nearest Stars that lie round it, whether they make a *Triangle* or a *Quadrangle*, *straight Lines* or *Curves*, *right Angles* or *oblique Angles* with the known Star. This is easily done by comparing the Stars on the Globe (being rectified to the Hour of the Night) with the present Face of the Heavens, and the Situations of the Stars there, as in *Problem XXXII. Sect. XIX.*

And indeed it is by this Method that we not only learn to *know the Stars*, but even some Points in the Heavens where no Star is. I would instance only in the *North Pole*, which is easily found, if you first learn to know those seven Stars which are called *Charles's Wain*, see *Figure xxx.* four of which in a *Quadrangle* may represent a *Cart* or *Waggon* *b, r, c, d*, and the three others representing the *Horses*.

Note also that the Star *a* is called *Alioth*, *d* is called *Dubbe*, *b* and *r* are called the two *Guards* or *Pointers*, for they point directly in a straight Line to the *North Pole* *p*, which now is near $2\frac{1}{4}$ Degrees distant from the Star *s*, which is called the *North Pole Star*.

You may find the *North Pole* also by the Star *Alioth*, from which a straight Line drawn to the *Pole Star* *s* goes through the *Pole Point* *p*, and leaves it at $2\frac{1}{4}$ Degrees Distance from the *Pole Star*.

You

You may find it also by the *little Star n*, which is the nearest Star to the *Pole Star s*; for a Line drawn from *n* to *s* is the Hypothenufe of a Right-angled Triangle, whose right Angle is in the *Pole Point p*.

Problem XXXII. *To find the Latitude by any Star that is on the North Meridian.*

It has been already shewn in the Xth Problem of this Section, how to find the Latitude of a Place by the Meridian Altitude of a Star on the South Meridian; but the Methods of Performance on the North Meridian are different.

The *first Way* is this. Take the Altitude of it when it is upon the North Meridian at 5 or 6 or 7 o'Clock in the Winter, then 12 Hours afterwards take its Altitude again, for it will be on the Meridian on the other Side of the Pole; subtract half the Difference of those two Altitudes from the greatest Altitude, and the Remainder is the true *Elevation of the Pole, or Latitude of the Place.*

A *second Way.* Observe when the Star *Alioth* comes to the Meridian under the Pole; then take the Height of the Pole Star, and out of it subtract $2\frac{1}{4}$ Degrees (which is the Distance of the Pole Star from the Pole) the Remainder will be the true Elevation of the Pole, or the Latitude. The Reason of this Operation is evident by the xxxth Fi-

gure, for *Alioth* is on the Meridian under the Pole just when the *Pole Star* is on the Meridian above the Pole.

Note, The *Pole Star* is upon the Meridian above the Pole just at 12 o'Clock at Night on the 13th Day of *May*, and under the Meridian on the 16th Day of *November*: Fifteen Days after that it will be upon the Meridian at 11 o'Clock: Thirty Days after at 10 o'Clock: So that every Month it differs about two Hours.

Problem XXXIII. *To find the Hour of the Night by the Stars which are on the Meridian.*

If you have a Meridian Line drawn, and such a Board as I have described under the 9th Use of the Meridian Line, you may exactly find when a Star is on the Meridian; and if you are well acquainted with the Stars, wheresoever you set up that Board upright on a Meridian Line, you will see what Star is on the Meridian. Suppose *Aldebaran* or the *Bull's Eye* on the 30th of *January* is on the South Part of the Meridian; then in some Tables find the Sun's and that Star's Right Ascension, add the Complement of the Right Ascension of the Sun for that Day, (*viz.*) 3 Hours 6 Minutes to the Right Ascension of the Star 4 Hours 17 Minutes, and it makes 7 Hours 23 Minutes the true Hour of the Afternoon.

Note,

Note, If the Star be on the *North Part of the Meridian*, or below the *North Pole*, it is just the same Practice as on the *South*: for when any Star is on the Meridian, the Difference between the Sun's R. A. and that Star's R. A. is the Sun's true Hour, *i. e.* its Distance from 12 o' Clock at Noon or Midnight, at which Time the Sun is on the Meridian either *South* or *North*.

If you have no Meridian Line drawn, you may find within two or three Degrees what Stars are on the North Meridian thus; Hold up a String and Plummet and project it with your Eye over-right the *Pole Star*, or rather the *Pole Point*, and observe what other Stars are covered by it or close to it, for these are on or near the Meridian.

Or it may be done with very little Error by standing upright and looking straight forward to the Pole Star, with a Stick, or Staff between your Hands, then raise up the Staff as straight as you can over-right the Pole, and observe what Stars it covers in that Motion.

But these Methods are rude, and only serve for vulgar Purposes.

Problem XXXIV. *To find at what Hour of any Day a known Star will come upon the Meridian.*

Subtract the Right Ascension of the Sun for that Day from the Right Ascension of the
the

the Star, the Remainder shews how many Hours after Noon the Star will be on the Meridian. Suppose I would know at what Hour the *Great Bear's Guards* or *Pointers* will be on the Meridian on the 27th of *April*; (for they come always to the Meridian nearly both at once.) The Right Ascension of the Sun that Day is about two Hours 19 Minutes. The Right Ascension of those Stars is always ten Hours 24 Minutes. Subtract the Sun's R. A. from the Star's R. A. the Remainder is five Minutes past eight a Clock at Night, and at that Time will the *Pointers* be on the *Meridian*.

	H.	M.
Right Ascen. of <i>Pointers</i> is	10	24
Right Ascen. of <i>Sun April 27th</i> is	2	19
		5
Time of Night	8	5

Note, If the Sun's Right Ascension be greater than the Right Ascension of the Star, you must add 24 Hours to the Star's Right Ascension, and then subtract as before.

You may easily find also what Day any Star (suppose either of the *Pointers*) will be on the *Meridian* just when the Sun is there, (*viz.*) at 12 a Clock. Find in the Tables of the Right Ascension of the Sun what Day that is wherein the Sun's Right Ascension is the same (or very near the same) with that Star's, which is the 28th of *August*. The Sun's
Right

Right Ascension is 10 Hours 28 Minutes, then the Sun and Star are both on the Noon Meridian near the same time. But the Sun's Right Ascension on the 23d of *February* is 22 Hours 24 Minutes. Therefore the Sun at that Time is in the Noon Meridian when the Star is in the Midnight Meridian, there being just 12 Hours Difference.

Thence you may reckon when the Star will be on the Meridian at any Time; for about 15 Days after it will be on the Meridian at 11 a Clock, 30 Days after at 10 a Clock. So that every Month it differs about two Hours; whence it comes to pass that in 12 Months its Difference arising to 24 Hours it comes to be on the Meridian again at the same Time with the Sun.

