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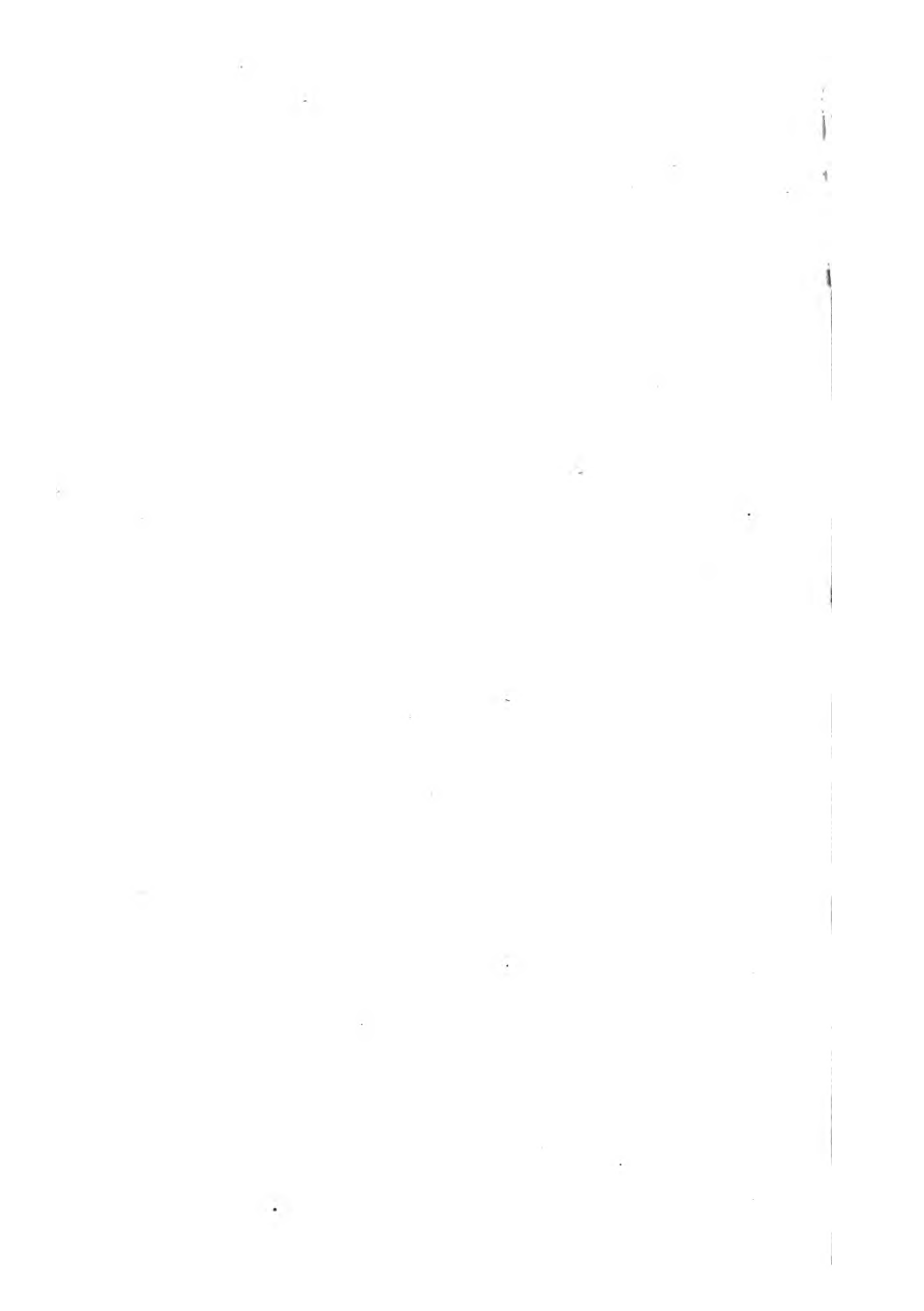
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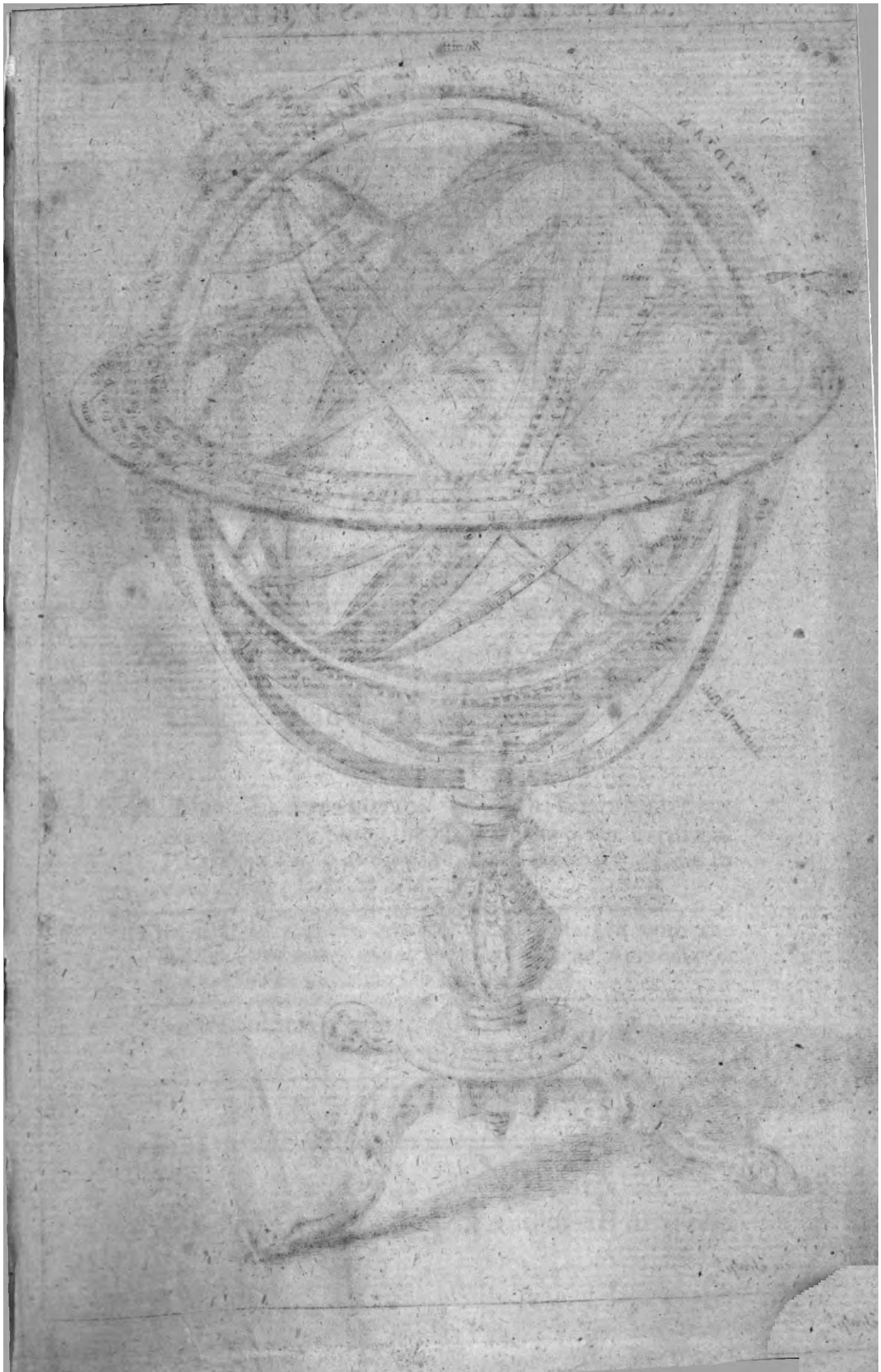


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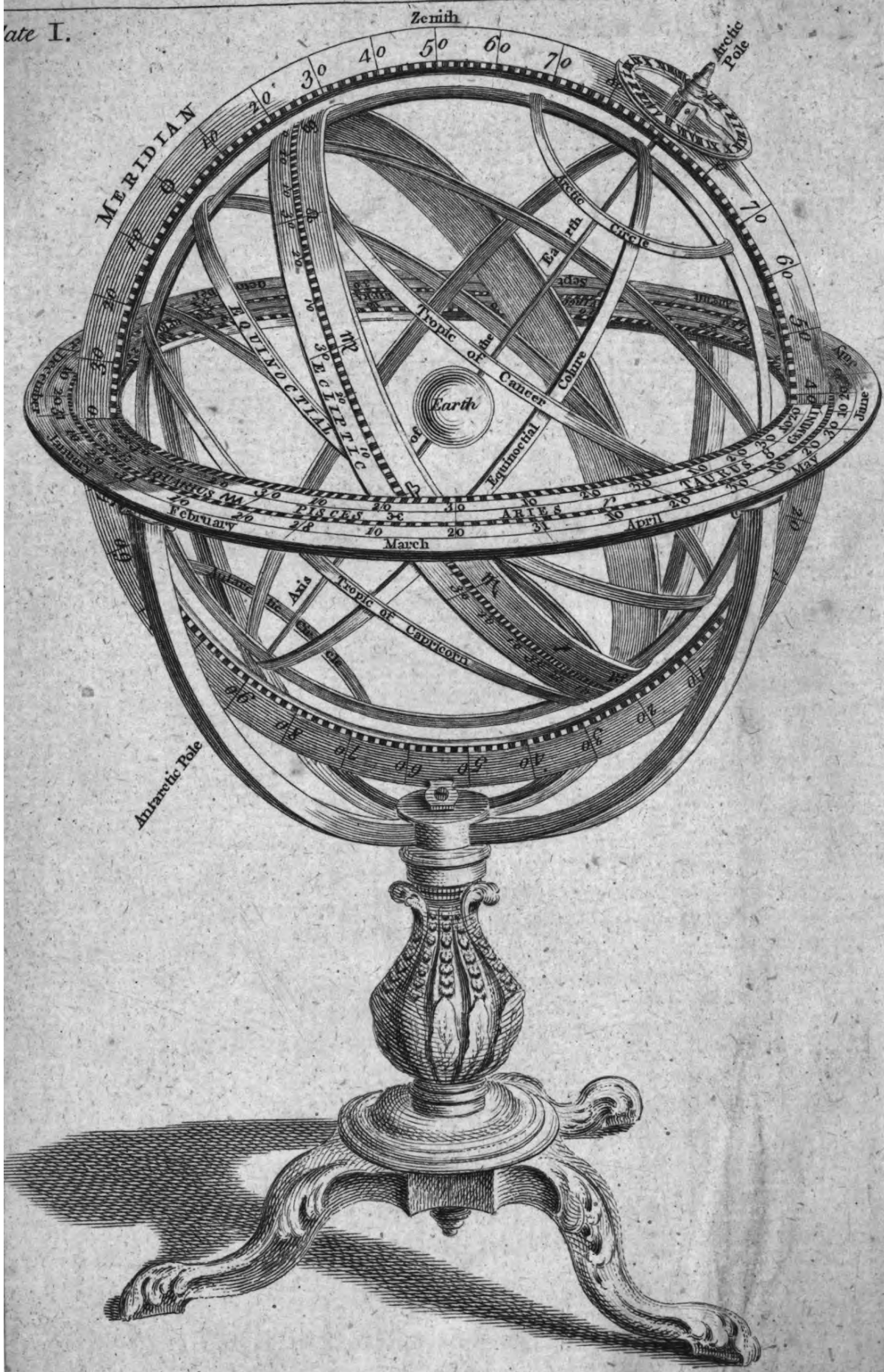






The ARMILLARY SPHERE.

Plate I.



Man^l. Bowen Sculp^t.

THE
DESCRIPTION and USE
OF BOTH THE
GLOBES,
THE
ARMILLARY SPHERE,
AND
ORRERY,
EXEMPLIFIED

In a large and select Variety of Problems in
ASTRONOMY, GEOGRAPHY, DIALLING,
NAVIGATION, Spherical TRIGONOMETRY,
CHRONOLOGY, &c.

ALSO,

A NEW CONSTRUCTION of each GLOBE, by an
Apparatus exhibiting the Phænomena of the Earth and
Heavens exactly as they are, and adapting the same to
every Age of the World.

The Second Edition corrected, and enlarged with the
Addition of many useful Subjects; and an Appendix of
CHRONOLOGY, or the Doctrine of TIME.

The Whole embellished with FIVE COPPER PLATES
of the INSTRUMENTS, &c.

By BENJ. MARTIN.

L O N D O N:

Printed for, and Sold by the Author in *Fleet-street*.





PREFACE.

THE Necessity of the Knowledge of the Use of the Globes, Sphere, and Orrery, for an easy Conception and due Understanding of the first Principles of Geography, Astronomy, Dialling, Navigation, Chronology, and other liberal Sciences, is known to every one; and is of the first Consideration among those Qualities required for forming the SCHOLAR and the GENTLEMAN.

The Invention of these Instruments lies very high in Antiquity; that of the Armillary Sphere is not certainly known; some ascribe it to Musæus, Anaximander, Posidonius, &c. We meet with some Hints of the Celestial Globe as early as Hipparchus's Time, from the Writings of Pliny and Ptolemy. Strabo mentions the Terrestrial Globe; and Propertius (who lived about his Time) speaks directly of depicted Worlds;

Cogor et è Tabula pictos ediscere Mundos.

And Claudian's Description of Archimedes's Sphere in Glass leaves no Room to doubt of the extreme Accuracy to which the Knowledge of the Construction and Use of an Orrery had arrived in the Time of that great Mathematician, who lived about 112 Years before Christ.

Amongst the Improvers and Makers of modern GLOBES we find the following of the first Class, viz. Tycho Brahe, Regiomontanus, Schonerus, Gemma Frisius, Ger. Mercator, J. Hondius, Johnsonius, William Saunderson, William Bleau, and above all Coronelli at Venice, whose Globes were 42. Inches Diameter. Many of these wrote, also, very learnedly of their Uses; but in this Respect we must give the Preference to our own Countryman Robert Hues, whose Latin Treatise was afterwards published by Hondius, and then by Pontanus, with Figures and large

Notes; which were translated into English by J. Chilmead, in the Year 1639.

But after all, no Globes were ever constructed with so much exquisite Skill, Taste, and Elegance as those of the late Mr. SENEX, F. R. S. (now known and celebrated to the remotest Limits of the literary World) and since it has been lately my Province to make and sell these GLOBES, with many Corrections and Improvements; I thought it would be very agreeable to the Public to have a Treatise of the Uses of GLOBES particularly adapted to them, as Mr. Senex himself has left us nothing of his own upon the Subject; and this is the general Reason of the present Publication.

In this Second EDITION the Errors of the First are corrected; several Alterations are made, rendering the Solutions of Problems more perspicuous and elegant in many Respects. There is also an Addition of many New Subjects, viz. (1.) A TABLE of the Longitudes and Latitudes of all the most noted CITIES and TOWNS in the known World. (2.) A Chapter on the TRUE FIGURE and MAGNITUDE of the EARTH, and the Proportion of LAND and WATER on its Surface. (3.) The Etymologies of Arabic Names of the Circles and Points of the Sphere, of Constellations and principal Stars, for the Sake of the Curious in Astronomy. (4.) An Appendix of CHRONOLOGY, by Reason of its near Relation to, and Connection with Astronomy and Geography.

With Respect to the GLOBES themselves, the Celestial has been greatly improved and embellished very lately; and the Terrestrial Plates have been altered and compleated by an Addition of all the Discoveries lately made in the Great South-Sea, and other Parts of the Globe, to the present Year. In short, I can think of nothing material by which they can be rendered more ornamental or useful than they now are; and as they have always been remarkably distinguished and preferred in Point of Accuracy, by the judicious Public; there is no Doubt but in this improved State they will appear more eligible than ever to the Students in this Part of Literature, who, by a Glance of the Eye only, can be fully satisfied of the enormous Difference there is between the very best and the very worst Constructions of Globes that can possibly be.