Problem XXXV. *Having the Altitude of any Star given to find the Hour.*

To perform this Problem you should never seek the Altitude of the Star when it is within an Hour or two of the Meridian, because at that Time the Altitude varies so very little. When you have gotten the Altitude, then seek what is the Star's *Hour*, that is, its Equatorial Distance * from the Meridian at that Altitude, which may be done by the Globe, or any

* The Sun or Star's *Horizontal* Distance from the Meridian is the *Azimuth*: It is the *Equatorial* Distance from the Meridian which is called the Sun or Star's *Hour*.

Quadrant, or by the *Analemma*, just as you would seek the Sun's Hour if its Altitude were given: After this, seek the Difference between the Sun's Right Ascension for that Day and the Star's Right Ascension, and by comparing this Difference with the Star's Hour you will find the true Hour of the Night.

Note, This Method of Operation though it be true in Theory, yet it is tedious and very troublesome in Practice. The most usual Ways therefore of finding the Hour of the Night by the Stars (whether they are on the Meridian or not) is by making use of a *large Globe*, or the Instrument called a *Nocturnal*, wherein the most remarkable Stars are fixed in their proper Degrees of Declination and Right Ascension: And their Relation to the Sun's Place in the Ecliptick and to his Right Ascension every Day in the Year being so obvious, makes the Operation of finding the true Hour very easy and pleasant.

S E C T. XXI.

Tables of the Sun's Declination, and of the Declination, and Right Ascension of several remarkable fixed Stars, together with some Account how they are to be used.

THE Resolution of some of the *Astronomical Problems* by *Geometrical Operations* on the *Analemma* requires the Knowledge

ledge of the true *Place* of the Sun, his *Right Ascension*, or his *Declination* at any given Day of the Year. But since the Knowledge of his *Declination* is of most easy and convenient Use herein, and since his true *Place* in the Ecliptick as well as his *Right Ascension* may be nearly found Geometrically when his *Declination* is given, (except when near the Solstices) I have not been at the Pains to draw out particular Tables of the *Sun's Place*, but contented my self with Tables of *Declination* for every Day in the Year, and Tables of *Right Ascension* for every tenth Day. These are sufficient for a young Learner's Practice in his first Rudiments of *Astronomy*. Those who make a further Progress in this Science and would attain greater Exactness, must seek more particular Tables relating to the *Sun* in other larger Treatises.

Here let these few things be observed.

I. These Tables shew the *Declination* of the Sun each Day at *Noon*; for it is then that the *Astronomer's Day* begins. If you would therefore know the Sun's *Declination*, suppose at *six* o'Clock in the Morning of any given Day, you must compare the *Declination* for that Day with the Sun's *Declination* the *foregoing* Day, and make a proportionable Allowance, (*viz.*) three fourth Parts of the Difference of those two *Declinations*

tions. If at *six* in the Afternoon, you must compare it with the following Day, and allow in the same manner one fourth Part.

II. These Tables are fitted for the *Meridian of London*. If you would know therefore the Sun's Declination the same Day at Noon at *Port-Royal* in *Jamaica*, you must consider the Difference of Longitude. Now that Place being about 75 Degrees *Westward* from *London*, that is, five Hours later in Time, it is but seven o'Clock in the Morning there when it is Noon at *London*: and you must make a proportionable Allowance for the Difference of the Sun's Declination by comparing it with that of the foregoing Day. If that Place had the same Longitude *Eastward* from *London*, it would be five o'Clock in the Afternoon there; and then you must compare the Sun's present Declination with that of the Day following, and make Allowance for the five Hours, *i. e.* almost $\frac{1}{4}$ of the Difference of the two Declinations. But if you would know the Sun's Declination at any Place and at any Hour of the Day at that Place; find what Hour it is at *London* at the given Hour at that Place, and find the Declination of the Sun for that Hour at *London* by *Note* the first.

Note,

Note, These Allowances must be *added* or *subtracted* according as the Sun's Declination is increasing or decreasing.

Yet in any of these Geometrical Operations the Difference of the Sun's Declination at other *Hours* of the Day or at other *Places* of the World is so exceeding small that it is not sufficient to make any remarkable Alterations, except when the Sun is near the Equinoxes ; and then there may be some Allowances made for it in the manner I have described ; nor even then is there any need of any such Allowances except in Places which differ from *London* near 5 or 6 Hours in Longitude.

III. Let it be noted also, that as the *Place of the Sun*, so consequently his *Declination* and *Right Ascension* for every Day do vary something every Year by reason of the odd *five Hours* and *forty nine Minutes* over and above 365 Days, of which the Solar Year consists. Therefore it was proper to represent the Sun's Declination every Day for *four Years* together, (*viz.*) the three Years before *Leap-Year*, and the *Leap-Year* itself. For in the Circuit of those four Years the Sun returns very nearly to the same Declination again on the same Day of the Year, because those odd five Hours and 49 Minutes do in four Yearstime make up 24 Hours, or a whole Day (wanting but four times eleven, *i. e.* 44 Minutes ;)
which

which Day is super-added to the Leap-Year, and makes the 29th of *February*, as hath been said before.

It is true, that in a considerable Length of Time these Tables will want further Correction, because of those 44 Minutes which are really wanting to make up the super-added Day in the Leap-Year. But these Tables will serve sufficiently for any common Operations for forty or fifty Years to come, provided you always consult that Table which is applicable to the current Year, whether it be a *Leap-Year*, or the *first*, the *second* or the *third* Year after it.

IV. Observe also these Tables of the Sun's Declination are sometimes reduced (as it were) to one *single Scale*. And for this Purpose Men generally choose the Table of Declination for the Second after *Leap-Year*, and this is called the *Mean Declination*, that is, the Middle between the two *Leap-Years*. This is that Account of the *Sun's Place* and *Declination*, &c. which is made to be represented on all Mathematical Instruments, (*viz.*) *Globes*, *Quadrants*, *Projections of the Sphere*, and *graduated Scales*, &c. and this serves for such common Geometrical Practices in Astronomy without any very remarkable Error.

Concerning the *Table of the fixed Stars*, let it be remembered that they move slowly round the Globe Eastward in Circles parallel

parallel to the *Ecliptick*, and therefore they increase their *Longitude* 50 Seconds of a Minute every Year, that is, one Degree in seventy two Years. But their *Latitude* never alters, because they always keep at the same Distance from the *Ecliptick*.

Let it be noted also, that this slow Motion of the *fixed Stars* causes their *Declination* and their *Right Ascension* to vary (though very little) every Year. Their *Right Ascension* necessarily changes because their *Longitude* changes, though not exactly in the same Quantity. And though their *Latitude* never alters, because *Latitude* is their Distance from the *Ecliptick*, yet their *Declination* must alter a little, because it is their Distance from the *Equator*. But the Tables of their *Right Ascension*, which I have here exhibited, will serve for any common Practices for at least twenty Years to come, and their *Declination* for near fifty Years, without any sensible Error in such Astronomical Essays as these.

It may be proper here to give Notice to Learners, that the same Stars may have *North Latitude* and *South Declination*; such are all those that lie between the *Equator* and the *Southern* half of the *Ecliptick*: But all those Stars which lie between the *Equator* and the *Northern* half of the *Ecliptick*, have *South Latitude* and *North Declination*.

*A Table of the Sun's Declination for the Year 1753,
being the First after Leap-Year, which will serve
for near 50 Years.*

Day.	Janu.	Febr.	March	April	May	June
	S.	S.	S.*	N.	N.	N.
	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.
1	22 59	16 57	07 24	04 43	15 12	22 08
2	22 53	16 40	07 01	05 06	15 30	22 16
3	22 48	16 22	06 38	05 29	15 48	22 23
4	22 41	16 04	06 15	05 52	16 05	22 30
5	22 35	15 46	05 51	06 14	16 23	22 36
6	22 27	15 28	05 28	06 37	16 40	22 43
7	22 19	15 09	05 05	07 00	16 56	22 49
8	22 11	14 50	04 42	07 22	17 13	22 54
9	22 03	14 31	04 18	07 44	17 28	22 59
10	21 54	14 11	03 55	08 07	17 44	23 04
11	21 45	13 52	03 31	08 29	17 59	23 08
12	21 35	13 32	03 07	08 51	18 14	23 12
13	21 25	13 12	02 44	09 12	18 29	23 16
14	21 14	12 52	02 20	09 34	18 44	23 19
15	21 03	12 31	01 57	09 55	18 58	23 22
16	20 52	12 10	01 33	10 17	19 12	23 24
17	20 39	11 49	01 09	10 37	19 26	23 25
18	20 27	11 28	00 45	10 58	19 39	23 26
19	20 14	11 06	00 22	11 19	19 52	23 27
20	20 01	10 45	N. 02	11 39	20 05	23 28
21	19 48	10 22	00 25	12 00	20 17	23 29
22	19 34	10 00	00 48	12 20	20 29	23 28
23	19 20	09 39	01 12	12 40	20 40	23 27
24	19 06	09 16	01 36	13 00	20 51	23 26
25	18 51	08 54	01 59	13 19	21 02	23 25
26	18 36	08 31	02 23	13 39	21 12	23 24
27	18 21	08 09	02 46	13 58	21 22	23 22
28	18 05	07 46	03 10	14 17	21 32	23 19
29	17 49		03 33	14 36	21 42	23 15
30	17 31		03 56	14 54	21 51	23 11
31	17 14		04 19		21 59	

A Table of the Sun's Declination for the Year 1753, being the First after Leap-Year, which will serve for near 50 Years.

Day.	July	Aug.	Sept.	Oct.	Nov.	Dec.
	N.	N.	N.*	S.	S.	S.
	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.
1	23 07	17 59	08 10	03 20	14 36	21 55
2	23 03	17 43	07 48	03 43	14 55	22 04
3	22 59	17 28	07 26	04 07	15 14	22 13
4	22 54	17 12	07 04	04 30	15 32	22 21
5	22 48	16 56	06 42	04 53	15 51	22 28
6	22 42	16 39	06 19	05 16	16 09	22 36
7	22 36	16 23	05 57	05 39	16 27	22 42
8	22 29	16 05	05 34	06 02	16 44	22 48
9	22 22	15 47	05 11	06 25	17 01	22 54
10	22 15	15 30	04 49	06 48	17 18	23 00
11	22 06	15 12	04 26	07 11	17 35	23 05
12	21 58	14 54	04 03	07 34	17 51	23 09
13	21 49	14 36	03 40	07 56	18 07	23 13
14	21 40	14 18	03 17	08 19	18 22	23 17
15	21 31	13 59	02 54	08 41	18 38	23 20
16	21 21	13 40	02 30	09 03	18 53	23 23
17	21 11	13 21	02 07	09 25	19 08	23 25
18	21 01	13 02	01 44	09 47	19 22	23 26
19	20 50	12 42	01 20	10 09	19 36	23 27
20	20 39	12 22	00 58	10 31	19 50	23 28
21	20 28	12 02	00 34	10 52	20 03	23 29
22	20 15	11 42	00 10	11 14	20 16	23 28
23	20 03	11 22	S. 12	11 34	20 29	23 28
24	19 50	11 01	00 36	11 55	20 41	23 27
25	19 37	10 41	00 59	12 16	20 53	23 25
26	19 24	10 20	01 23	12 36	21 04	23 23
27	19 11	09 59	01 46	12 57	21 15	23 21
28	18 57	09 37	02 10	13 17	21 25	23 18
29	18 43	09 16	02 33	13 37	21 36	23 14
30	18 28	08 55	02 57	13 57	21 46	23 10
31	18 14	08 33		14 16		23 05

A Table of the Sun's Declination for the Year 1754, being the second after Leap-Year, which will serve for near 50 Years.

Day.	Janu. S.		Febr. S.		March S.*		April N.		May N.		June N.	
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.
1	23	01	17	01	07	29	04	37	15	08	22	06
2	22	55	16	44	07	06	05	00	15	26	22	14
3	22	50	16	27	06	43	05	23	15	44	22	21
4	22	44	16	09	06	20	05	46	16	01	22	28
5	22	37	15	51	05	57	06	09	16	19	22	35
6	22	29	15	32	05	34	06	32	16	37	22	41
7	22	21	15	14	05	11	06	54	16	51	22	47
8	22	13	14	55	04	47	07	17	17	08	22	53
9	22	05	14	35	04	24	07	39	17	24	22	58
10	21	56	14	16	04	00	08	01	17	40	23	03
11	21	47	13	56	03	37	08	23	17	55	23	07
12	21	37	13	37	03	13	08	45	18	11	23	11
13	21	27	13	16	02	50	09	07	18	26	23	15
14	21	17	12	56	02	26	09	29	18	40	23	18
15	21	06	12	36	02	02	09	50	18	55	23	21
16	20	55	12	15	01	39	10	11	19	09	23	23
17	20	42	11	54	01	15	10	32	19	22	23	25
18	20	30	11	33	00	51	10	53	19	36	23	26
19	20	17	11	12	00	28	11	14	19	49	23	27
20	20	04	10	49	00	04	11	34	20	02	23	28
21	19	51	10	27	N. 19		11	55	20	14	23	29
22	19	38	10	06	00	43	12	15	20	26	23	29
23	19	24	09	44	01	06	12	35	20	38	23	28
24	19	09	09	22	01	30	12	55	20	49	23	27
25	18	55	08	59	01	53	13	15	20	59	23	26
26	18	40	08	37	02	17	13	34	21	10	23	24
27	18	24	08	14	02	40	13	53	21	20	23	21
28	18	08	07	52	03	04	14	12	21	30	23	18
29	17	52			03	27	14	31	21	39	23	15
30	17	36			03	51	14	50	21	49	23	12
31	17	18			04	14			21	57		

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A Table of the Sun's Declination for the Year 1754, being the ~~first~~ after Leap-Year, which will serve for near 50 Years.