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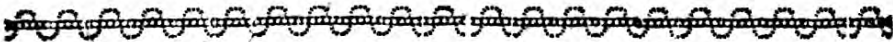
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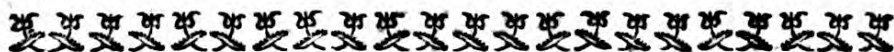
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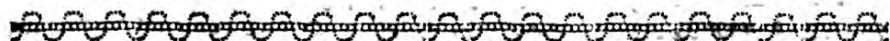
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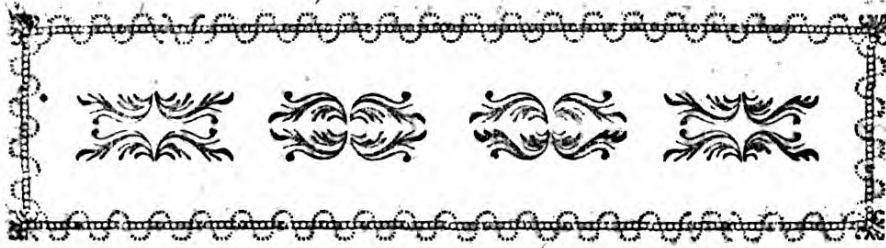
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C H A P. I.

DEFINITIONS *and* PRINCIPLES *necessary*
to be premised to the Use of the
 GLOBES. *Of the* FRAMES, EXTE-
 RIOR CIRCLES *and other* APPA-
 RATUS.

Definition I.

N *artificial* GLOBE is a round
 solid Body, having every Part of
 its Surface equally distant from
 a Point within it, called its
Centre. This, indeed, is rather a *geome-*
trical, than a *geographical* Definition of a
 Globe; because our artificial Globes are
 rather *solid Surfaces* than *solid Spheres*, as
 they are for the greatest Part hollow within-
 side.

Def. II. A SPHERE is the same with a
 Globe, in a geometrical Sense of the Word,
 whether superficial or solid; but an *Armil-*
lary SPHERE is that which consists of Circles
 only, properly put together, without any
 continued or entire Surface.

B

Of

2 DEFINITIONS *and* PRINCIPLES.

Of artificial Globes there are two Sorts, one called the *Celestial Globe*, and the other *Terrestrial*.

Def. III. The CELESTIAL GLOBE is that which has on its Surface a proper Representation of all the visible Stars in the Heavens, and the Images or Figures of the various CONSTELLATIONS into which those Stars are arranged, and which are called ASTERISMS.

Def. IV. The TERRESTRIAL GLOBE is an artificial Representation of all the Parts of LAND and WATER which constitute the Surface of the real Globe of the Earth in their proper Quantity, Form, Situation, and all other Circumstances.

To render these Globes useful, they are disposed in Frames, and are *moveable* round an Axis, so as to represent the diurnal Motion of the Earth and Heavens. They are also moveable in another Respect, so as to have any Part raised or depressed in a vertical Manner.

Def. V. The *Axis* of a Globe, is that Right Line which passes through the Center, and about which it revolves.

Def. VI. The POLES of a Globe are the two extreme Parts of the Axis in the Surface of the Globe.

Def. VII. A GREAT CIRCLE of a Globe, or Sphere, is that which divides it into *two equal Parts*.

Def.

For the USE of the GLOBES. 3

Def. VIII. A *small CIRCLE* is that which divides the Surface of a Globe, or Sphere, into *two unequal Parts*.

Def. IX. *PARALLELS*, or *secondary Circles*, are such small Circles on the Surface of the Globe, or Sphere, as are every where *equally distant* from their corresponding great Circle.

Def. X. A *DEGREE* is the 360th Part of a Circle, so that every Circle, *great or small*, is understood to be divided into 360 of those equal Parts, or Degrees; and each one of those Degrees is supposed to be subdivided into 60 equal Parts called *Minutes*, and each Minute is again divided into 60 equal Parts called *Seconds*, and so on to *Thirds, Fourths, &c.*

Def. XI. The *POLE* of any Circle in the Surface of a Globe, or Sphere, is a Point every way equally distant from it; consequently, the Pole of a *GREAT Circle* is every where at the Distance of *ninety Degrees*.

In order that the Globes may answer, in the best Manner, every Purpose they are designed for, 'tis necessary they should move within various Circles circumscribed without them, which may be called exterior, or *moveable Circles*; and also to have other Circles drawn on their Surfaces, as the Rules of Art require, which therefore may be considered, or distinguished as *fixed Circles*.—

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These Circles of the Globe, or Sphere, are to be conceived as corresponding to the same Circles supposed to be situated in similar Parts of the concave Surface of the Heavens, or upon and about the convex Surface of the Earth, which therefore are called the *imaginary Circles* of the Sphere: by Means of these Circles the various Parts of the Heavens and the Earth, together with their different Phænomena, may, by Means of the artificial Globe, be rendered very easy to *be* conceived and understood.

The exterior, or moveable Circles, are those which follows ;

Def. XII. The *wooden* HORIZON is the upper Part of the Frame, and is that broad Circle, whose upper Side represents the Horizon of the Place, and consists of several useful Circles; one of which contains the twelve Signs of the *Zodiack*, distinguished by their Names and Characters; and each Sign is divided into 30 Degrees: next to this are two Circles, with the *Julian* and *Gregorian* Calendars disposed according to their Months, and Days. Another Circle has all the *Points of the* COMPASS, or the WINDS, as they are denominated by Seamen. Besides the Circles of AMPLITUDE, AZIMUTHS, &c.

Def. XIII. *Cardinal* POINTS are the four principal Points of the Horizon, which are called

called *South, East, North, and West*. From hence, that Pole of the Globe which is turned towards the North Point of the Horizon is called, the *North Pole*; and, of Course, that which is opposite to it, the *South Pole*.

Def. XIV. The ZENITH is the uppermost Pole of the Horizon, or it is the most elevated Point on the Surface of the Globe, in which the Eye of the Spectator is supposed to be placed: or in the Heavens, it is the point *vertically* over ones Head; this artificial Horizon corresponds with that great Circle which bounds our Sight in the Heavens, and in which all the heavenly Bodies are said to *rise* and *set* when they ascend above, or descend below it.

Def. XV. The NADIR is the lower Pole of the Horizon, and therefore is a Point in the Surface of the Globe diametrically opposite to the Zenith.

Def. XVI. The AMPLITUDE is the Distance in Degrees, reckoned from the East or West Point of the Horizon, towards the South or North, and is distinguished into the *Ortive* and *Occasive*, or the Amplitude at the *rising* and *setting* of any heavenly Body.

Def. XVII. The ALMICANTHERS are small Circles, parallel to the Horizon, and are called *Parallels of Altitude*.

Def. XVIII. The *general, or brazen MERIDIAN*, is that large Brass Circle in
which

6 DEFINITIONS *and* PRINCIPLES.

which the Globe is suspended by the Ends of the Axis produced, and is voluble about it: It has its Name from representing that Circle in the Heavens, or on the Surface of the Earth, where the Sun is at the Moment of Noon, or twelve o'Clock, (because Noon, in *Latin*, is called *Meridies*, or Mid-day.) This Circle is divided, on that Side facing the East Point of the Horizon, into four Quarters, containing ninety Degrees each, which Division begins on the middle Point between the Poles on the southern Half of the Meridian, and is numbered each Way towards either Pole; but in the other Half the Meridian, the Degrees are numbered from the Poles towards the middle Point. This Meridian is supported, and moveable on a Brass Roller, fixed on the Pedestal, or Base of the Frame, as also in two Notches cut in the South and North Parts of the Horizon, by which Means the Poles of the Globe are elevated or depressed, alternately, to any Altitude, or Number of Degrees above the Horizon required.

Def. XIX. The *Quadrant* of ALTITUDE is a thin Slip of Brass, whose Edge is divided into ninety Degrees; and it is contrived to be moveable on the Brass Meridian, and to be fixed to any Part by a Nut and Screw: Of Course, when it is fixed to the Zenith, or Pole, of the Horizon, it will serve to
mea-

measure the Altitude of any *Phænomenon* above the Horizon; because the Divisions begin at the Horizon, and are reckoned upwards on the Quadrant.

Def. XX. A *Vertical CIRCLE* is a great Circle of a Sphere, which passeth through the Poles of the Horizon, or turns upon the Zenith and Nadir Points; and that which passeth through the East and West Points of the Horizon is called, the *prime Vertical*, or the Principal of them all. Hence it is easy to understand that the Quadrant of Altitude, fixed on the Zenith Point of the Meridian, will indifferently, and generally represent any of those *vertical Circles* in its Motion about the said Point, or Pole of the Horizon.

Def. XXI. The *AZIMUTH* is the Quantity of the Angle contained between a vertical Circle and the Meridian, reckoned or measured in Degrees of a Circle on the Horizon, from the North or South Points to the East or West. The Quadrant of Altitude therefore, being laid over any particular Place on the Surface of either Globe, will shew its Azimuth on the Horizon.

Def. XXII. The *SEMI-CIRCLE of Position*, is that whose Extremities are fixed to the North and South Points of the Horizon, so that it can be moved freely from the Horizon to the Meridian, or be placed in any Position between them: But as we have
little

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little to do with this Semi-circle in the general Use of the Globe, and is attended with Expence and Incumberance, it is not usually made with the Globe, unless bespoke.

Def. XXIII. The HOUR-CIRCLE is a small Circle fixed on the Brass Meridian, with the Pole of the Globe in its Center: It is divided into twice twelve Hours: The *twelfth Hour* at NOON, is upon the upper Part of it, at the Meridian; and the XII at NIGHT is on the Meridian, at the lower Part towards the Horizon. The Axis of the Globe, projecting above the Brass Meridian, carries round the *Index* or HAND, which shews the Hour, and is easily moveable, on the said Axis, to any Hour proposed, when the Globe is held at Rest.

Def. XXIV. The MARINERS COMPASS is a Box containing a magnetical Needle, freely moving on a fine Point, in the Center of a Circle divided into four times ninety Degrees, reckoning from the North and South towards East and West; and also into the thirty-two Points of the Compass, properly marked: As this Needle has the Property of making a certain constant Angle with the Meridian in every Place, which Angle is called the *Variation*, therefore this Compass, being added to the Frame, will shew the Position of the Meridian when the Variation of the Needle is known. Thus, at *London*, the Variation
is

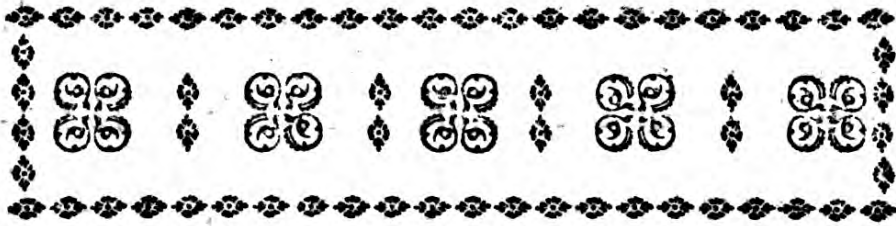
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is at this time about 21 Degrees Westward; therefore, by moving the Frame of the Globe one Way, or the other, 'till the Needle settles itself over the twenty-first Degree, reckoned Westward from the North Point, or *Flower-de-Luce*, we shall have the Brass Meridian coinciding with the true Meridian of *Lonaon*.



C

CHAP.




C H A P. II.

Of the CIRCLES delineated on the SURFACES of the GLOBES, and their various Uses.

On the Surfaces of the Globe are delineated the following Circles.

Definition XXV.

 THE EQUINOCTIAL or the Celestial or the EQUATOR on the Terrestrial Globe, is that great Circle whose Plane divides the Globe into two equal Parts, *viz.* the Northern and Southern Hemispheres, whose Poles are the Poles of the Globe itself. It is divided into 360 Degrees, reckoned Eastward quite round to the Point where they begin.

Def. XXVI. RIGHT ASCENSION, in MOTION is that Degree, or Point of the Equinoctial Line, (reckoned from the *first Point* of γ) which is upon the Meridian, with any Phænomenon in the Heavens upon the celestial

For the USE of the GLOBES. **II**

lestial Globe; and is so called, because it rises with the Luminary in a *Right Sphere*.

Def. XXVII. RIGHT ASCENSION in TIME, is the right Ascension in Motion converted into Time by allowing 15° to an Hour; for as the Globe revolves on its Axis in XXIV Hours, there must, in each Hour, pass under the Meridian 15° of the Equinoctial Line; and, consequently, every Degree will Answer to four Minutes of Time; and $15'$ of a Degree to one Minute of Time; $15''$ of a Minute of a Degree to one Second of a Minute in Time, and so on: so that the Time in which any Motion in the Equinoctial, or Equator, is performed, will be easily known by a Table hereafter inserted.

Def. XXVIII. OBLIQUE ASCENSION is that Point of the Equinoctial which rises with a Star, or other Phænomenon, in an oblique Sphere.

Def. XXIX. LONGITUDE, on the Terrestrial Globe, is that Degree of the Equator which comes to the Meridian with any given Place; or it is the Distance East or West of the Meridian of any Place from the first Point of the Equator; so, that Longitude on the Terrestrial Globe is the same as right Ascension in the Celestial, and is in the same Manner to be converted into Time.

Def. XXX. The DECLINATION is the Number of Degrees, reckoned in the Meri-

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dian, at which any Star is placed from the Equinoctial Line towards the North or South Pole.

Def. XXXI. The LATITUDE of a Place, on the Terrestrial Globe, is, in like Manner, the Distance of a Place from the Equator, measured in Degrees of the Meridian, towards the North or South Pole.

Def. XXXII. PARALLELS of *Declination* and *Latitude*, are those lesser Circles which are drawn on the Surface of the Globes, *parallel* to the Equinoctial, or Equator: they are usually drawn through every tenth Degree of Latitude, or Declination.

Def. XXXIII. The ECLIPTIC is a great Circle, divided into twelve equal Parts called SIGNS, and each Sign contains thirty Degrees. These take their Names from those Constellations in the Heavens, through or near which they passed at the Time those Names were given to them. This Circle makes an Angle with the Equinoctial of about $23^{\circ} 30'$, which is called, the *Obliquity* of the Ecliptic. This Circle represents the annual Path of the Sun through the Heavens among the fixed Stars; and because the *Eclipses* must necessarily happen in this Line, where the Sun always is, it is therefore, called, the *Ecliptic*. The Names, Characters, and Order of the Signs of the Ecliptic are as follow:

Aries,

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1. ♈ *Aries*, or the Ram.
2. ♉ *Taurus*, the Bull.
3. ♊ *Gemini*, the Twins.
4. ♋ *Cancer*, the Crab.
5. ♌ *Leo*, the Lion.
6. ♍ *Virgo*, the Virgin.
7. ♎ *Libra*, the Balance.
8. ♏ *Scorpio*, the Scorpion.
9. ♐ *Sagittarius*, the Archer.
10. ♑ *Capricornus*, the Goat.
11. ♒ *Aquarius*, the Water-Bearer.
12. ♓ *Pisces*, the Fishes.

The first six are called the *northern* Signs, as they lie on the Northern Hemisphere; and the latter are the *Southern* Signs. By this Division of the ecliptic Line, we can more readily point out the Sun's Place in the Heavens, for any given Time, by saying, *he is in such a Degree of such a Sign.*

*Def.*XXXIV. The EQUINOCTIAL POINTS are those in which the Ecliptic and Equinoctial intersect each other; of which that is called, the *Vernal Equinox* when the Sun is in the Equinoctial Line in the *Spring*: and the other is called the *Autumnal Equinox*, as the Sun, at that Season of the Year, crosses the Equinoctial Line again. The beginning of the Ecliptic, as well as of the Equinoctial Line, is at the Vernal Equinox; and, accordingly, the right Ascension is reckoned from the first Point of Aries,

Def.

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Def. XXXVI. The LONGITUDE of a Star, or Planet, is its Distance from the first Point of *Aries* in the Ecliptic, reckoned in Signs, Degrees, Minutes, &c.

Def. XXXVI. The LATITUDE of a Star, or Planet, is its nearest Distance from the Ecliptic, towards the Poles of the Ecliptic, on either Side, North or South: As the Ecliptic makes an Angle of $23^{\circ} 29'$ with the Equinoctial, so the Poles of the Ecliptic will of Course be at the same Distance from the Poles of the World.

Def. XXXVII. CIRCLES of LATITUDE are those great Circles which pass through the Poles of the Ecliptic, and consequently intersect the Ecliptic at right Angles. These are peculiar to the Celestial Globe, and are usually drawn through every 30° , dividing the whole Surface of the Globe into twelve equal Parts: By some Authors, these are also called *Circles of Longitude*, because, being drawn through any Star, they reduce it to, and shew its *Longitude* in the Ecliptic.