Day.	July	Aug.	Sept.	Oct.	Nov.	Dec.
	N.	N.	N.*	S.	S.	S.
	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.
1	23 08	18 02	08 15	03 14	14 31	21 53
2	23 04	17 47	07 54	03 38	14 50	22 02
3	23 00	17 32	07 31	04 01	15 09	22 11
4	22 55	17 16	07 09	04 24	15 28	22 19
5	22 49	17 00	06 47	04 47	15 46	22 27
6	22 44	16 43	06 25	05 11	16 04	22 34
7	22 37	16 26	06 02	05 34	16 22	22 40
8	22 31	16 09	05 40	05 57	16 40	22 47
9	22 24	15 52	05 17	06 20	16 57	22 53
10	22 17	15 34	04 54	06 43	17 14	22 58
11	22 09	15 17	04 31	07 05	17 31	23 03
12	22 00	14 59	04 09	07 28	17 48	23 08
13	21 51	14 40	03 45	07 51	18 04	23 12
14	21 43	14 22	03 22	08 13	18 19	23 16
15	21 33	14 03	02 59	08 36	18 34	23 19
16	21 24	13 45	02 36	08 58	18 49	23 22
17	21 14	13 26	02 13	09 20	19 04	23 24
18	21 03	13 06	01 49	09 42	19 19	23 26
19	20 53	12 47	01 26	10 04	19 33	23 27
20	20 42	12 27	01 03	10 25	19 47	23 28
21	20 30	12 07	00 39	10 46	20 00	23 29
22	20 18	11 47	00 16	11 08	20 13	23 29
23	20 06	11 27	S. 07	11 29	20 26	23 28
24	19 53	11 06	00 30	11 51	20 38	23 27
25	19 40	10 46	00 54	12 11	20 50	23 26
26	19 27	10 25	01 17	12 31	21 02	23 24
27	19 14	10 04	01 41	12 52	21 13	23 21
28	19 00	09 43	02 04	13 12	21 23	23 18
29	18 46	09 21	02 27	13 32	21 33	23 15
30	18 32	08 59	02 51	13 52	21 43	23 11
31	18 17	08 37		14 12		23 06

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A Table of the Sun's Declination for the Year 1755, being the Third after Leap-Year, which will serve for near 50 Years.

Day.	Janu.	Febr.	March	April	May	June
	S.	S.	S.*	N.	N.	N.
	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.
1	23 02	17 06	07 35	04 30	15 04	22 04
2	22 57	16 48	07 12	04 54	15 22	22 12
3	22 51	16 31	06 49	05 17	15 39	22 20
4	22 45	16 13	06 26	05 39	15 57	22 27
5	22 38	15 55	06 03	06 03	16 14	22 33
6	22 31	15 37	05 40	06 26	16 31	22 39
7	22 23	15 18	05 16	06 49	16 48	22 46
8	22 15	14 59	04 53	07 11	17 04	22 51
9	22 07	14 40	04 29	07 34	17 20	22 57
10	21 58	14 21	04 06	07 56	17 36	23 02
11	21 49	14 01	03 43	08 18	17 52	23 06
12	21 40	13 41	03 19	08 40	18 07	23 10
13	21 30	13 21	02 55	09 02	18 22	23 14
14	21 19	13 01	02 32	09 24	18 37	23 17
15	21 09	12 41	02 08	09 45	18 51	23 20
16	20 57	12 20	01 44	10 06	19 05	23 23
17	20 45	11 59	01 21	10 27	19 19	23 25
18	20 33	11 38	00 57	10 48	19 33	23 26
19	20 20	11 17	00 33	11 09	19 46	23 27
20	20 08	10 55	00 10	11 29	19 59	23 28
21	19 54	10 33	N. 13	11 50	20 11	23 29
22	19 41	10 11	00 37	12 10	20 23	23 29
23	19 27	09 49	01 00	12 30	20 35	23 28
24	19 13	09 27	01 24	12 50	20 46	23 27
25	18 58	09 05	01 48	13 10	20 57	23 26
26	18 43	08 42	02 11	13 29	21 07	23 24
27	18 28	08 20	02 35	13 49	21 18	23 22
28	18 12	07 57	02 58	14 08	21 28	23 19
29	17 56		03 22	14 27	21 37	23 16
30	17 40		03 45	14 45	21 46	23 13
31	17 23		04 08		21 55	

A Table of the Sun's Declination for the Year 1755, being the Third after Leap-Year, which will serve for near 50 Years.

Day.	July N.		Aug. N.		Sept. N.*		Oct. S.		Nov. S.		Dec. S.	
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.
1	23	09	18	06	08	21	03	09	14	26	21	50
2	23	05	17	51	07	59	03	32	14	46	22	00
3	23	01	17	35	07	37	03	55	15	05	22	09
4	22	56	17	20	07	15	04	19	15	23	22	17
5	22	51	17	04	06	53	04	42	15	42	22	24
6	22	45	16	47	06	30	05	05	16	00	22	31
7	22	39	16	30	06	08	05	28	16	18	22	38
8	22	32	16	13	05	45	05	51	16	36	22	45
9	22	26	15	56	05	22	06	14	16	53	22	51
10	22	18	15	38	04	00	06	37	17	10	22	57
11	22	10	15	21	04	37	07	00	17	26	23	02
12	22	02	15	03	04	14	07	23	17	43	23	07
13	21	53	14	45	03	51	07	45	17	59	23	11
14	21	45	14	27	03	28	08	07	18	15	23	15
15	21	36	14	08	03	05	08	29	18	30	23	18
16	21	26	13	49	02	42	08	51	18	46	23	21
17	21	16	13	30	02	18	09	14	19	01	23	23
18	21	06	13	11	01	55	09	36	19	15	23	25
19	20	55	12	51	01	32	09	57	19	30	23	27
20	20	44	12	32	01	08	10	19	19	43	23	28
21	20	33	12	12	00	45	10	41	19	57	23	29
22	20	21	11	52	00	21	11	02	20	10	23	29
23	20	09	11	32	S.	02	11	23	20	23	23	28
24	19	56	11	11	00	25	11	45	20	35	23	27
25	19	44	10	51	00	48	12	05	20	47	23	26
26	19	31	10	30	01	11	12	26	20	58	23	24
27	19	17	10	09	01	35	12	47	21	09	23	21
28	19	04	09	48	01	58	13	07	21	20	23	18
29	18	50	09	26	02	22	13	27	21	31	23	15
30	18	35	09	04	02	45	13	47	21	41	23	12
31	18	21	08	42			14	07			23	08

A Table of the Sun's Declination for the Year 1756, being Leap-Year, which will serve for near 50 Years.