Def. XXXVIII. The ZODIAC is a broad Space on the Surface of the Celestial Globe, extending to about 8° on each Side of the Ecliptic, in which are contained, the twelve *Asterisms*, or Constellations which give Names to the Signs; and because most of these have the Likeness of some living Creature, this Space received the Name of *Zodiac*, which signifies a *Zone of Animals*. In this
broad

broad Circle are included, the Orbits of the Moon and all the Planets; and, as it is of the greatest Use in practical Astronomy and Navigation, it has lately been put on Mr. *Senex's* Globes, and divided into each single Degree of Latitude on either Side the Ecliptic.

Def. XXXIX. The TROPICS are those Parallels of *Declination*, on the Celestial Globe, (of *Latitude* in the Terrestrial) which touch the Ecliptic on either Side; and, because one in the Northern Hemisphere touches the Ecliptic in the Beginning of *Cancer* it is called the *Tropic of Cancer*: for the same Reason, *that* which touches the Ecliptic in the Southern Hemisphere is called the *Tropic of Capricorn*. The Word *Tropic* denotes a *Return*, because, in those Points, the Sun returns again to the Equinoctial Line.

Def. XL. The POLAR CIRCLES are those Parallels of Declination (or Latitude in the Terrestrial Globe) which circumscribe the Poles of the World at the Distance of $23\frac{1}{2}$ Degrees; or they are the Parallels of $66\frac{1}{2}$ Degrees. That on the Celestial Globe, about the North Pole, passes through the Constellation called *Arctos*, or the *Bear*; from whence it is usually called the *Arctic Circle*: and that which is opposite to it, about the South Pole, is called the *Antarctic Circle*. Both these and the Tropics are delineated on the Globes by double Lines, to distinguish them from other Parallels.

Def.

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Def. XLI. The MERIDIANS are those great Circles, on the Terrestrial Globe, which pass through, or intersect each other in the Poles of the World, and, of Course, are at right Angles to the Equator, where they determine the Longitude of Places through which they are drawn: one of these Meridians is called the FIRST MERIDIAN, from which the Reckoning in the Equator begins. The Position of this Meridian is arbitrary: But, to render the Globes more useful, we generally have two; one which passes through the Island of *Ferro*, and the other through the City of LONDON, as being the Capital of our own Country, and thereby saving us a great deal of Trouble in counting the Longitude of other Places. On large Globes, these Meridians are drawn thro' every tenth Degree; but in small Ones, through every fifteenth Degree.

Def. XLII. HOUR CIRCLES are those Meridians which pass through every fifteenth Degree of the Equinoctial, on the Celestial Globe, dividing the Surface of the Globe into 24 equal Parts, each of which, therefore, passeth under the Brazen Meridian in the Space of one Hour, as we have hinted before.

Def. XLIII. The SOLSTICES are those Points of the Ecliptic which have the greatest Declination, and consequently the Beginning of *Cancer* and *Capricorn*: They are
so

so called from the Sun appearing, as it were, *stationary* in those Points, with respect to its Motion Northward and Southward; for its Declination alters but very little, or is scarcely sensible for many Days on one Side or the other of these Points, which are therefore called the *Solstitial Points* of the Ecliptic.

Def. XLIV. The COLURES are those two Meridians which pass through the Equinoctial and Solstitial Points, and consequently cross each other at right Angles in the Poles of the World: Hence one of them is called the *Equinoctial Colure*, and the other the *Solstitial Colure*. These Circles divide the Surface of the Globe into four equal Parts, denoting the four SEASONS of the Year.

Def. XLV. The RECESSION of the EQUINOXES is that slow Motion which the Equinoctial Points are, by long Observation, found to have from East to West, contrary to the Order of the Signs, at the Rate of one Degree in 72 Years, and by this retrograde Motion of the Equinoctial Points, and consequently of the Ecliptic, the Signs have departed from the Constellations in which they originally were, which has caused all those Constellations to have an apparent Motion forward: and thus we find the Constellation of *Aries* is now (not in the Sign of that Name, but is) advanced forward into the second Sign, taking the Place which *Taurus*

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formerly had, *Taurus* being now in *Gemini*, and so on; which is the Reason why you see the Constellations drawn as they are on the Celestial Globe. The physical Cause of all which is, our Earth, not being of a truly spherical Figure, but a little flatted at the Poles, must have a *conical Motion* of its Axis, which carries the Poles of the World round the Poles of the Ecliptic in the long Period of nearly 26000 Years, which has been called the great *Platonic Year*.

Def. XLVI. An *Armillary SPHERE* is an astronomical Instrument, consisting of an artificial Disposition of all the great and small Circles of Note, before described, *viz.* the *Horizon*, the *Brass Meridian*, the *Equinoctial*, the *Ecliptic* with the *Zodiac*, the *Equinoctial* and *Solstitial Colures*, the *Tropics* and *Polar Circles*, the *Axis* of the *World* with the small *Hour Circle* and *Index*; all which compages of Circles revolve, like the Globe, on the Axis of the World, and thereby greatly facilitate the Idea we ought to have of those imaginary Circles in the Heavens, and their several Uses; And, by Means of the *Quadrant of Altitude*, any spherical Triangle may be formed, and its Solution given by Inspection; which renders this Instrument of great Utility in Astronomy, and the Use of the Globes; a Print of which we have therefore thought necessary to prefix to these Definitions.

With

With respect to the Position of the Sphere, or Globe, there are the following Distinctions:

Def. XLVII. A *Parallel SPHERE* is that Position of it where the Equator coincides with the Horizon, and consequently the Poles of the World are the *Zenith* and *Nadir* Points. The Parallels of Latitude here are all parallel to the Horizon; but there can be no such Disposition of the Sphere, but to an Inhabitant immediately under the Poles.

Def. XLVIII. A *right, or direct SPHERE* is that Position where the Equator and all its Parallels make *right Angles* with the Horizon. The Inhabitants of this Sphere are only those who live under the Equinoctial Line.

Def. XLIX. An *Oblique SPHERE* is when the Equinoctial makes an *oblique Angle* with the Horizon: and therefore is any other Position than the two former, and which every Inhabitant must have who does not live under the Equator and the Poles.

Def. L. The *Diurnal ARCH* is that Part of a Parallel of Declination which stands above the Horizon; the other Part, which is below it, is called the *Nocturnal Arch*.

Def. LI. *Ascensional DIFFERENCE* is the Difference in the *Ascension* of an Object

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above the Horizon, in a right and an oblique *Sphere*; but in a right *Sphere*, every Celestial Phænomenon must rise and set at the Distance of *six Hours*, from the Time of its being on the Meridian; therefore the ascensional Difference, turned into Time, shews how long the Star rises or sets before, or after the Hour of *six*, in an oblique *Sphere*.




CHAP.



CHAP. III.

Geographical *and* Astronomical DEFINITIONS *and* PRINCIPLES *relative to the USE of the GLOBES*, continued.

 THE Surface of the *Terrestrial* or *Terraqueous Globe*, consists, as hath been said, of LAND and WATER, very nearly in Proportion as *one to three*; which I have found, by weighing all those Papers that represent the Land and Water separately, which cover Mr. *Senex's* Terrestrial Globe of 28 Inches Diameter. The Weight of the Paper for Land was 367 Grains, those for the aqueous Surface weighed 1125 Grains, which Numbers give the Proportion above mentioned.

The LAND is divided as follows :

I. A CONTINENT is the largest Division, or extent of Land, comprehending diverse Countries and Kingdoms not separated by Water.

II. An

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II. An ISLAND is any small Tract of Land surrounded by Water.

III. A PENINSULA is a Part of Land encompassed with Water all round, except on one Part, which is called

IV. An ISTHMUS, being that narrow Neck of Land which joins it to the Continent.

V. A PROMONTORY is a mountainous Part of Land, standing far out in the Sea, whose Fore-part is called

VI. A CAPE, or *Head-Land*.

The aqueous Part of the Surface of the Earth has the following Distinctions, or Divisions :

I. The OCEAN is the largest Collection of Waters which lie between, and environs the Continents.

II. The SEA is a smaller Part of the aqueous Surface of the Earth, lying between the Islands, Promontories, &c.

III. A GULPH is a Part of the Sea every where environed with Land, except on one small Part, called

IV. A STREIGHT, or STRAIT, which is that narrow Passage joining it to the adjacent Sea.

V. A LAKE is any large Quantity of stagnant Water, entirely surrounded by Land.

These

These several Denominations of Land and Water need no farther Account or Description, as a bare Inspection of the Globe will present them sufficiently to the View.

The most famous Division of the Surface of the Earth, with regard to Heat and Cold, is into the five ZONES, of which, one is called the *Torrid Zone*, two are called *Temperate Zones*, and the other two *Frigid Zones*.

I. The *Torrid ZONE* is so called, from the Inhabitants being, as it were, *torrified* or scorched with the Sun's Heat; for this Part of the Earth is all that which lies between the two Tropics of *Cancer* and *Capricorn*, and over which the Ecliptic Line is obliquely posited: from whence you will easily observe, that the Inhabitants of this Zone will have the Sun vertical two Days in the Year, in passing from Tropic to Tropic, in each Half of the Ecliptic.

II. The *Temperate ZONES* are all those Parts of the terraqueous Globe which lie between the TROPICS and *Polar CIRCLES*; and consequently there is one of these in the Northern, and one in the Southern Hemisphere, as you may see very plainly on the Surface of the Globe. As we ourselves are Inhabitants of the North Temperate Zone, we find the Seasons of the Year in a *temperate* Degree: Our *Summer*

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mer Suns are at a Distance from our *Zenith*, and we do not therefore experience the greatest Force of his Beams. Again, we are never without his enlivening Influence the Space of one natural Day; so that, upon the whole, we must reckon our situation the best that the Surface of the Earth can afford; the paradisaical Situation of *England* being the *most temperate Part of the Temperate Zone*.

III. The two *Frigid ZONES* are so called because of the *excessive Cold* in those Parts: These are improperly called *Zones*, being rather *Areas* comprehended between the *Arctic* and *Antarctic* Circles; but, as with a little Consideration it will appear, that since one Half of the Year the Sun is above the Horizon, to the greatest Part of these *Zones* for many Days and Months together, without setting, they must have a very considerable Interval of *warm*, or rather *hot Season*; and, since the *Pole* itself is enlightened constantly for six Months together, it must be considered as the *hottest* at one Time, as well as the *coldest Part* at another, of the whole Earth.

There is another Division of the Earth's Surface into what they call *CLIMATES*; but this was more in Use among ancient Geographers than the Modern: They called all that Part of the Earth, a *Climate*, which
allowed

allowed an Increase of Half an Hour to a natural Day of 24; or the *first Climate*, extending from the Equator to that Parallel where the Day was $12\frac{1}{2}$ Hours long; from thence to the Parallel where the Day was 13 Hours, was called the *second Climate*, and so on, thro' a Succession of 24 *Climates*, till they came to the *Polar Circles*, where, the Sun not setting, the Day is 24 Hours long. Here they reckoned their *Climates* by monthly Illuminations, and so had *six Climates* within each *Frigid Zone*. But, to give a clearer Idea of this Matter, we shall give the following Table of *Climates*.

A TABLE of the CLIMATES.

CLIMATES between the Equator and the Polar Circles.											
Climates	Longest Day.	Latitude.		Breadth.		Climates.	Longest Day.	Latitude.		Breadth.	
		D.	M.	D.	M.			D.	M.		M.	D.
1	12 $\frac{1}{2}$	8	25	8	25	13	18 $\frac{1}{2}$	59	58	1	29
2	13	16	25	8	00	14	19	51	18	1	20
3	13 $\frac{1}{2}$	23	50	7	25	15	19 $\frac{1}{2}$	62	25	1	7
4	14	30	25	6	30	16	20	63	22	0	57
5	14 $\frac{1}{2}$	36	28	6	8	17	20 $\frac{1}{2}$	64	6	0	44
6	15	41	22	4	54	18	21	64	49	0	43
7	15 $\frac{1}{2}$	45	29	4	7	19	21 $\frac{1}{2}$	65	21	0	32
8	16	49	1	3	32	20	22	65	47	0	26
9	16 $\frac{1}{2}$	51	58	2	57	21	22 $\frac{1}{2}$	66	6	0	19
10	17	54	27	2	29	22	23	66	20	0	14
11	17 $\frac{1}{2}$	56	37	2	10	23	23 $\frac{1}{2}$	66	28	0	8
12	18	58	29	1	52	24	24	66	31	0	3

CLIMATES between the Polar Circles and the Poles.							
Length of Days.		Latitude.		Length of Days.		Latitude.	
Months.		D.	M.	Months.		D.	M.
1		67	21	4		78	30
2		69	48	5		84	5
3		73	37	6		00	00

E

There

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There are some other Distinctions in Geography concerning the INHABITANTS of the Earth, in regard to their different Meridians or Parallels, *viz.* some are called the

PERIOECI, that live under the *same Parallel*, but, in the *opposite Semi-circles of the same Meridian*; both of them have the Seasons of the Year the same; the Sun, by its annual apparent Motions, coming to, or receding from the Vertex of both Places at the same Time of the Year: but they change their Turns of *Night and Day*, so that when it is *Mid-day* to one, it is *Mid-night* to the other.

ANTOECI, are such whose Habitations lie in the *same Semi-circle* of the Meridian, but in *opposite Parallels*, and both of them have *Mid-day and Mid night* at the same Instant of Time: but the Seasons of the Year are different, it being *Summer* to the one when it is *Winter* to the other.

Lastly, the ANTIPODES, are those whose Habitations being situated in *opposite Parallels*, and *opposite Meridians*, have their *Feet directly opposite to one another*, in a Line passing through the Center of the Earth: and they have not only their *Days and Nights directly contrary*, but also the *Seasons of the Year*; when it is *Summer* in the one, it is *Winter* in the other Place, and when *Mid-day* in the first, the second has *Mid-night*.

The

The Inhabitants likewise receive another Denomination from their *Shadows*, viz. the Inhabitants of the Torrid Zone, are called

The AMPHISCII, having their Meridian Shadows at Different Times of the Year, projected towards *both Poles*; but when the Sun comes to be vertical to them, then they have no Shadow, and are called *Ascii*, or *shadowless*, nothing that stands upright, having a Shadow at Noon.

The HETEROSCII are those who inhabit the Temperate Zone, as having the Meridian Shadow projected *only towards one Pole* throughout the whole Year.

The PERISCII are those who inhabit the two Frigid Zones, so called, because their Shadow turns *quite round* them in the Space of 24 Hours.

To these Definitions we may add, the Distinctions which the ancient Poets made, and are still retained in the Writings of Astronomy, relative to the rising and setting of the Stars, which they call the *Cosmical*, *Acronical* and *Heliacal*.

The *Cosmical* RISING OR SETTING of a Star, is when it rises or sets at the Time when the *Sun rises*.

The *Acronical* RISING of the Star, is when it rises when the *Sun setts*.

The *Heliacal* RISING, is when the Star, or Planet *emerges out of the Sun-beams*, and is seen in a Morning before Sun rising; and

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it sets *Heliacally* when it is so near the Sun-beams that it ceases to be seen.

Some other Definitions result from the Consideration of the Motion of the Earth; that the Earth hath a Motion about its Axis is well known, and because we call the Time in which it makes one Revolution a DAY, therefore this is called the *diurnal Motion* of the Earth.

It is also well known, that the Direction of this Motion is from West to East, or according to the Order of the Signs of the Ecliptic in which they *follow* one another; and therefore this, and all such Motions are said to be in *Consequentia*.

This real Motion of the Earth, from West to East, occasions an apparent Motion of all the heavenly Bodies in a contrary Direction, or from East to West, which is therefore said to be in *Antecedentia*.

The Space of Time in which the Earth revolves upon its Axis is twenty-three Hours, fifty-six Minutes, three Seconds, and twenty-eight Thirds; in which Space of Time a fixed Star will make one complete Revolution: This Space of Time is therefore called the *Sidereal-Day*.

But the Time in which the Sun departs from the Meridian and returns to it again, or makes one Revolution, is called the *Solar-Day*. After the same Manner, we may consider that the Space of Time in which those

those Meridian-Revolutions are performed by the Moon and Planets, may, in like Manner, be called *Lunar* and *Planetary Days*.

ASTRONOMERS begin the Day at Noon, and call the natural Day, including Common Day and Night, the *Nycthemeron*; and they Number the Hours from one to twenty-four Hours successively, and not by twice twelve, as the common Usage is by Clocks.

The YEAR, with Astronomers, begins when the Sun enters the first Scruple of *Aries*, on the first Sign of the Ecliptic: but this Beginning of the Year cannot, on that Account, be stable, or fixed; because, as we have before observed, the Equinoctial Points have a slow Motion in *Antecedentia*, or contrary to the Order of the Signs: Therefore the Sun, which moves in a contrary Direction, or in *Consequentia*, will arrive at the vernal Equinox sooner, each Year, than it would have done, had that Point been fixed: consequently, the Moment of Time in which the Sun enters the *vernal Equinox* will happen a little Matter sooner, every Year, than it did in the preceding Year, viz. by about *twenty Minutes*. The Time of this vernal Equinox will, therefore, constantly anticipate the Time of the preceding One, and this is what is so frequently called, the *Precession* of the *Equinox*.

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The PLACES in which the heavenly Bodies appear, as viewed from the Earth or Sun, are differently denominated: The Place of a Planet when viewed from the EARTH, is called the *Geocentric* Place; but when it is viewed from the SUN, it is called the *Heliocentric* Place. Accordingly, in the *Ephemeris*, (which ought ever to be at Hand when the Globes are in Use) these Places are properly tabulated, the *Geocentric* Places of the Sun, Moon, and Planets, for every Day of the Month through the Year; and the *Heliocentric* Places for every *sixth* Day only.

These *Geocentric* Places we have regard to in the Use of the GLOBES, and the *Heliocentric* ones become necessary in the Use of the ORRERY. The Difference between the *Geocentric*, and the *Heliocentric* Place of a Planet, is equal to the Quantity of the Angle under which the Radius of the Earth's Orbit is seen from the Planet, which is therefore called the *Parallax* of the *annual* ORBIT. The Word *Parallax* meaning no more than the *Difference of Places* in which the same Object will appear if viewed from two different Stations.

The NODES of a Planet's Orbit are those Points in which the Orbit intersects the Ecliptic. Thus the Equinoctial Points may be called the Nodes of the Sun's Orbit, with respect to the Equinoctial Line; but the Nodes of the Planets are of little

Ac-

Account, as they are too slow to have a sensible Motion in the Space of a few Years; and the Obliquity of their Orbits, or their Inclinations to the Plane of the Ecliptic, are for the most Part too small to be regarded in the Use of the Globes: But it is far otherwise with respect to the NODES and ORBIT of the MOON; the latter of which makes an Angle of no less than $5^{\circ} 18'$ with the Ecliptic, and the *Lunar Nodes* have too sensible a Motion not to be regarded even in the Use of the Globes, and therefore a Table is provided in the *Ephemeris* to ascertain the Place of the ascending Node for every sixth Day of the Month throughout the Year. This gives Occasion for the Nodes and Orbit of the Moon to be continually *rectified* on the Surface of the Celestial Globe.

As we see not the *true* and *real* MOTION of the Planets from the EARTH, but only their *apparent* ones, the Direction of those Motions will be often apparently variable; for sometimes they will appear to be *direct* in Motion, sometimes *retrograde*, or to move from *East* to *West*; and between these two contrary Directions, they will appear to have no Motion for some Time, or to be *stationary* in the Heavens; Therefore, in the *Ephemeris*, among the Geocentric Places of the Planets, you will see the Letter D at the Place where the Planet begins to appear *direct* in Motion; and against the Place where it
begins

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begins to appear *retrograde* there is this Character R.

All that we have hitherto said concerning the Places, Nodes, &c. of the Planets, are on the Left-hand Page of *Parker's Ephemeris*: On the Right-hand Page are contained the various Aspects of the Planets, with respect to the Moon and to each other, as they are seen from the Earth. These ASPECTS they denote by different Symbols; they use the Symbol of a *Triangle* Δ for the Aspect they call the *Trine*, that is, when the Planets are a *third Part* of the Ecliptic distant from one another, *viz. four signs*: If they are but *three Signs* apart, that Aspect is called *Quartile*, denoted by a *Square* \square : If but *two signs* from each other, it is called a *Sextile*, and is shewn by this Mark *; If they are in *Conjunction*, it is shewn by ϕ ; and if in *Opposition*, by \otimes ; and the Number placed by the Symbol, shews the Hour after Noon, when that Aspect happens. But these Aspects are of little Moment, therefore shall say no more about them here.

The Figure of the Earth being nearly Globular, a Person who walks directly North or South, as his Eye is always the Pole of the Horizon, that horizontal Circle in the Heavens must ever move through the same Space, or describe the same Arch on the Meridian in the Heavens, as he describes or goes through on the Meridian of the Earth:
that

that is, if he walk through one Degree of the Terrestrial Meridian Northward, then will his Horizon descend one Degree on the Northern Part of the Meridian in the Heavens, and ascend one Degree on the Southern Part, and so for any other Space or Number of Degrees. Therefore if an Inhabitant of the Equator, who views the Poles of the World in the Horizon itself, were to set out on a Journey directly Northward, when he had travelled over *one Degree* he would observe the North Pole of the World to be elevated just *one Degree* above his Horizon; when he had proceeded over the Space of *ten Degrees*, as his Horizon was depressed so many Degrees below the Pole, so the Pole must of Course appear *elevated ten Degrees* above the Horizon, and so much will the South Pole be depressed: From whence it appears, that the Elevation of the Pole above the Horizon of any Inhabitant is always equal to his Distance from the Equator, in Degrees of the Terrestrial Meridian: And therefore it is evident, that *the Elevation of the Pole is always equal to the Latitude of the Place*: and this is a fundamental Theorem for the Rectification of both the Globes.

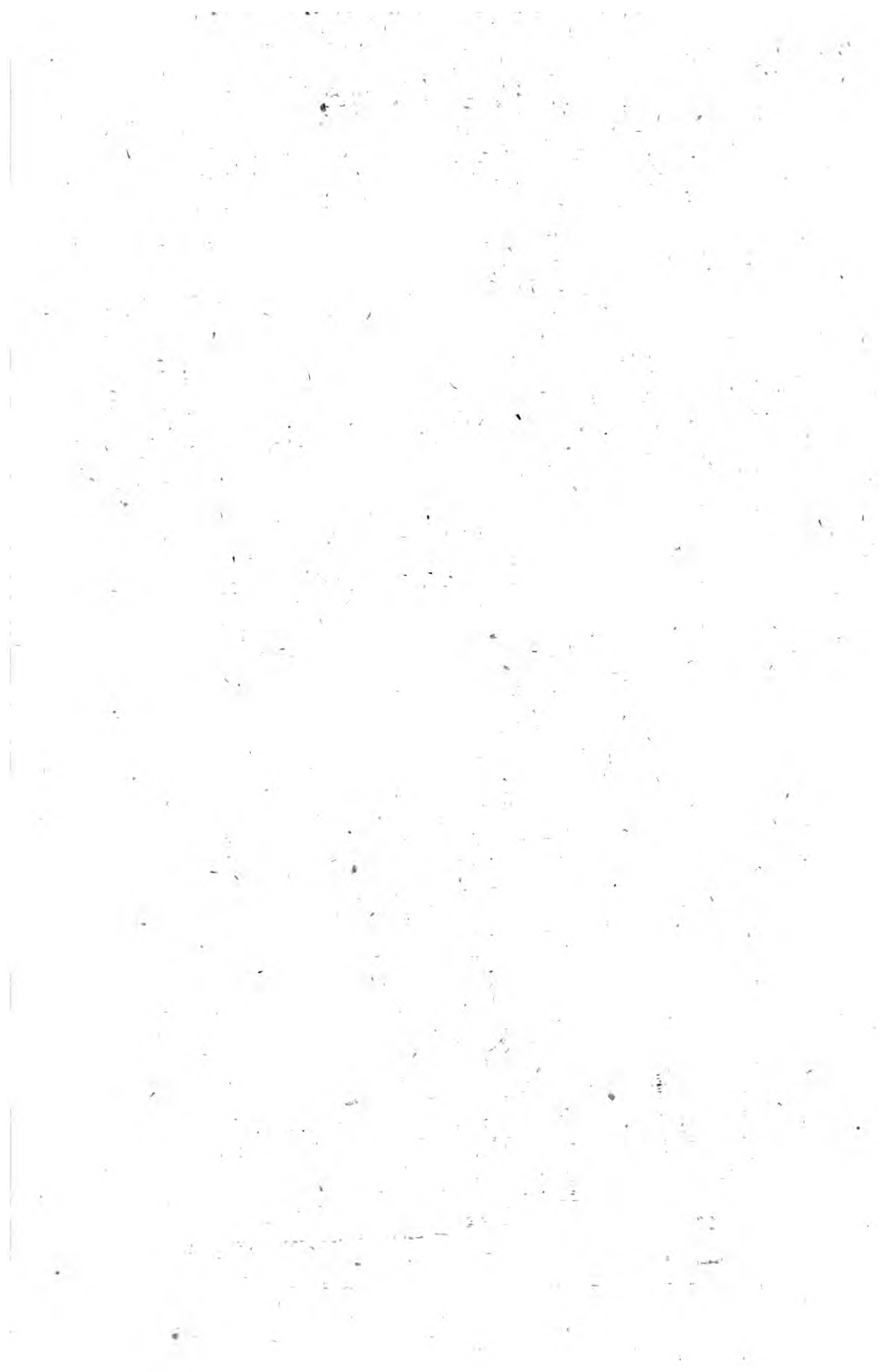
It has been found, by frequent Mensurations, that, in order to raise or depress the Pole one Degree, a Person must pass over the Space of $69 \frac{1}{2}$ MILES directly North,

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or South, which, therefore, is the *English* Measure of one Degree of a Terrestrial Meridian.

Having now premised every Thing that seems to be necessary for the due Understanding the Use of the Globes, we proceed to the Solution of such Problems in Astronomy, Geography, Navigation, Dialing, &c. as will afford a rational and instructive Amusement to the young Student in those Sciences, and to Ladies and Gentlemen in general.





The CELESTIAL GLOBE.

Plate II.






CHAP. IV.

The Use of the CELESTIAL GLOBE in the SOLUTION of PROBLEMS relative to the SUN.

Problem I.

RECTIFY the Globe for any particular Place, as LONDON.

To *rectify* the Globe implies several particular Things to be done, as (1) Elevate the North Pole above the Horizon so many Degrees as is equal to the *Latitude of the Place*, (2) Find the *Sun's Place* in the Ecliptic on the Surface of the Globe, and bring it to the brazen Meridian. (3) The Sun's Place being under the Meridian, set the *Index* of the *Hour Circle* to the upper XII. (4) Set the Meridian of the Globe *North* and *South* by the *Compass*, or *Magnetical Needle*, as directed in the Definition thereof. These Things being done, the Globe is *rectified*, or put into a Position similar to the concave Surface of the Heavens for the Latitude of *London*.

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Prob. II. *To find the SUN'S PLACE in the Ecliptic for any given Day.*

For this Purpose, there are, on the broad Frame of the Horizon, two Calendars of Months and Days, placed by the Ecliptic, divided into its twelve Signs and Degrees, in one Calendar, which is now principally in Use, (and called the *New Stile*) the Beginning of the 21st of *March* nearly answers to the Beginning of the Ecliptic, or first Point of *Aries*; but in the Calendar of the *Old Stile* the 10th of *March* answers to the same Point. In either Calendar, therefore, find the given day of the Month, and, against it, observe the corresponding Part of Ecliptic, and that is the Sun's *mean Place* for that Day. Thus, for Example, against *May* 11th you find the 21st Degree of *Taurus* for the Place of the Sun in the Ecliptic at that Time, *New Stile*.

Prob. III. *To find the Sun's DECLINATION for any given Day in the Year.*

Find the Sun's Place in the Ecliptic, and bring it to the Meridian; and the Degree of the Meridian immediately over it, is the *Declination* sought. For Example; On *May* 11th the Sun's Place is in the 21st Degree of *Taurus*; this, being brought to the Meridian, will shew the Sun's Declination immediately over it to be 18 Degrees.

Prob.

Prob. IV. *To find the SUN'S RIGHT ASCENSION.*

Bring the Sun's Place to the Meridian, and see what Point of the Equinoctial is intersected by the Meridian; which, for the 11th of *May*, will be found to be the $47^{\circ} 40'$ for the *Right Ascension* required for that Day.

Prob. V. *To find the SUN'S AMPLITUDE.*

Bring the Sun's Place to the eastern Part of the Horizon, and the Arch of the Horizon betwixt it and the eastern Point is the *Amplitude Ortive*, North or South: Then turn the Globe about till the Sun's Place is in the western Horizon, then will its *occasive* Amplitude be equal to the *Ortive*, and of the same Denomination. Thus, on the 11th of *May*, the Sun will rise with 30° of North Amplitude, and set as far from the western Point of the Horizon to the North.

Prob. VI. *To find the TIME when the SUN RISES, or SETS, on any given Day.*

Rectify the Globe for the given Day; then turn the Globe till the Sun's Place touches the eastern Part of the Horizon, and the Index of the Horary Circle will shew the Time of its rising. After that turn the Globe about till the Sun's Place comes into the western Semi-circle of the Horizon, and the Index will shew the Time of its setting for the given Day. Thus, on the 11th of *May* the Sun

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Sun will be seen to rise about a Quarter after IV. and set the same Time before VIII.

Prob. VII. *To find the LENGTH of any given DAY or NIGHT.*

This is immediately deduced from the foregoing Problem; for since the Time between *rising* to the Meridian, and descending from thence to the Horizon, must be equal, therefore twice the Hour of setting will be the Length of the Day. Thus, on *May 11*, the Sun sets at VII^h 45', the double of which Number is XV^h 30', the Length of the Day; the Length of the Night must then be of Course VIII^h 30'. Thus the Length of the longest and shortest Days must be found on the Globe, as also the greatest Amplitudes, Declinations, &c. and, by a bare Inspection of the Globe, it will appear, that the *longest Summer Day* is equal to the *longest Night* in *Winter*, and, *Vice Versa*, in regard to the Nights.

Prob. IX. *To find the SUN'S oblique ASCENSION.*

Find the Place of the Sun in the Ecliptic, and bring it to the eastern Horizon: then observe the Degree of the Equinoctial in its Intersection with the Horizon, which for the 11th of *May* you will find to be 21° 40', the *Oblique Ascension* required.

Prob.

in PROBLEMS *of the* SUN, 39

Prob. X. *To find the Ascensional DIFFERENCE, or the Time the SUN rises before or after SIX,*

From the right Ascension (found by Prob. IV.) subtract the oblique Ascension, found by the last, and the Remainder is the Ascensional Difference in Degrees.

Thus for the	}	The Right Ascension is	47 ^o 40 [']
11th of <i>May.</i>	}	Oblique Ascension	21 40
			26 00
Ascensional Difference			26 00

Prob. XI. *To Convert the DEGREES, Minutes, and Seconds, of right ASCENSION in the EQUINOCTIAL, into HOURS, Seconds, and Minutes of TIME.*

This Problem, very useful in Astronomy, is most readily solved by the following Table :

TABLE

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A T A B L E,

By which the Longitude exprest in Degrees, Minutes, and Seconds, &c. may be reducea to Hours, Minutes, and Seconds.

Deg.	H. M.	Deg.	H. M.	Degrees.	Hours.
Min.	M. S.	Min.	M. S.		
Sec.	S T.	Sec.	S. T.		
1	0 4	31	2 4	70	4 40
2	0 8	32	2 8	80	5 20
3	0 12	33	2 12	90	6 0
4	0 16	34	2 16	100	6 40
5	0 20	35	2 20	110	7 20
6	0 24	36	2 24	120	8 0
7	0 28	37	2 28	130	8 40
8	0 32	38	2 32	140	9 20
9	0 36	39	2 36	150	10 0
10	0 40	40	2 40	160	10 40
11	0 44	41	2 44	170	11 20
12	0 48	42	2 48	180	12 0
13	0 52	43	2 52	190	12 40
14	0 56	44	2 56	200	13 20
15	1 0	45	3 0	210	14 0
16	1 4	46	3 4	220	14 40
17	1 8	47	3 8	230	15 20
18	1 12	48	3 12	240	16 0
19	1 16	49	3 16	250	16 40
20	1 20	50	3 20	260	17 20
21	1 24	51	3 24	270	18 0
22	1 28	52	3 28	280	18 40
23	1 32	53	3 32	290	19 20
24	1 36	54	3 36	300	20 0
25	1 40	55	3 40	310	20 40
26	1 44	56	3 44	320	21 20
27	1 48	57	3 48	330	22 0
28	1 52	58	3 52	340	22 40
29	1 56	59	3 56	350	23 20
30	2 0	60	4 0	360	24 0

EXAMPLE.