Day.	Janu.	Febr.	March	April	May	June
	S.	S.	S.*	N.	N.	N.
	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.
1	23 03	17 10	07 17	04 49	15 17	22 10
2	22 58	16 53	06 54	05 12	15 35	22 17
3	22 52	16 35	06 28	05 35	15 52	22 24
4	22 46	16 17	06 08	05 58	16 09	22 31
5	22 39	15 59	05 45	06 21	16 26	22 38
6	22 32	15 41	05 22	06 43	16 43	22 44
7	22 25	15 23	04 59	07 06	17 00	22 50
8	22 17	15 04	04 35	07 28	17 16	22 56
9	22 09	14 45	04 12	07 50	17 32	23 01
10	22 01	14 26	03 48	08 13	17 48	23 05
11	21 52	14 06	03 25	08 35	18 03	23 10
12	21 42	13 46	03 01	08 57	18 18	23 14
13	21 32	13 26	02 37	09 18	18 33	23 17
14	21 22	13 06	02 14	09 39	18 48	23 20
15	21 11	12 46	01 50	10 00	19 02	23 22
16	21 00	12 25	01 26	10 22	19 16	23 24
17	20 49	12 04	01 03	10 43	19 29	23 26
18	20 37	11 43	00 39	11 04	19 42	23 27
19	20 24	11 22	00 16	11 24	19 55	23 28
20	20 11	10 00	N. 07	11 45	20 07	23 28
21	19 58	10 38	00 31	12 05	20 19	23 29
22	19 44	10 16	00 55	12 25	20 31	23 28
23	19 30	09 54	01 18	12 45	20 43	23 28
24	19 16	09 32	01 42	13 05	20 54	23 27
25	19 02	09 10	02 06	13 25	21 05	23 25
26	18 47	08 48	02 29	13 44	21 15	23 23
27	18 32	08 25	02 53	14 03	21 25	23 20
28	18 16	08 03	03 16	14 22	21 35	23 17
29	18 00	07 40	03 39	14 41	21 44	23 14
30	17 44		04 03	14 59	21 53	23 10
31	17 27		04 26		22 02	

A Table of the Sun's Declination for the Year 1756, being Leap-Year, which will serve for near 50 Years.

Day.	July	Aug.	Sept.	Oct.	Nov.	Dec.
	N.	N.	N.*	S.	S.	S.
	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.
1	23 06	17 55	08 04	03 26	14 41	21 57
2	23 02	17 39	07 42	03 50	15 00	22 06
3	22 57	17 24	07 20	04 13	15 19	22 15
4	22 52	17 08	06 58	04 36	15 37	22 23
5	22 46	16 51	06 36	04 59	15 56	22 30
6	22 40	16 34	06 13	05 23	16 14	22 37
7	22 34	16 17	05 51	05 46	16 31	22 43
8	22 27	16 00	05 28	06 09	16 49	22 50
9	22 20	15 43	05 05	06 32	17 06	22 56
10	22 12	15 25	04 42	06 54	17 23	23 01
11	22 04	15 07	04 20	07 17	17 39	23 06
12	21 55	14 49	03 57	07 40	17 55	23 10
13	21 47	14 31	03 33	08 02	18 11	23 14
14	21 38	14 13	03 10	08 25	18 27	23 18
15	21 28	13 54	02 47	08 47	18 42	23 21
16	21 19	13 35	02 24	09 09	18 57	23 23
17	21 08	13 16	02 01	09 31	19 12	23 25
18	20 58	12 56	01 37	09 53	19 26	23 27
19	20 47	12 37	01 14	10 15	19 40	23 28
20	20 36	12 17	00 51	10 36	19 54	23 28
21	20 24	11 57	00 27	10 57	20 07	23 29
22	20 12	11 37	00 04	11 18	20 20	23 28
23	19 59	11 16	S. 19	11 39	20 32	23 28
24	19 47	10 56	00 42	12 00	20 45	23 27
25	19 34	10 35	01 06	12 21	20 56	23 25
26	19 21	10 14	01 29	12 42	21 07	23 22
27	19 07	09 53	01 53	13 02	21 18	23 19
28	18 53	09 32	02 16	13 22	21 28	23 16
29	18 39	09 10	02 40	13 42	21 38	23 13
30	18 24	08 48	03 03	14 02	21 48	23 09
31	18 10	08 26		14 22		23 04

A Table of the Right Ascension and Declination of some of the most noted among the fixed Stars for the Year 1754, which will serve for near 20 Years without sensible Errors.

The Names of the Stars.	Magni.	Right Ascen.		Declination.		N. or S.
		d.	m.	d.	m.	
<i>Algenib</i> in the flying Horse's } Wing, called also <i>Ala</i> } <i>Pegasi</i> - - - - - }	2	00	10	13	40	N
<i>Scheder</i> in <i>Cassiopeia's</i> Breast	3	06	41	55	03	N
Bright Star in <i>Aries</i> - -	2	28	20	22	09	N
<i>Mandibula</i> , or <i>Mencar</i> , the } Whale's Jaw - - - }	2	42	23	02	06	N
<i>Algol</i> in the Head of <i>Medusa</i>	3	43	01	39	53	N
<i>Aldebaran</i> , the Bull's Eye	1	65	29	15	55	N
<i>Capella</i> , the Goat-Star -	1	74	35	45	41	N
<i>Regell</i> , the bright Foot of } <i>Orion</i> - - - - - }	1	75	28	08	33	S
<i>Orion's</i> preceding Shoulder	2	77	49	06	04	N
Middlemost in <i>Orion's</i> Girdle	2	81	01	01	24	S
Last in <i>Orion's</i> Girdle - -	2	82	12	02	07	S
<i>Orion's</i> following Shoulder	1	85	31	07	19	N
<i>Syrius</i> , the Dog-Star - -	1	98	44	16	20	S
<i>Castor's</i> Head, i. e. the } Northermost Twin - }	2	109	41	32	27	N
<i>Procyon</i> , or the little Dog } Star - - - - - }	2	111	41	05	54	N
<i>Hydra's</i> Heatt - - - -	2	138	56	07	30	S
<i>Regulus</i> , the Lion's Heart -	1	148	49	13	18	N
<i>Deneb</i> , the Lion's Tail -	2	174	08	16	06	N
First in the Great Bear's Tail	3	190	28	21	53	N
<i>Vindemiatrix</i> , <i>Virgin's</i> } North Wing - - - }	2	192	53	57	03	N
<i>Virgin's</i> Spike - - - -	1	198	05	09	44	S
Middlemost in the Great } <i>Bear's</i> Tail - - - }	2	198	06	56	23	N
Last in the Great <i>Bear's</i> Tail	2	204	34	50	43	N
<i>Arcturus</i> - - - - -	1	211	11	20	39	N