EXAMPLE.

In what Time will 49° 37' and 13'' of the Equinoctial pass under the Meridian?

Against	{	49°	0'	0''	—	3 ^h	16'	0''	0'''
			37	0	—		2	28	0
				13	—				0	52

Answer 49 37 13 — 3^h 18' 28'' 52'''

In like manner the Ascensional Difference, being just 26°, answers to 1^h 44', which is an Hour and $\frac{3}{4}$ before six, agreeable to Problem VI.

Prob. XI. *To convert TIME into MOTION, or to tell what Number of Degrees, Minutes, and Seconds pass under the Meridian in a given Time.*

The Solution of this Problem is likewise most easy by a Table, which we have therefore here inserted :

EXAMPLE.

Suppose it be required to know what Number of Degrees, Minutes, and Seconds, of the Equinoctial, pass under the Meridian in 3^h 18' 28'' 52''', the Quantities of Motion taken out of the Second Column, answering to the several Parts of Time in the first Column, being placed apositely, and added together as before, will give the Answer, 49^h 37' 13''.

G

TABLE.

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A T A B L E.

By which the Longitude exprest in Hours, Minutes, and Seconds, &c. may be reduced to Degrees, Minutes, and Seconds, &c.

Hours.	Degrees.	Min.	Deg. Min.		Min.	Deg. Min.	
		Sec.	Min.	Sec.	Sec.	Min.	Sec.
		Th.	Sec.	Th.	Th.	Sec.	Th.
1	15	1	0	15	31	7	45
2	30	2	0	30	32	8	0
3	45	3	0	45	33	8	15
4	60	4	1	0	34	8	30
5	75	5	1	15	35	8	45
6	90	6	1	30	36	9	0
7	105	7	1	45	37	9	15
8	120	8	2	0	38	9	30
9	135	9	2	15	39	9	45
10	150	10	2	30	40	10	0
11	165	11	2	45	41	10	15
12	180	12	3	0	42	10	30
13	195	13	3	15	43	10	45
14	210	14	3	30	44	11	0
15	225	15	3	45	45	11	15
16	240	16	4	0	46	11	30
17	255	17	4	15	47	11	45
18	270	18	4	30	48	12	0
19	285	19	4	45	49	12	15
20	300	20	5	0	50	12	30
21	315	21	5	15	51	12	45
22	330	22	5	30	52	13	0
23	345	23	5	45	53	13	15
24	360	24	6	0	54	13	30
		25	6	15	55	13	45
		26	6	30	56	14	0
		27	6	45	57	14	15
		28	7	0	58	14	30
		29	7	15	59	14	45
		30	7	30	60	15	0

Thus

Thus, againſt	{	h	i	ii	iii	}	You find	{	o	i	ii
		3	o	o	o				45	o	o
			18	o	o				4	30	o
				28	o					7	o
					52						13
3 18 28 52						Sum	49 37 13				

Prob. XII. *To find the Beginning and End of the Crepusculum, or TWILIGHT, for any given Day of the Year.*

In the Solution of this and the following Problem, the *Quadrant of Altitude* will be necessary, which, therefore, must now be screwed on to the Zenith Point, or so that the *Fiducial Edge* of the Nut may cut $51^{\circ} 30'$ of the Meridian, which is the Zenith of *London*, the Globe being supposed rectified for this Metropolis.

It is collected from many Observations that have been made by Astronomers, that the Sun, after its Descent below the Horizon, has its Rays refracted through, and enlightening the Atmosphere near the Earth, till his Depression be equal to about 18° ; at the End of which Time, the Atmosphere becomes wholly Dark, at least what we call *dark Night* then begins; and the Time from his setting, 'till his Depression be 18° below the Horizon, is called the *Crepusculum, or Twilight*. But when the Sun is 18° below the Horizon, at any Time,

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the Place in the Ecliptic Diametrically opposite to the Sun, is, of Course, 18° above the Horizon: And therefore let us suppose the Sun in the first Degree of *Taurus*, which, by the Calendar, you will see is on the 21st of *April*. The Point of the Ecliptic opposite to this is the beginning of *Scorpio*: Therefore, when the Sun, in the first Scruple of *Taurus*, is below the Horizon in the Western Hemisphere, the beginning of *Scorpio* will be 18° above the Eastern Horizon: Consequently, if the Quadrant of Altitude, and the Globe be so movéd together 'till the beginning of *Scorpio* coincides with the 18° of the Quadrant, then will the Index Point to the Time when the *Twilight* Ends on the 21st of *April*, which will be about 25' after IX, and the Sun sets that Day about VII, as is found by *Problem VI*. Therefore the Length of the Morning and Evening *Twilight*, will, on that Day, be near $2^{\text{h}} 25'$

• *Prob. XIII. To find the ALTITUDE of the SUN on any given HOUR of the DAY, and Latitude of the Place.*

Find the Sun's Place in the Ecliptic, bring it to the Meridian, and set the Hour Index to XII; then move the Globe about 'till the Index points to the given Hour; and the Quadrant of Altitude being screwed to the Zenith, bring it to lie over the Sun's
Place,

Place, and the Number of Degrees upon the Quadrant, contained between the Sun's Place and the Horizon, will be the Altitude required. Thus, for Example; on the 11th of *May*, at IX in the Morning, the Sun's Altitude will be found near 42 Degrees.

N. B. If the Place of the Sun be brought to the Meridian, it is then said to *Culminate*; and its *Meridian Altitude* for that, or any other Day, while it is in the six Northern Signs, will be evidently equal to its *Declination* added to the *Elevation* of the *Equator*, or Complement of the Latitude. But, while the Sun is in the six Winter Signs, the Sun's *Declination*, deducted from the *Co-latitude*, will give his *Meridian Altitude*, and *vice versa*.

Prob. XIV. *To find the* SUN'S AZIMUTH *for any given* HOUR of the DAY, *and* Latitude of the Place.

Rectify the Globe, and proceed as directed in the last Problem: then the *Angle* or *Arch of the Horizon* contained between the Meridian and Quadrant of Altitude, will be the *Azimuth* of the Sun at the North or South Part of the Horizon, at the given Hour of the Day.

Prob. XV. *To find the* SUN'S ALTITUDE, *when it shines, by the* GLOBE *only.*

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Set the Frame of the Globe truly level, and turn the North Pole towards the Sun; then gently move the Frame, and the Meridian, up and down in the Notches of the Horizon, 'till the Axis casts no Shadow: Then the Arch of the Meridian, contained between the Pole and the Horizon, is the Sun's *Altitude*.

Prob. XVI. *To find the HOUR of the DAY and the Sun's AZIMUTH, having the Latitude of the Place, the Place of the Sun, and its Altitude known by Observation.*

Rectify the Globe for the Latitude and Place of the Sun, then move the Globe and Quadrant of Altitude so together, that the Sun's Place may cut the given Degree of Altitude on the Quadrant: Then the Index will shew the Hour, and the Quadrant will cut the Azimuth in the Horizon. Thus, at *London*, on the 11th of *May*, supposing the Sun's Altitude to be observed in the Forenoon to be 42° , then will the Index point to the Hour of IX, and the Sun's Azimuth is about 63° from the South.

N. B. The Sun's ALTITUDE is easily taken by any QUADRANT having *Sights* and a *Plumb-line*; for, holding the Quadrant toward the Sun, so that its Rays, passing through a small Hole in one Sight, may fall exactly on the correspondent Hole on the other,

other, the Plumb-line will cut the Degree on the Limb of the Quadrant equal to the *Height of the Sun*. But the best and most accurate Method of taking the Sun's Altitude, is by a *Hadley's* Quadrant with an ARTIFICIAL HORIZON, with a Compass and Azimuth-Circle on a proper Foot, or Stand.

Prob. XVII. *To find the HOUR of the DAY, when the SUN shines, for any given Latitude and Day of the Month.*

Place the Frame of the Globe level, and the Meridian due North and South by the Needle; then Rectify the Globe to the Latitude, and fix a Pin or Needle perpendicular to the Surface of the Globe, in the Place of the Sun, which bring to the Meridian, and fix the Hour Index to XII: then turn the Globe about till the Pin cast no shadow, for it will then be exactly under the Sun, and the Index will shew the Hour of the Day,

Prob. XVIII. *To find the ALTITUDE of the Sun and Hour of the Day, from the LATITUDE, Place of the SUN, and his AZIMUTH given.*

Rectify the Globes for the Latitude, Place of the Sun, &c. then Place the Quadrant of Altitude to the given Azimuth in the Horizon, and move the Globe about till the Sun's Place comes upon the Edge of the
Qua-

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Quadrant, which will then shew its Altitude, and the Index will point to the Hour. Thus, suppose, at *London* on the 11th of *May*, I observe the Azimuth of the Sun in the Forenoon to be 63° from the South, then having placed the Quadrant of Altitude to that Degree of the Horizon, and brought the Sun's Place, or 21st Degree of *Taurus*, to the Edge of it, it will cut 42° of the Quadrant for the *Sun's Altitude*, and the Index will point to IX o'Clock.

Prob. XIX. *To find the LATITUDE of the PLACE, from the given Declination and Meridian ALTITUDE of the SUN.*

Mark the Point of Declination upon the Meridian, whether North or South, then slide the Meridian up or down in the Notches till the Point of Declination be so far distant from the Horizon, as is equal to the given Meridian Altitude: then will the Axis of the Earth, or Pole of the World have its proper Height above the Horizon, and shew the true Latitude of the Place. The Reason of this Problem is very evident, from the Note of Problem XIII.

Prob. XX. *To find the ANGLE which the ECLIPTIC makes with the HORIZON, for any HOUR of a given DAY and LATITUDE of the Place.*

Rectify

Rectify the Globe for the Latitude, Sun's Place, and given Hour; then lay the Quadrant of Altitude over the Pole of the Ecliptic, and the Arch of the Quadrant, contained between that Pole and the Zenith, will shew the Number of Degrees in the *Altitude* of the Ecliptic, or *Nonagesimal* Degree: Thus on the 11th of *May* at IX in the Morning, the Pole of the *Ecliptic* will be distant from the Zenith $44^{\circ} 30'$, which is equal to the Elevation of the Ecliptic above the Horizon at that Time.

Prob. XXI. *To find the POSITION, or AZIMUTH of the NONAGESIMAL DEGREE of the Ecliptic, for any given LATITUDE, and TIME of the DAY.*

Let every Thing be done as directed in the last Problem; then observe the Number of Degrees in the Arch of the Horizon, intercepted between the North Point and the Quadrant of Altitude, lying over the Pole of the Ecliptic; for that will be the Azimuth of the *Nonagesimal* Degree from the South Point of the Horizon. Thus, for the 11th of *May*, in the Latitude of *London*, at IX in the Morning, it will be about 35 Degrees.

Prob. XXII. *To find the POINT of the ECLIPTIC, which is the NONAGESIMAL*
H DE-

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DEGREE, for any given TIME of the DAY,
and LATITUDE of the Place.

Having found the Azimuth of the *Nonagesimal* Degree by the last Problem, bring the Quadrant of Altitude to cut the South Part of the Horizon in the same Number of Degrees, while the Hour-hand points at the given Time; then will the Edge of the Quadrant intersect the Ecliptic in the *Nonagesimal* Degree required, which for the 11th of *May*, at IX in the Morning, at *London*, will be 29° of *Aries*.

N. B. In the six ascending Signs, the *Nonagesimal* Degree is always to the *East* of the Meridian; but in the six descending Signs, it is to the *Westward* of it. Note also, the Point called *Medium Cæli*, or *Mid-Heaven*, is that Degree of the Ecliptic which *culminates*, or is in the Meridian; and therefore is always known by Inspection, which in this Example is about 5° of *Aries*.

Prob. XXIII. *To find the DEPRESSION of the SUN below the HORIZON, and the AZIMUTH at any HOUR in the NIGHT, for the GIVEN TIME and LATITUDE of the Place.*

Having rectified the Globe for the Latitude, Sun's Place, and Hour of the Night; take a Point in the Ecliptic exactly opposite to the Sun's given Place, and then find the Sun's Altitude and Azimuth for that Point, as directed in Prob. XIII. and XIV. and these
will

will be the Depression and the *Azimuth* required. Thus, for the 11th of *May*, the Sun being in the 21st of *Taurus*, and turning the Globe about till the Index points at IX at Night, you will observe the opposite Point of the Ecliptic, which is the 21st of *Scorpio*, just as far above the Southern Horizon as the Sun's Place is depressed below the Northern Part: Then bringing the Quadrant of Altitude to lie over that Degree, you will observe its Altitude on the Edge of the Quadrant to be 10° ; and its Azimuth $40^{\circ} 30'$ from the South; and such is the *Depression* of the Sun, and its *Azimuth* from the North, at the given Time.



CHAP. V.

The Use of the CELESTIAL GLOBE in the SOLUTION of PROBLEMS concerning the MOON.

THE foregoing Problems are such as relate to the SUN, whose Path is constantly the same in the Heavens, and the Motion of the Nodes of his Orbit not being sensible in a few Years. Solutions of the Problems relative to this Luminary are of the *most simple Kind*, and admit of no Variation in a long Course of Time;

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But it is far otherwise with respect to the MOON, whose Orbit constantly varies its Position, and the Place of her *Node* is always changing; we do not here speak of its variable Inclination to the Ecliptic, as being too nice an Affair in the *Use of the Globe*.

Again: the Motion of the Moon being very irregular, and *variable* in every Part of its Orbit, this, together with the *Motion* of the *Orbit itself*, make it impossible to ascertain her Place by any constant Calendar, such as we use for the Sun; but her Place must be previously calculated for *every Day* in *every Month*, and that for *every particular Year*: Such Calculations disposed in proper Tables, make what is called an *Ephemeris* of the Moon's Motion: but, even in this *Ephemeris*, her Place is only shewn at the Beginning of each Day, or XII *o'Clock at Noon*. If her Place be required for any other Time of the Day, that must be found by considering what is the Quantity of her *diurnal Motion*, or the Space in the Ecliptic she passes through for that Day. For this Purpose, we shall insert a proper TABLE at Problem XXVI. And whereas there have been many Contrivances for representing the *variable PATH, or ORBIT* of the MOON, over the Surface of the *Celestial GLOBE*, and some of them both troublesome and expensive, I shall here describe the Method which I have always used myself, and think to be the most natural, easy, and demonstrable

demonstrable of any, which is, by tying fast a *silken* LINE over the Surface of the Globe, exactly on the *Ecliptic*; which may be afterwards removed towards the North, or South, just equal to the Latitude of the Lunar Orbit in the Heavens, and the Points of Interfection with the *Ecliptic* (or *Nodes*) will be such, as the Table in the *Ephemeris* assigns for every Sixth Day in the Year.

That Point of Interfection, or NODE of the *Lunar Orbit*, in which the Moon *ascends* from the Southern to the Northern Part, is called the *Ascending Node*, or, (according to the *astrological Cant*) the *Dragon's Head*, and is distinguished by this Character Ω ; and the other Node, or *Dragon's Tail*, is represented by the same Character inverted, thus $\var�$: But this last is not found in the *Ephemeris*, as not being necessary; for the Place of one Node being given, the Place of the other is known, as being diametrically opposite to it.

Because an *Ephemeris* is not in every one's Hands, and yet is very necessary for the Use of the Celestial Globe in its full Extent, it will be proper here to insert that Part of it which contains the Calculations in the Month of *May*, of the Year 1762*, and to demonstrate the Necessity of its Use, in a Solution of the following Lunar Problems.

* The Year in which this Book was first printed, and to which the Examples are adapted.