The Names of the Stars.	Magni.	Right Ascen.		Declination.		N. or S.
		d.	m.	d.	m.	
Southern <i>Balance</i> - - -	2	219	21	14	53	S
Northern <i>Crown</i> - - -	2	231	11	27	40	N
<i>Antares</i> , the Scorpion's Heart	1	243	37	25	47	S
<i>Serpentarius's</i> Head - -	2	260	58	12	46	N
<i>Dragon's</i> Head - - - -	2	268	00	51	32	N
<i>Lucida Lyræ</i> , in the Harp	1	277	21	38	33	N
<i>Eagle</i> , or <i>Vultur's</i> Heart -	1	294	46	08	10	N
<i>Antinous's</i> Hand - - -	3	299	54	01	37	S
<i>Fomabant</i> , the Southern } Fish's Mouth - - - }	1	340	57	31	04	S
<i>Scheat</i> , in the flying Horse's } Shoulder - - - - }	2	343	00	26	36	N
<i>Marchab</i> , in the flying } Horse's Neck - - - }	2	343	09	13	44	N
<i>Andromeda's</i> Head - - -	2	358	58	27	35	N

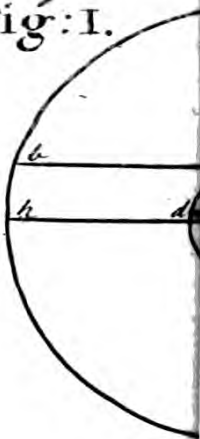
Note, In this Edition, which is taken from the fourth published by the Doctor, there are no Alterations made, except what were necessary to adapt the various Parts thereof, particularly the *Tables*, to the *New Style*, and the present Time.

☞ These *Tables* will answer pretty exactly for every other 50 Years, counting from the Date of the Years here mentioned, *viz.* the *Tables* for 1803, will be the same with those for 1703, Allowance being made for the Variation of the *Stile*; and those for 1853, will be nearly the same with the *Tables* here exhibited for the Year 1753. In like Manner the *Tables* for 1754, 1755, 1756, will nearly represent the Sun's Declination for the Years 1854, 1855, 1856.

Tables of the Sun's Right Ascension for every tenth Day of the Years 1753, 1754, 1755, 1756. The Sun's Right Ascension for all the intermediate Days may be nearly computed by allowing about four Minutes of an Hour, i e. one Degree for every Day.

Y.	D.	Jan.	Feb.	March	April	May	June
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1753.	I	18 49	20 59	22 51	0 44	2 35	4 38
	II	19 33	21 40	23 28	I 20	3 13	5 19
	2I	20 16	22 20	00 04	I 57	3 53	6 01
1754.	I	18 48	20 58	22 50	0 43	2 34	4 37
	II	19 32	21 39	23 27	I 19	3 12	5 18
	2I	20 15	22 19	00 03	I 56	3 52	6 00
1755.	I	18 47	20 57	22 49	0 42	2 33	4 36
	II	19 31	21 38	23 26	I 18	3 11	5 17
	2I	20 14	22 18	00 02	I 55	3 51	5 59
1756.	I	18 50	21 00	22 52	0 45	2 36	4 39
	II	19 34	21 41	23 29	I 21	3 14	5 20
	2I	20 17	22 21	00 05	I 58	3 54	6 02
Y.	D.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1753.	I	6 42	8 41	10 43	12 31	14 27	16 32
	II	7 23	9 22	11 19	13 08	15 08	17 15
	2I	8 04	10 03	11 55	13 45	15 49	18 00
1754.	I	6 41	8 40	10 42	12 30	14 26	16 31
	II	7 22	9 21	11 18	13 07	15 07	17 14
	2I	8 03	10 02	11 54	13 44	15 48	17 59
1755.	I	6 40	8 39	10 41	12 29	14 25	16 30
	II	7 21	9 20	11 17	13 06	15 06	17 13
	2I	8 02	10 01	11 53	13 43	15 47	17 58
1756.	I	6 43	8 42	10 44	12 32	14 28	16 33
	II	7 24	9 23	11 20	13 09	15 09	17 16
	2I	8 05	10 04	11 56	13 46	15 50	18 01

Fig: I.



Fig

Fig: II.



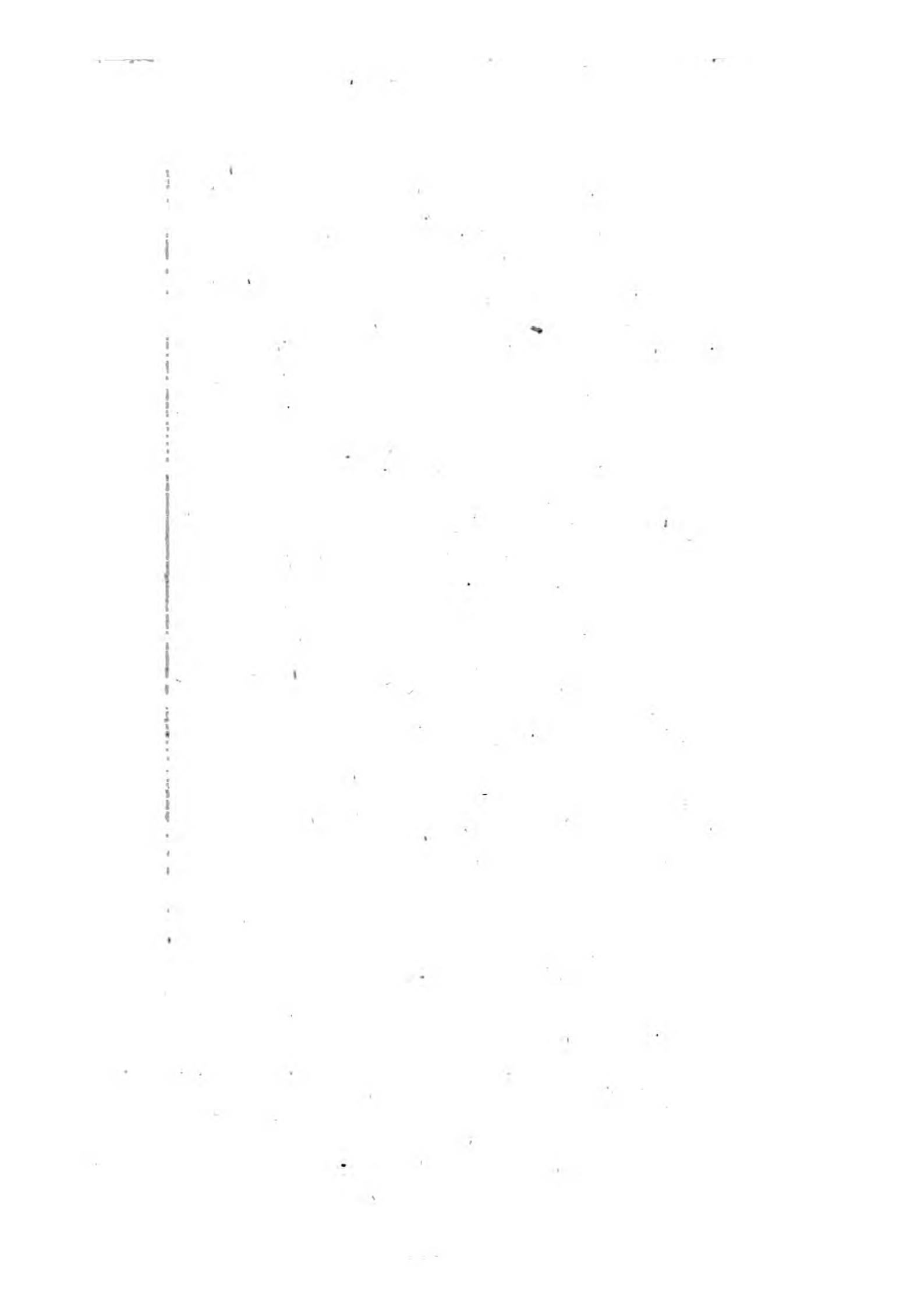
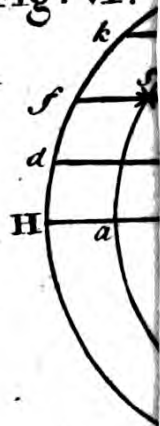
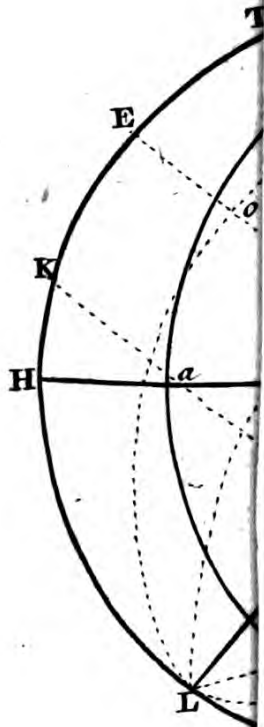


Fig: VI.



Fig



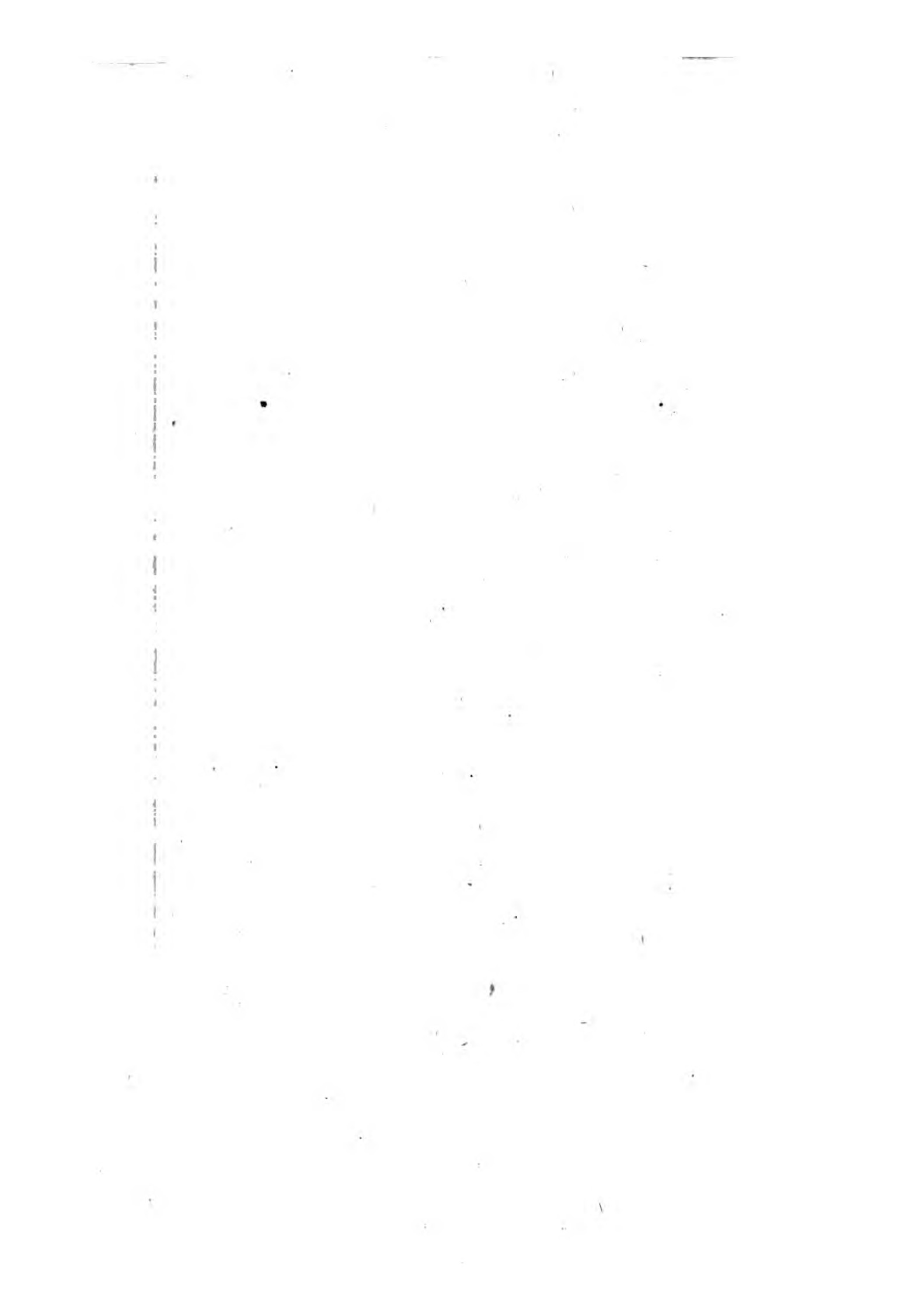


Fig. XIII. A Map of a Country amplified

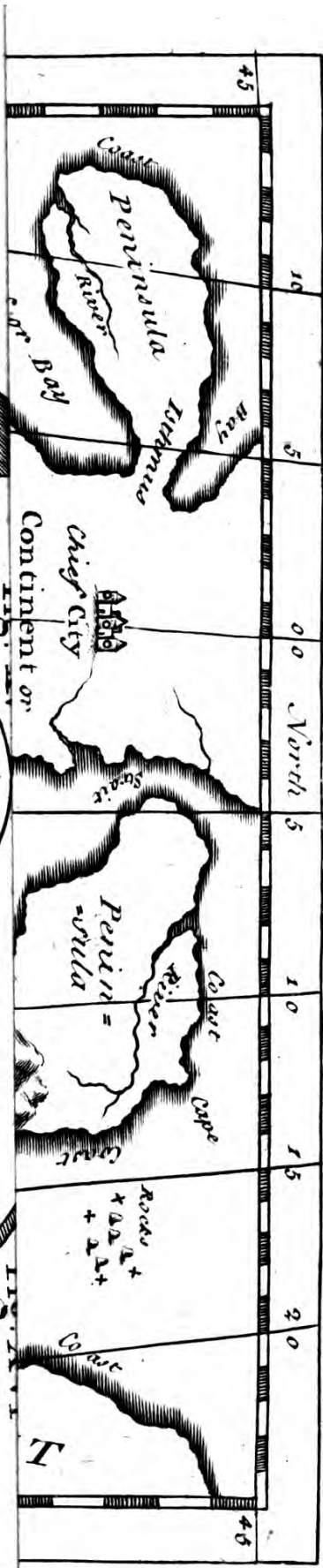


Fig. XIV

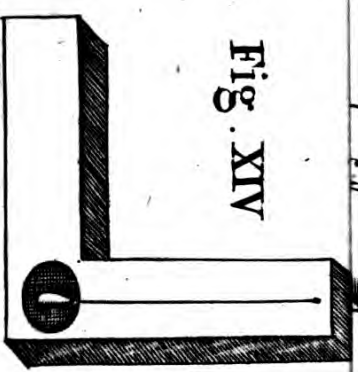
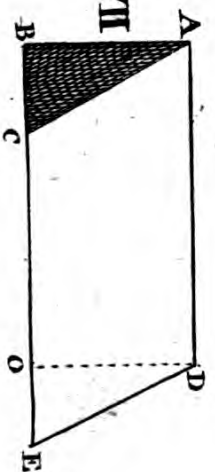


Fig. XVII