May 1762.																		
The Planets daily Motions Geocentrick.														168	8			
The Planets Lat. and Place of D's to every 6th Day.		1	2 S.	16	1 S.	5	1 N	17	0 S.	19	2 S.	46	11	34				
		7	2	16	1	5	1	1	0	5	2	22	11	34				
		13	2	17	1	6	0	45	0 N	10	1	39	11	34				
		19	2	18	1	6	0	30	0	25	0	42	11	32				
		25	2	19	1	7	0	10	0	39	0 N	21	11	26				
M	D	☉	♃	♄	♅	Moon's Lat. Bor.	♁	♂	♆	♇	♈	♉	♊	♋	Sun's Dec. North.			
1	11	1	14	36	5	17	17	29	22	50	18	51	19	39	17	28	15	10
2	11	59	28	50	5	3	17	36	23	10	18	33	20	53	18	59	15	28
3	12	57	13	1	4	31	17	44	23	24	18	16	22	7	20	32	15	45
4	13	55	27	8	3	42	17	51	23	38	17	59	23	21	22	7	16	3
5	14	53	11	8	2	41	17	58	23	52	17	43	24	35	23	44	16	20
6	15	51	24	57	1	31	18	5	24	6	17	28	25	49	25	23	16	37
7	16	49	8	34	0	17	18	12	24	20	17	13	27	3	27	3	10	53
8	17	47	21	54	0 A.	57	18	19	24	34	16	59	28	17	28	46	17	10
9	18	45	4	58	2	6	18	26	24	48	16	46	29	30	0	31	17	26
10	19	43	17	45	3	7	18	33	25	2	16	33	0	44	9	18	17	42
11	20	40	0	17	3	58	18	40	25	15	16	21	1	58	4	17	17	57
12	21	38	12	34	4	37	18	46	25	29	16	10	3	12	5	57	18	12
13	22	36	24	40	5	3	8	5	25	43	16	0	4	25	7	49	18	27
14	23	34	6	38	5	15	19	0	25	57	15	51	5	39	9	43	18	42
15	24	32	18	32	5	14	19	6	26	10	15	43	6	53	11	40	18	56
16	25	29	0	26	4	59	19	31	26	24	15	35	8	6	13	39	19	10
17	26	27	12	26	4	31	19	20	26	37	15	28	9	20	15	40	19	24
18	27	25	24	35	3	51	19	26	26	51	15	22	10	34	17	42	19	37
19	28	22	6	58	2	59	19	33	27	4	15	17	11	47	19	46	19	50
20	29	20	19	38	1	58	19	39	27	17	15	12	13	1	21	52	20	3
21	30	18	2	38	0	49	19	46	27	31	15	8	14	14	23	59	20	15
22	1	15	11	59	0 B.	25	19	52	27	44	15	5	15	28	26	8	20	27
23	2	13	29	41	1	39	19	59	27	57	15	3	16	41	28	18	20	39
24	3	10	13	42	2	48	20	5	28	10	15	2	17	55	0	28	20	50
25	4	8	27	58	3	49	20	11	28	23	15	2	19	8	2	39	21	1
26	5	5	12	24	4	35	20	17	28	36	15	D.	3	20	22	4	51	11
27	6	3	26	53	5	4	20	23	28	49	15	4	21	35	7	2	21	21
28	7	0	11	20	5	14	20	29	29	2	15	6	22	49	9	14	21	31
29	7	58	25	41	5	4	20	35	29	14	15	8	14	2	11	26	21	41
30	8	55	9	52	4	34	20	40	29	27	15	11	25	15	13	37	21	50
31	9	53	23	52	3	51	20	46	29	30	15	15	26	29	15	28	21	58

The Heliocentrick Motions.												May 1702.			
Days	♄	♃	♂	♆	♁	♂	♁	♂	♁	♂	♁	Day-lig. B. & E.	Sun Ri. Set	Clock tooflow	
1	15	1	19	19	2	46	11	1	1	48	4	52	2 6 10	4 40 8	3 8
7	15	14	19	52	5	41	16	49	11	30	26	24	1 44 11	4 29 8	3 45
13	25	26	20	25	8	38	22	36	21	8	21	49	1 19 11	4 20 8	4 1
19	15	39	20	58	11	36	28	22	0	50	22	17	0 48 12	4 12 8	3 58
25	15	51	21	31	14	36	4	8	10	33	27	48	No Nig	4 4 8	3 33

Days	H. Wat. Lon. B.		The Lunar Aspects.						The Mutual Aspects.	
	Morn.	Attern.	☉	♄	♃	♂	♀	♁	♂	♀
1	7 48	8 23		Δ 5	Δ 14	♁ 7	□ 9	Δ 5	♂ ♃ ♁ ♀	♁ Perig.
2	8 59	9 35							♂ ♃ ♁ ♀	
3	10 7	10 40	^ 0				Δ 17			
4	11 11	11 42								
5	0 9	0 9		♂ 13	♂ 23	♂ 11				
6	0 36	1 1						♁ 1		
7	1 26	1 51		♂ 16						
8	2 16	2 37					♂ 13			
9	2 58	3 15				* 22				
10	3 32	3 48		Δ 2	Δ 15					
11	4 5	4 26				♁ 9		Δ 8		
12	4 46	5 7	□ 19	□ 15						
13	5 27	5 51			♁ 2			♁ 21		
14	6 15	6 40				Δ 19		□ 6		♁ Apog.
15	7 5	7 31	□ 13	* 2	* 17					
16	7 58	8 24					□ 16			
17	8 50	9 19						* 6		
18	9 48	10 14	* 6							
19	10 40	11 7				♂ 17	* 10			
20	11 34			♂ 0	♂ 14					
21	0 1	0 27								
22	0 54	1 20						♁ 21		
23	1 46	2 12	♁ 5							
24	2 36	3 0		* 12		Δ 2	♁ 8			
25	3 20	3 41			♁ 1					
26	4 2	4 23		□ 14		□ 5				♁ ♁ ♁ * ♁ ♁
27	4 47	5 10	* 14	□ 4				* 16		
28	5 36	6 2		Δ 16		* 7	* 20			♁ Perig.
29	6 31	7 0	□ 22		Δ 6					
30	7 29	7 58						□ 7		
31	8 20	9 0					□ 5			Δ ♁ ♁

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Prob. XXIV. *To find the* NODES *of the* MOON'S ORBIT *for any given* TIME.

On the first Page, *May* 1762, in the Table of *Geocentric* Motions, is a small Table, on the Top, containing the *Latitude* of the Planets for every sixth Day; but in the last Column of this Table, towards the Right-hand, are the Numbers which shew the Sign, Degree, and Minutes of the Place of the *Node*. Thus, for Instance, on the 11th of *May*, 1762, the Place of the ascending Node will be found in $8\ 11^{\circ}\ 34'$; and, therefore the descending Node will be in the same Degree and Minute of the opposite Sign *Scorpio* ♏ .

N. B. You will find, by this Table, that the Motion of the Lunar Nodes is so very slow as to alter but a few Minutes in a Month, it making one Revolution through the *Ecliptic* in almost 19 Years.

Prob. XXV. *To assign the* ORBIT *of the* MOON *its proper* POSITION *in the* Heavens *for any given* TIME.

Having found the Nodes by the foregoing Problem, reckon from thence 90° each Way in the *Ecliptic*, where you must begin to elevate, or remove the Silk Line, (now lying on the *Ecliptic*) towards each of its Poles, keeping it, without any Motion, in the *Points of the Nodes*, by a gradual removing

moving the Moon's Orbit from the Ecliptic you will stop at her utmost Latitude, which is $5\frac{1}{4}$ Degrees; which points on either Side of the Ecliptic, are easily determined by the Parallels of Latitude which pass through every Degree, to the extent of the *Zodiac*, on either Side the Ecliptic in all Mr. *Senex's* Globes. The *Silk-line*, in this Position, will duely represent the *Lunar* ORBIT in the Heavens for that Day.

Prob. XXVI. *To find the Moon's DIURNAL MOTION, in the ECLIPTIC, for any given DAY.*

Find her Place for the given Day at Noon in the second Column of daily Geocentric Motions, and subtract from it her Place on the preceding Day at Noon, and the Difference will be the Space she has described for that Day, and is the *Quantity* of the *Diurnal Motion* sought. For Example, let her Diurnal Motion be required for the 11th of *May*, 1762.

On the 11th of <i>May</i> her Place is	♄	0°	17'
On the 10th of <i>May</i>	♄	17	45
The Diurnal Motion sought		12°	32'

Now the Diurnal Motion of the Moon being variable from $11^{\circ} 46'$ when *least*, to $15^{\circ} 16'$, when *greatest*; I have added the following Table containing the *Diurnal Motions*,

A TABLE for finding the hourly Motion of the Moon, and thereby her true Place at any Time of the Day.

Ho.	11 46	11 56	12 6	12 16	12 26	12 36	12 46	12 56	13 6	13 16	12 26
	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.
1	0 29	0 30	0 30	0 30	0 31	0 31	0 32	0 32	0 33	0 33	0 34
2	0 59	1 0	1 0	1 1	1 2	1 33	1 4	1 5	1 5	1 6	1 43
3	1 28	1 20	1 31	1 32	1 33	1 35	1 36	1 37	1 38	1 39	1 41
4	1 58	1 59	2 1	2 3	2 4	2 6	2 8	2 9	2 11	3 13	2 14
5	2 27	2 29	2 31	2 34	2 35	2 37	2 40	2 42	2 44	2 46	2 48
6	2 57	2 59	3 1	3 4	3 6	3 9	3 11	3 14	3 16	3 19	3 21
7	3 26	3 29	3 32	3 35	3 38	3 40	3 43	3 46	3 49	3 52	3 55
8	3 55	3 59	4 2	4 6	4 9	4 12	4 15	4 19	4 22	4 25	4 20
9	4 25	4 28	4 32	4 36	4 40	4 43	4 47	4 51	4 55	4 58	5 2
10	4 54	4 58	5 3	5 7	5 11	5 1	5 19	5 23	5 27	5 32	5 56
11	5 24	5 28	5 33	5 37	5 42	5 4	5 51	5 56	6 0	6 3	6 9
12	5 53	5 58	6 3	6 8	6 13	6 18	6 23	6 28	6 33	6 38	6 43
13	6 22	6 28	6 33	6 39	6 44	6 49	6 55	7 0	7 6	7 11	7 17
14	6 52	6 58	7 3	7 9	7 15	7 21	7 27	7 33	7 38	7 44	7 50
15	7 21	7 27	7 34	7 40	7 46	7 52	7 59	8 5	8 11	8 17	8 24
16	7 51	7 57	8 4	8 11	8 17	8 24	8 31	8 37	8 44	8 51	8 57
17	8 20	8 27	8 34	8 41	8 48	8 55	9 3	9 10	9 17	9 24	9 31
18	8 49	8 57	9 4	9 12	9 19	9 27	9 34	9 42	9 49	9 57	10 4
19	9 19	9 26	9 35	9 43	9 51	9 58	10 6	10 14	10 22	10 30	10 38
20	9 48	9 56	10 5	10 13	10 21	10 30	10 38	10 47	10 55	11 3	11 12
21	10 17	10 26	10 35	10 44	10 53	11 1	11 10	11 19	11 27	11 36	11 45
22	10 47	10 56	11 6	11 15	11 21	11 33	11 42	11 51	12 0	12 10	12 19
23	11 17	11 26	11 36	11 46	11 55	12 4	12 14	12 24	12 33	12 43	12 52
24	11 46	11 56	12 6	12 16	12 26	12 36	12 46	12 56	13 6	13 16	13 26

Motions; from the least to the greatest, which differ only by 10', in 22 different Columns; of Course, upon the Top of one of these you will observe the Diurnal Motion, just now found, pretty nearly; and the 24 Hours being placed by the Side of the Table,

A TABLE for finding the hourly Motion of the Moon, and thereby her true Place at any Time of the Day.

h	13 30	13 40	13 50	14 0	14 10	14 20	14 30	14 40	14 50	15 0	15 10
5	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.
1	0 31	0 34	0 35	0 36	0 36	0 36	0 36	0 37	0 37	0 36	0 38
2	1 8	1 9	1 16	1 10	1 11	1 12	1 13	1 14	1 15	1 15	1 16
3	1 42	1 42	1 46	1 46	1 47	1 48	1 49	1 51	1 51	1 53	1 54
4	2 16	2 8	2 19	2 21	2 23	2 24	2 26	2 28	2 20	2 31	2 33
5	2 50	2 52	2 54	2 56	2 58	3 0	3 3	3 5	3 7	3 9	3 11
6	3 24	3 26	3 29	3 31	3 34	3 39	3 39	3 41	3 45	3 46	3 9
7	3 58	4 1	4 4	4 7	4 10	4 10	4 15	4 18	4 21	4 24	4 7
8	4 32	4 35	4 39	4 42	4 45	4 49	4 52	4 55	4 59	5 2	5 5
9	5 6	5 10	5 13	5 17	4 21	5 25	5 28	5 32	5 36	5 40	5 43
10	5 40	5 42	5 48	5 52	5 57	6 1	6 5	6 9	6 13	6 17	6 22
11	6 14	6 19	6 23	6 28	6 32	6 37	6 41	6 46	6 51	6 55	7 0
12	6 48	6 53	6 58	7 3	7 8	7 13	7 28	7 23	7 28	7 33	7 28
13	7 22	7 27	7 33	7 38	7 44	7 49	7 54	8 6	8 5	8 11	8 10
14	7 56	8 0	8 8	8 13	8 19	8 25	8 31	8 37	8 43	8 48	8 54
15	8 30	8 36	8 42	8 49	8 55	9 1	9 7	9 14	9 20	9 26	19 32
16	9 4	9 11	9 17	9 21	9 12	9 37	9 44	9 51	9 57	10 4	10 11
17	9 38	9 45	9 52	9 59	10 26	10 13	10 20	10 28	10 33	10 42	10 49
18	10 12	10 19	10 27	10 34	10 42	10 49	10 57	11 4	11 12	11 19	11 27
19	10 46	10 54	11 5	11 10	11 18	11 26	11 34	11 41	11 49	11 57	12 5
20	11 29	11 38	11 37	11 24	11 8	12 2	12 10	12 18	12 17	12 35	12 42
21	11 58	12 3	12 11	12 20	12 9	12 38	12 40	12 55	13 4	13 13	13 21
22	12 28	12 37	12 46	12 55	13 5	13 14	13 23	13 33	13 41	10 50	10 0
23	13 2	13 12	13 21	13 31	13 43	13 59	13 59	14 9	14 10	14 28	14 38
24	13 36	13 46	13 56	14 6	14 16	14 26	14 36	14 46	14 56	15 6	15 16

Table, it will be easy from thence, to see what Part of the Diurnal Motion of the Moon answers to any given Number of Hours. Thus, for the Diurnal Motion above found of $12^{\circ} 32'$, you will find, on the Top of the 6th Column, $12^{\circ} 36'$, and
 1 2 under

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under it, against the 9^h, you will find 4° 43', which is her Motion in the Ecliptic in the Space of 9 Hours for that day.

Prob. XXVII. *To find the MOON'S PLACE in the Ecliptic for any given HOUR of the DAY.*

Look in the second Column of the large Table of the daily *Geocentric Motions*, and you will find, opposite to the given Day of the Month, the Moon's Place in the Ecliptic for that Day at Noon; and, by the foregoing Problem, find the Space she has described since Noon to the given Moment of Time, which, added to the former, will be her Place in the Ecliptic, as required for the present Moment: Thus on the 10th of *May* her Place at Noon will be found in 17° 45' of δ , and since her Motion for that Day is 12° 32', in nine Hours she will have passed over 4° 43', which added to her Place at Noon, will give 22° 28' of δ for her Place on the 10th of *May* at IX at Night.

Prob. XXXVIII. *To find the MOON'S PLACE in her ORBIT for any given DAY and HOUR.*

Having found her Place in the *Ecliptic* by the preceding Problem, you are to observe, that through every Degree of the Ecliptic, perpendicular thereto, are drawn in the Zodiac, *Circles of Latitude*: Then that Circle which

which passes through the Moon's Place in the Ecliptic will intersect the *Silken-line*, and, thereby, shew her true Place in that *Artificial Orbit*, which may be denoted by a Piece of a *Patch*, cut in Form of a *Crescent*, and placed upon the said Line, where we suppose it to remain during the Course of these Problems, which will all have regard to the 10th of *May* at IX o'Clock at Night.

Prob. XXIX. *To find the LATITUDE of the MOON for any given DAY and HOUR.*

Having found her Place in the *Ecliptic*, and also in *her Orbit*, the Arch of a Circle of Latitude between these two Points, will be the Quantity of her Latitude sought, and is easily seen in Degrees and Parts of a Degree on the *Zodiac* of the Globe. Thus, for the 10th of *May*, 1762, at Noon, her Latitude is $3^{\circ} 7'$, the same as you will observe in the *third Column of Geocentric Motions* against the given Day.

N. B. In the Column of Latitudes you will see the Letter A, denoting the *South LATITUDE*, and the Letter B denoting the *North Latitude*; and by these you will easily see when the Moon is in either *Node*, as there she has *no Latitude at all*.

Prob. XXX. *To find the MOON'S DECLINATION for any given DAY or HOUR.*

The

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The Place in her Orbit being found, by Problem XXVIII, bring the *Crescent* to the *General Meridian*: Then the Arch of the Meridian, contained between it and the Equinoctial, will be the *Declination* sought, which, in the foregoing Example on the 10th of *May* at Noon, 1762, will be about 25° .

Prob. XXXI. *To find the MOON'S greatest and least MERIDIAN ALTITUDES in any given LATITUDE, that of LONDON, for Example.*

It is evident, this can happen only when the *ascending Node* of the MOON is in the *vernal Equinox*; for then her greatest *Meridian ALTITUDE* will be 5° greater than that of the Sun, and therefore about 67° : also her least *Meridian Altitude* will be 5° less than that of the Sun, and therefore only 10° : there will therefore be 57° *Difference* in the *Meridian Altitude* of the Moon; whereas, that of the Sun is about 47° .

N. B. When the same *ascending Node* is in the *autumnal Equinox*, then will her *Meridian Altitudes* differ by only 37° : But these *Phænomena* can separately happen but once in the revolution of a Node, or of *nineteen Years*: And it will be a pleasant Entertainment to place the Silk-line to cross the *Ecliptic* in the *Equinoctial Points*

Points *alternately*; for then the Reason will more evidently appear, why you observe the Moon sometimes within 23° of *our Zenith*, and at other Times not more than 10° above the *Horizon*, when she is full South.

Prob. XXXII. *To find the Time of the MOON'S RISING, SOUTHING, and SETTING, for any LATITUDE and given DAY of the YEAR.*

First, rectify the Globe for the Latitude of the Place, and find the Moon's Place in her Orbit at Noon, for the given Day, which bring to the General Meridian, and set the Hour Index at XII; Then bring her Place to the Eastern Part of the Horizon, and the Index will shew the Time of her Semi-diurnal Arch, supposing the Moon were *fixed* in her Orbit; but as she is not, the Quantity of her Motion, during the Time of that Semi-diurnal Arch, must be found and *subtracted* from her Place at Noon, in order to give her Place in her Orbit pretty nearly at rising; and the same Motion must be *added* to her Place at Noon, in order to give her Place in her Orbit at setting. Thus, for Example: on the 10th of *May*, 1762, at *London* the Moon's Place was found in 18° of *Sagittarius*, which will give the Semi-diurnal Arch about 4^{h} , in which Time the Motion of the Moon will be about 2° ;

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2° ; therefore her Place, at rising, will be 16° of that Sign, and her Place at setting about 20° .

Secondly, find the Sun's Place for the 10th of *May* at Noon, bring it to the Meridian, and set the Hour Index to the upper XII: Then turn the Globe about till the 16° of *Sagittarius* coincides with the *Eastern* Part of the Horizon; then will the Index Point to nearly Half an Hour after X at Night, which will be the Time of her *rising*. Then bring the 18° of the same Sign to the Meridian, and the Index will point to II in the Morning for the Time of her *Southing*. Lastly, the 20° of *Sagittarius*, being brought to the *Western* Part of the Horizon, will shew the Time of her *setting* about a $\frac{1}{4}$ after V in the Morning.

Prob. XXXIII. *To find the* AMPLITUDE, AZIMUTH, ALTITUDE, &c. &c. of the Moon for any given DAY, HOUR, and LATITUDE of the PLACE.

When the Place of the Moon in her Orbit is found for the given Day and Hour, and the Globe rectified for the given Latitude, then the *Amplitude, Azimuth, Altitude, &c.* of the MOON will be found in the same Manner as directed for those of the SUN, *viz.* by observing the Degrees of the Horizon in which the Moon rises and sets on the given Day; and by laying the Quadrant of
of

of Altitude (fixed in the Zenith) over the Moon's Place, or *Crescent*, when in any Position above the Horizon, or else over the Point of the Moon's Orbit exactly opposite to it, when it is depressed below it.

Prob. XXXIV. *To explain the Phænomena of the HARVEST, or SHEPHERDS MOON.*

What is usually called the HARVEST MOON is the *full Moon* that happens when the Sun is near the *autumnal EQUINOX*, which every Night successively rises within a very short Time of the Sun's setting, by which Means the Hemisphere becomes almost constantly enlightened by one Luminary or the other; whence it happens, that the Nights become very lightsome and pleasant, and therefore, very advantageous for *Harvest People, Shepherds, Sportsmen, &c.* on which Account it receives those various Appellations.

On the contrary, at the opposite Time of the Year, or *vernal EQUINOX*, a considerable Time elapses between the setting of the Sun and rising of the full Moon; thereby occasioning the Nights to be dark even at the Time of a full Moon: The Reason of all which will very easily appear, by only considering the very different Angle which the Ecliptic makes with the Horizon at those two opposite Seasons of the Year: For in the Latitude of LONDON, at the Time of the *ver-*

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nal Equinox, when the Sun is setting in the Western Part of the Horizon, the Ecliptic then makes an Angle of 62° with the Horizon; but when the Sun is in the *autumnal Equinox*, and setting in the same Western Part of the Horizon, the Ecliptic makes an Angle but of 15° with the Horizon: All which is evident by a bare Inspection of the Globe only.

Again, according to the greater, or less *Inclination* of the Ecliptic to the *Horizon*, so a greater or less Degree of Motion of the Globe about its Axis will be necessary to cause the same Arch of the Ecliptic to pass through the Horizon; and, consequently, the Time of its Passage will be greater, or less, in the same Proportion: But this will be best illustrated by an Example.

Therefore, suppose the Sun in the *vernal Equinox*, and rectifying the Globe for the Latitude of *London*, and Place of the Sun, bring the *vernal Equinox*, or Sun's Place to the Western Edge of the Horizon, and the Hour Index will point precisely to VI; at which Time, we will also suppose the Moon to be in the *Autumnal Equinox*, and, consequently, at *Full*, and *rising* exactly at the Time of *Sun-set*.

But on the following Day, the Sun, being advanced scarcely one Degree in the Ecliptic, will set again very nearly at the
same

same Time as before: But the Moon will, at a mean Rate, in the Space of one Day, pass over 13° in her Orbit; and therefore, when the Sun sets in the Evening after the Equinox, the Moon will be below the Horizon, and the Globe must be turned about till 13° of *Libra* comes up to the Edge of the Horizon, and then the Index will Point to $7^{\text{h}} 16'$, the Time of the Moon's rising; which is an Hour and $\frac{1}{4}$ after Sunset. The next day following, there will be 2^{h} and $\frac{1}{2}$, and so on successively, with an increase of 1^{h} and $\frac{1}{4}$ Dark-night each Evening respectively, at this Season of the Year; all owing to the very great Angle which the Ecliptic makes with the Horizon at the Time of the Moon's rising.

On the other Hand, suppose the Sun in the *Autumnal* EQUINOX, or beginning of *Libra*, and the Moon opposite to it in the vernal Equinox, then the Globe (Rectified as before) being turned about till the Sun's Place comes to the Western Edge of the Horizon, the Index will point to VI, for the Time of his *setting*, and the rising of the *Full-moon* on that Equinoctial Day. On the following Day, the Sun will set nearly at the same Time; but the Moon being advanced (in the 24 Hours) 13° in the Ecliptic, the Globe must be turned about till that Arch of the Ecliptic shall ascend

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the Horizon, which Motion of the Globe will be very little, as the Ecliptic now makes so small an Angle with the Horizon, as is evident by the *Index*, which now points to VIⁿ 17' for the Time of the Moon's rising on the second Day, which is but about $\frac{1}{4}$ of an Hour after Sun-set. The third Day, the Moon will rise within $\frac{1}{2}$ an Hour; on the 4th, within $\frac{3}{4}$ of an Hour, and so on; so that it will be near a Week before the Nights will be an Hour without Illumination: and in greater Latitudes this Difference will be still greater, as you will easily find by varying the Case, in the Practice of this celebrated Problem, on the Globe. This Phænomenon will be also variable by the *different Position* of the *Moon's Orbit* at different Times.

Prob. XXXV. *To find the TIMES of the YEAR when the SUN and the MOON are subject to be ECLIPSED.*

Were the MOON to describe the *same Path* in the Heavens with the SUN, or if she always moved in the *Eliptic*, there would always be a *central and total* ECLIPSE of the SUN in every *Conjunction*, and a *central Eclipse* of the MOON at every *Opposition*; and these Eclipses would alternately return every *Fortnight*.

But,

But, as the Case now stands, the Moon's Orbit not coinciding with the Ecliptic, but making an Angle of 5° therewith, there can be but *two Points* in the *Ecliptic* in which she can be found in a whole LUNATION; and as these two Points, or NODES of the Moon's Orbit, are diametrically opposite to each other, there are but *two Days* in the YEAR when it is possible for the Sun and Moon to be both together in the same Point of the Ecliptic, and, Consequently, that a *central*, or *total* ECLIPSE of the SUN can happen.

Now these two Days may be easily determined by finding the Places of the Moon's Nodes for the given Year, by Prob. XXIV, and then, when the Sun possesses that Degree of the Ecliptic, see what Days in the Month correspond thereto in the Calendar, for they are the Times required for a central Eclipse of the Sun.

Thus, for Instance; in the Year 1762, the *ascending Node* was in the $11^{\circ} 34'$ of ϑ , and the *descending Node* in the same Number of Degrees of ϑ : By the Calendar I observe, the Sun is in those Points of the Ecliptic, on *May* the 1st, and *November* the 3d; but on those Days our Almanack mention no Eclipses, the Reason of which is, that, when the Moon passed her Nodes, the Sun was at some small Distance from them, and the Eclipses of the Sun, in such a Case, could be

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be only *partial*. Thus, the Moon past the ascending Node in that Year, on the 24th of *April*, when the Sun was about 6° distant from the Node, as is evident by the *Ephemeris* for the Month of *April*. The same you will likewise observe for the Eclipses in *November*, at the descending Node.

By the Doctrine of Eclipses it is found, that the Sun must be within 12° of the Node to suffer an Eclipse in any Degree; and the Moon within 16° , otherwise she cannot enter the Earth's Shadow. These Distances are, therefore, called the *Ecliptic Limits* for *solar* and *lunar* ECLIPSES; because beyond these, the *Latitude* of the Moon will be too great to admit of any Eclipses.

See this curious Part of Astronomy explained at large in my *Philosophia Britannica*; with all the *Mathematical* ELEMENTS and CALCULATIONS. You may also find much on the same Subject in the *Young GENTLEMAN AND LADIES PHILOSOPHY*, Second Edition.



CHAP.



CHAP. VI.

*The Use of the CELESTIAL GLOBE in
the SOLUTION of PROBLEMS relative
to the various Phænomena of the
PLANETS.*

HAVING dispatched the Problems
relative to the SUN and MOON,
we come now to those of the
PLANETS. In the Solution of
Planetary PROBLEMS, the signal and im-
portant Use of the Celestial Globe will be no
less conspicuous than in the former, and
must be very entertaining and advantageous,
as by this Means we are always enabled to
find how many, and what Planets are *above
the Horizon*; and, consequently, the proper
Subjects for our *Inspection* and *Observation* at
any given Time of the Year.

But, as the Motion of some of the Planets
are very quick, and even those of the slowest
are very sensible in the Space of 12 Months,
therefore it becomes necessary, by previous
Calcula-

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Calculation, to have their Places ascertained for every Day in the Year, (in the same Manner as for the Moon) in an *Ephemeris*; and hence it is we find *five several Columns* following that of the Moon's Latitude in the Table of Geocentric Motions, appropriated to the *five PLANETS* respectively, shewing the *Sign, Degree, and Minute* of the Ecliptic which each Planet possesses on the NOON of every Day throughout the Year. This is evident by Inspection of the *Ephemeris* for *May*, which we gave in the foregoing Chapter, and is to be now consulted for the *Planets*.

The INCLINATIONS of the *Planetary ORBITS*, or the *Angle* they make with the Ecliptic, is, in general, so small as not to be regarded, except only for *Mercury*; and therefore the silk String, which was used for the Moon's Orbit, is not here necessary. The Problems, therefore, peculiar to the Planets, are but very few, and their Solutions are as follow:

Prob. XXXVI. *To find the PLACE of the given PLANET in the ECLIPTIC for a given TIME.*

Look for the given Month in the *Ephemeris*, and opposite to the given Day of the Month is the Planet's Place in the Ecliptic, in the Column proper to that Planet. Thus, for Example: On *May 9th, 1762*, you will find

Saturn's

in PROBLEMS *of the* PLANETS. 73

<i>Saturn's</i> Place at Noon is	♄	18	26
<i>Jupiter's</i>	♃	24	48
<i>Mar's</i>	♂	16	46
<i>Venus's</i>	♀	29	30
<i>Mercury's</i>	☿	0	31

Having found these Places, you stick Patches on the respective Points in the Ecliptic, to denote them.

Prob. XXXVII. *To find the PLACE of a PLANET in its proper ORBIT.*

This Problem is inserted for the Satisfaction of those who have Mr. *Senex's* large Globes of 17 or 28 Inches Diameter; because, in them the Inclination of the Planetary Orbits to the Ecliptic will appear considerable, as a Degree in the latter Globes is full a Quarter of an Inch,) and that of *Jupiter*, which is the least of all, is near $1^{\circ} 30'$: but *Mercury's* greatest Latitude is not much less than $7^{\circ} 00'$, and therefore, on this large Globe, it might answer in some Cases to have the *silk String* representing the Orbit of the *Planets*, as well as that of the *Moon*.

Having therefore found its Place in the Ecliptic, you will take out of a small Table, on the Top of the Page, the Numbers proper to the Planet for the Day of the Month, nearest to that of the given Day: This is the Planet's LATITUDE, *North* or
L *South*

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South, according as the Letters N. or S. stand above it. This Quantity of the Latitude is to be set off in the Circle of Latitude in the Planet's given Place, towards the North or South Pole of the Ecliptic, as the said Letter N or S directs, and that is the Planet's true Place in its Orbit. Thus on the 9th of *May*, 1762, I find the Latitude, in the Column for *Saturn* answering to the 7th Day, to be $2^{\circ} 16^{\circ}$ *South*, which, therefore, is nearly the same on the 9th, and consequently gives the Planet's Place in the *Southern Part* of his orbit. On this Point, therefore, the patch must be put to represent the Planet's Place truly on the Surface of the Globe.

N. B. Tho' the *Geocentric* or *Apparent Latitudes* of *Saturn* and *Jupiter* are nearly the same as their *real Latitude*, yet, that of *Mercury* will always be less, being seldom more than $4^{\circ} 30'$. On the contrary, that of *Venus* and *Mars* will sometimes much exceed the true Latitudes, as being at those Times much nearer to us than to the Sun.

Prob. XXXVIII. To find the TIME when a given PLANET RISES, CULMINATES, or SETS on a given Day of the Year, and in a given Latitude.

Rectify the Globe for the Latitude of the Place, bring the Sun's Place for the given Day
Day

Day to the Meridian, and set the Hour Index to the upper XII: Then having found the Planet's Place, bring it to the Eastern Edge of the Horizon, and the Index will point out the Time of its *rising*. Then bring the said Place, or Patch, to the Meridian, the Index will then show the Time of its *culminating*, or being *full South*. Lastly, turn the said Patch into the Western Edge of the Horizon, and the Index will there shew the Time of its *setting*.