[The main body of the page contains extremely faint and illegible text, likely bleed-through from the reverse side of the paper. The text is scattered across the page and cannot be transcribed.]



Fig: 2



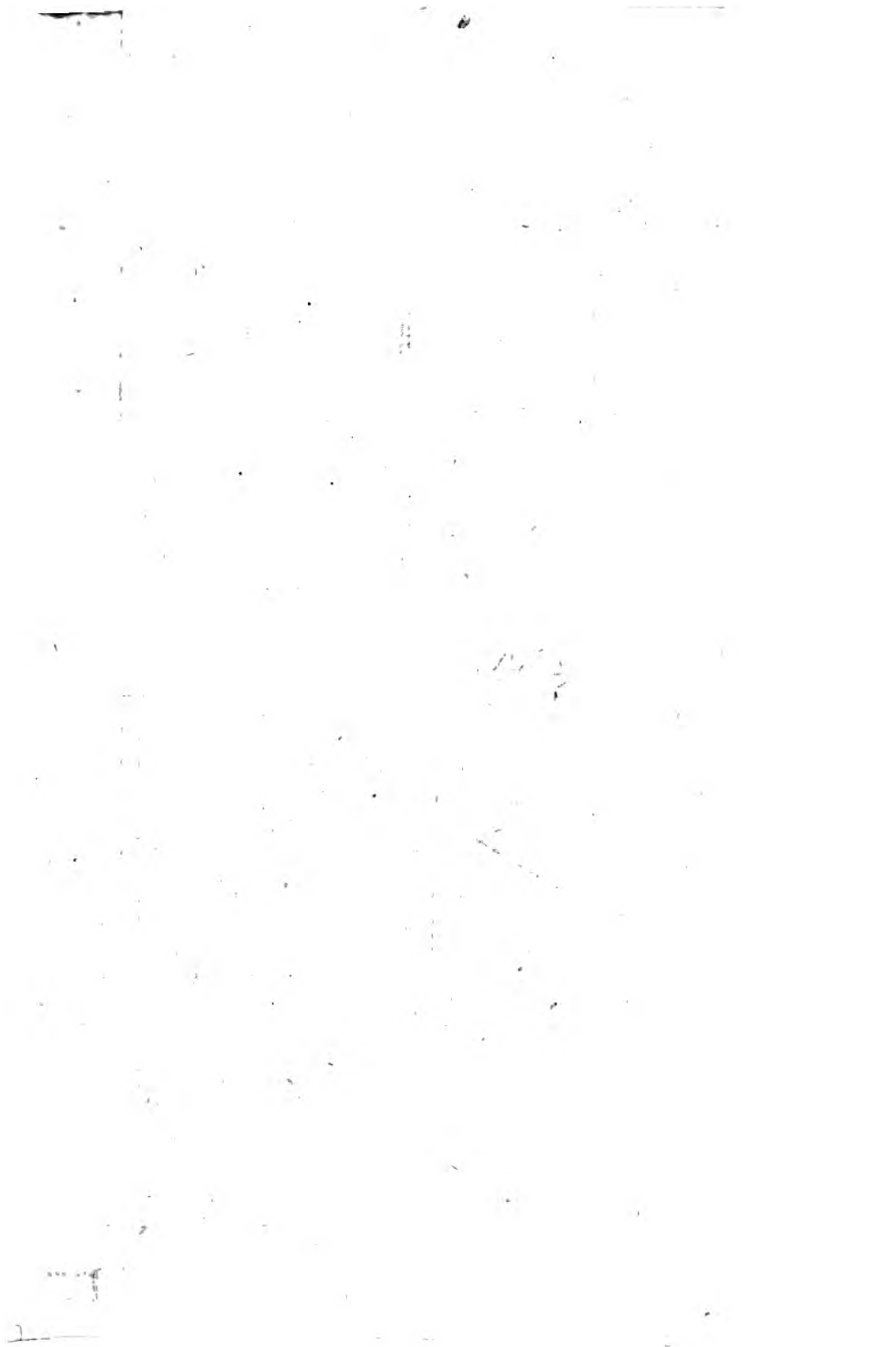


Fig:XXII

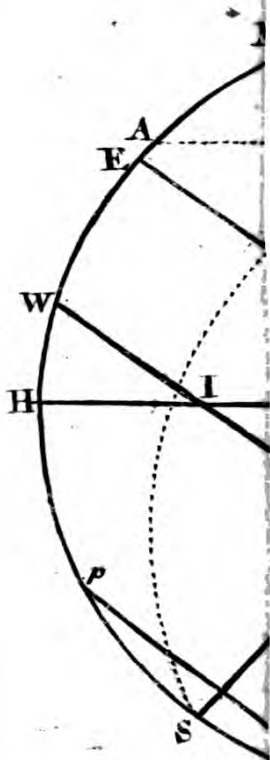


Fig:XXI