For Example: On the 9th of *May*, 1762, at *London*, the Place of the Planet *Jupiter* was in ν $24^{\circ} 48'$: Then, rectifying the Globe, bring the said Place to the Western Horizon, and the Index will point to III Hours 20', the Time of his rising in the Morning: Then, revolving the Globe till the said Point comes to the Meridian, the Index will shew the Time of its culminating to be 15' after X; and bringing the said Place to the Western Part of the Horizon, the Index will point to 15' after V, the Time of the Planet's setting.

From all which it evidently appears, that at that Time *Jupiter* was not to be observed in the *Evening*, and but a very little Time in the *Morning*; for, as he rose but about half an Hour before the Sun, neither his Altitude nor the *Aurora* would permit his being viewed to any Advantage. And thus this Problem repeated for each of the Planets, will shew which of them are, or are

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not, in a Position to be seen on any given Night of the Year.

Prob. XXXIX. *To find directly the PLANETS which are ABOVE the HORIZON at SUNSET, upon any given DAY and LATITUDE.*

Find the Sun's Place for the given Day, bring it to the Meridian, set the Hour Index to XII, and elevate the Pole for the given Latitude: then bring the Place of the Sun to the *Western Semi-circle* of the Horizon, and observe what Signs are in that Part of the Ecliptic above the Horizon, then cast your Eye upon the *Ephemeris* for that Month, and you will at once see what Planets possess any of those *elevated Signs*; for such will be *visible*, and fit for Observation on the Night of that Day.

Thus, for Example: On the 9th of *May*, the Sun being in $19^{\circ} 00'$ of δ and in the Western Horizon, the Signs above the Horizon, will be *Gemini, Cancer, Leo, Virgo, Libra, and Scorpio*: But in the *Ephemeris* you will see only one of those Signs possessed by a Planet, which is *Mars*, who is then in $\approx 16^{\circ} 46'$ in the *Eastern Hemisphere*.

But then, two Signs more may be added for the Planets that may arise *before Midnight* for that Day, which added to the former, make eight; but no Planet is found in them; therefore *Mars* will be the only Planet to be seen that Night.

Prob. XL. *To find when any of the three superior PLANETS will RISE at SUN-SET, in a given Latitude.*

Rec-

Rectify the Globe for the Latitude, and in the *Ephemeris* find the Planet's Place, which bring to the Eastern Part of the Horizon, then the Point of the Ecliptic, exactly opposite to the Planet's Place, will be in the Western Part of the Horizon ; and when the Sun comes to be in that Point, it will, of Course, set when the Planet rises on that Day ; and in the Calendar it may be seen, when the Sun possesses that Part of the Ecliptic, which will be the time required.

But this is very easy to be observed in the *Ephemeris* only, by taking Notice of that Time of the Year when the Sun and the Planet possess two opposite Points in the Ecliptic ; for, in this opposition, the Planet must rise when the sun sets.

Thus, for Example ; On the 29th Day of *October*, 1762, the Sun and *Jupiter* will be in *Opposition*, and consequently the Planet will rise when the Sun sets.

But as to *Venus* and *Mercury*, as one is never seen to depart from the Sun more than about $47^{\circ} 00'$, and the other not more than about 21° , the Times of their rising at Sun-set will be easy to observe, among the Tables of mutual Aspects, on the Right-hand Pages of the *Ephemeris*.

Prob. XLI. *To find the right ASCENSION, DECLINATION, AMPLITUDE, AZIMUTH, ALTITUDE, HOUR of the NIGHT, &c. of any given PLANET, for a Day of a Month and Latitude given.*

Rec-

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Rectify the Globe for the given Latitude and Day of the Month, then find the *Planet's Place*, as directed; and then the *right Ascension, Declination, Amplitude, Azimuth, Altitude, Hour, &c.* are all found as directed in the Problems for the Sun; there being no Difference in the Process, no Repetition can be necessary.

But lest any of our Readers should have the Curiosity of performing these Problems according to the precise Truth, and would chuse to represent their Orbits by a silk String, or Thread, as was directed in the Case of the Moon, it will be necessary to give here the Places of the Nodes, and Inclination of the Orbit, for each particular Planet, as below:


		0	1
The Place of the <i>Ascen- ding</i> NODE of the Orbit of	{ <i>Mercury</i>	8	16 2
	{ <i>Venus</i>	II	14 46
	{ <i>Mars</i>	8	18 30
	{ <i>Jupiter</i>	9	8 57
	{ <i>Saturn</i>	9	21 35

The INCLI- NTION of the Orbit of	{ <i>Mercury</i>	6	54
	{ <i>Venus</i>	3	24
	{ <i>Mars</i>	1	52
	{ <i>Jupiter</i>	1	20
	{ <i>Saturn</i>	2	30



C H A P. VI.

The Use of the Celestial GLOBE in the SOLUTION of PROBLEMS ascertaining the PLACES, and visible MOTIONS or ORBITS of COMETS.

 HERE is another Class, or Species of PLANETS, which are called COMETS. These move round the Sun in regular and stated Periods of Times in the same Manner and from the same Cause that the rest of the Planets do, that is, by a centripetal Force, every where decreasing as the Squares of the Distances increase, which is the general Law of the whole planetary System: But this centripetal Force in the Comets, being compounded with the projectile Force, in a very different *Ratio* from that which is found in the Planets, causes their Orbits to be much more *Ecliptical* than those of the Planets, which are almost *circular*.

But

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But whatever may be the Form of a Comet's Orbit in Reality, their *Geocentric Motions*, or the apparent Paths which they describe in the Heavens among the fixed Stars, will always be circular ; * and therefore may be shewn upon the Surface of a Celestial Globe, as well as the Motions and Places of any of the rest of the Planets.

And to give the most signal Instance of the *cometary PRAXIS* on the Globe, I shall chuse that COMET, for the Subject of these Problems, which made its Appearance at *Boston in New England* in the Months of *October* and *November*, 1758, in its Return to the Sun ; after which, it approached so near the Sun as to set *Heliacally*, or to be lost in its beams for some Time, which was spent in passing the *Perihelion*. Then afterwards, emerging from the solar rays, it appeared *retrograde* in its Course from the Sun towards the latter end of *March*, and so continued the whole Month of *April* and part of *May* in the *West Indies*, particularly in *Jamaica*, whose Latitude rendered it visible in those Parts, when it was, for the greatest Part of the Time, invisible to us, by reason of its Southern Course through the Heavens.

When two Observations can be made of a Comet, it will be very easy to assign its
Course,

* This the Reader may see demonstrated in my new THEORY of the COMETS.

Course, or mark it out upon the surface of the Celestial Globe: These, with regard to the above mentioned Comet, we have, and are sufficient for our purpose in regard to the Solution of *Cometary Problems*. By an Observation made at *Jamaica* on the 31st of *March*, 1759, at V 0'Clock in the Morning, the Comet's *Altitude* was found to be $22^{\circ} 50'$, and its *Azimuth* 71° South East. From hence we shall find its Place on the Surface of the Globe, by the following Problems,

Prob. XLII. *To rectify the GLOBE for the Latitude of the Place of Observation in JAMAICA, Latitude $17^{\circ} 30'$ and given Day of the Month, viz. March 31st.*

Elevate the North Pole to $17^{\circ} 30'$ above the Horizon, then fix the Quadrant of Altitude to the same Degree in the Meridian, or *Zenith-point*: Again, the Sun's Place for the 31st of *March* is in $10^{\circ} 34'$ of ν , which bring to the Meridian, and set the Hour Index at XII, and the Globe is then rectified for the Place and Time of Observation.

Prob. XLIII. *To determine the PLACE of a COMET on the Surface of the Celestial Globe from its given ALTITUDE, AZIMUTH, HOUR of the DAY, and LATITUDE of the Place.*

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The Globe being rectified to the given Latitude and Day of the Month, turn it about toward the East, till the Hour-Index points to the given Time, *viz.* V o'Clock in the Morning: Then bring the Quadrant of Altitude to intersect the Horizon in 71° , the given Azimuth in the *South-East* Quarter; and, under $22^{\circ} 50'$, the given Altitude, you will find the Comet's Place, where you may put a small Patch to represent it.

Prob. XLIV. *To find the* LATITUDE, LONGITUDE, DECLINATION, *and right* ASCENSION *of the* COMETS.

In the Circles of Latitude contained in the *Zodiac*, you will find the *Latitude* of the Comet to be about $3^{\circ} 30'$ from the *Ecliptic*; the same Circle of Latitude reduces its Place to the *Ecliptic* in $26^{\circ} 30'$ of ♈ , which is its *Longitude* sought. Then bring the Cometary Patch to the brazen Meridian, and its *Declination* will be shewn to be $9^{\circ} 15'$ South. At the same Time its *right Ascension* will be $227^{\circ} 30'$.

Prob. XLV. *To shew the Time of the* COMET'S RISING, SOUTHING, SETTING, *and* AMPLITUDE *for the* DAY *of the* Observation *at* JAMAICA.

Bring the Place of the Comet into the Eastern Semi-Circle of the Horizon, (the Globe being rectified as above directed,) the
Index

Index will point to III Hours 15', which is the Time of its *rising* in the Morning at *Jamaica*, the *Amplitude* 10° very nearly, to the South. The *Patch* being brought to the Meridian, the Index points to IX o'Clock 10' for the Time of *culminating*, or being *South* to them. Lastly, bring the *Patch* to touch the Western Meridian, and the Index will point to III in the Afternoon, for the Time of the Comet's setting, with 10° of *Southern Amplitude*, of Course.

Prob. XLVI. *From the* COMET'S *Place being given, to find the Time of its* RISING *in the Horizon of* London, *on the* 31st *Day of* March, 1759.

For this Purpose, you need only rectify the Globe for the given Latitude of *London*, and bring the *Cometary Patch* to the Eastern Horizon, and the Index points to III Hours 45' for the Time of its *rising* at *London*, with about 14° of *South Amplitude*: then turn the *Patch* to the Western Horizon, and the Index points to II Hours 25', the Time of its *setting*.

N. B. From hence it appears, the Comet rose soon enough that Morning to have been observed at *London*, had the Heavens been clear, and the Astronomers been before-hand apprized of such a *Phænomenon*.

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Prob. XLVII. *To determine another Place of the same COMET, from an OBSERVATION made at LONDON on the 6th Day of May, at X in the Evening.*

On the 6th Day of *May*, 1759, at X at Night, I very carefully observed the Place of the Comet, and measured its Distance, with a *Micrometer*, from two fixed Stars marked μ and ν in the Constellation called *Hydra*, and by an Azimuth Quadrant I found its *Altitude* 16° , and its *Azimuth* 37° S. W. from whence its Place on the Surface of the Globe is exactly determined, as in Prob. XLIII; and having stuck a Patch thereon, you will have the *two Places* of the Comet on the Surface of the Globe, for the two distant Days and Places of Observation, as required.

Prob. XLVIII. *From two given Places of a COMET, to assign its apparent PATH among the fixed Stars in the Heavens.*

The two Places of the Comet being determined by the Observations on the 31st of *March*, 1758, and the 6th of *May* following, and denoted by two Patches respectively, you must move the Globe up and down, in the Notches of the Horizon, till such Time you bring *both the Patches to coincide with the Horizon*: Then will the Arch of the Horizon between the two Patches shew, upon the Celestial Globe, the apparent Place
of

of the Comet in the Interval between the two Observations, and by drawing a Line with Chalk or a black Lead Pencil, along by the Frame of the Horizon, its *Path on the Surface of the Globe* will be delineated, as required. And here it may be observed, that its apparent Path lay through the following *Southern CONSTELLATIONS*, *viz.* the Tail of *Capricorn*, the Tail of *Pisces Australis*, by the Head of *Indus*, the Neck and Body of *Pavo*, through the Neck of *Apus*, below *Triangulum Australe*, above *Musca*, by the Lowermost of the *Croifers*, across the hind Legs and through the Tail of *Centaurus*, from thence between the two Stars in the Back of the *Hydra*, before mentioned; after this, it passes on to *Sextans Uranicæ*, and then to the *Ecliptic* near *Cor Leonis*; soon after which, it totally disappeared.

Prob. XLIX. *To estimate the apparent VELOCITY of a COMET, from two Places thereof being given by Observation.*

Let one Place be ascertained near the beginning of its Appearance, and the other towards the End thereof; then bring these two Places to the Horizon, and count the Number of Degrees intersected between them, which, being the Space apparently described in a given Time, will be the Velocity required. Thus, in the Case of the above-mentioned

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mentioned Comet, you will find, that it described more than 150° in the Space of 36 Days, which is more than 4° *per* Day.

Prob. L. *To represent the general Phænomena of the COMET for any given Latitude.*

Bring the visible Path of the Comet to coincide with the Horizon, by which it was drawn, and then observe what Degree of the Meridian is in the North Point of the Horizon, which, in the Case of the foregoing Comet, will be the 23° : This will be the *greatest Latitude* in which the whole Path can be visible; *in any Latitude less than this*, as that of *Jamaica*, for Instance, the most southern Part of the Path will be elevated more than 5° above the Horizon, and the Comet visible through the whole Time of its Apparition. But rectifying the Globe for the Latitude of *London*, the Path of the said Comet will be for the *most Part invisible*, or below the Horizon; and therefore it could not have been seen in our Latitude, but at Times very near the Beginning and End of its appearance; because, by bringing the Comet's Path on one Part to the South Point of the Horizon, it will immediately appear in what Part the Comet *ceases to be visible*: And then bringing the other Part of the Path to the same Point, it will appear in what Part it will again become visible.

After

After this Manner may the Problems relating to *any other Comets* be performed; and so the Paths of the *several Comets*, which have hitherto been observed, may be severally delineated on the Celestial Globe, and their various *Phænomena* in different Latitudes thereby shewn.





C H A P. VIII.

The Use of the CELESTIAL GLOBE *in*
the SOLUTION *of* PROBLEMS *relative*
to the fixed STARS.

WE now proceed to those *Problems* on the Celestial Globe in which the STARS are concerned, which, with respect to the present Age, we may very well consider as *fixed*, since their Motion is so exceeding slow as not to be sensible in less than *Half a Century*: And their Places having been very carefully rectified by Mr. *Senex* but a few Years ago, as we intend not here a Philosophical Discourse on the Stars, shall only observe, that they are ranged into various CONSTELLATIONS on the Surface of the *Celestial GLOBE*, as artificial Helps for directing us how to know, and where to find them in the Heavens. The *Names* of these *Constellations* are to be learnt by Inspection of the Globe, where they appear very plain; as also their Forms and Disposition; you will find the Stars depicted in dif-

different Degrees of *Magnitude*, as they appear to the Eye, the largest being called Stars of the *first Magnitude*; and upon the Globes you will see them decreased to the 6th or 7th Magnitude. Whenever you are to perform any Problem of the Stars on the Globe, it is supposed that you have *rectified the Globe* for the *Latitude* of the Place, and for the *Sun's Place* for the given Day at Noon, as in all the other Problems, and then the Process will be very easy and short.

Prob. LI. *To find the right ASCENSION and DECLINATION of any given STAR.*

Bring the given Star to the Meridian, and the Degree under which it lies, is its *Declination*; and the Point in which the Meridian intersects the Equinoctial, is its right *Ascension*. For Instance, let *Arcturus* be the given Star; this brought to the Meridian will be seen under the $20^{\circ} 20'$, which is therefore its *Declination, North*; and its *right Ascension* is, at the same Time, shewn in the Equinoctial to be $211^{\circ} 00'$. Again, another Instance may be *Sirius*, the *Dog-star*, which, brought to the Meridian, will be seen under the $16^{\circ} 30'$, which is his *Declination, South*; and its *right Ascension* $98^{\circ} 20'$ in the Equinoctial Line.

Prob. LII. *To find the LATITUDE and LONGITUDE of a given Star.*

N

Bring

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Bring the POLE of the *Ecliptic* to the Meridian, over which fix the Quadrant of Altitude, and, holding the Globe very steady, move the Quadrant to lie over the given Star, and it will cut that Degree in the Edge as will shew its *Latitude* from the *Ecliptic*, and in the *Ecliptic* that Quadrant will cut that Degree which is called its Place *reduced to the Ecliptic*, or LONGITUDE from the Beginning of *Aries*. Thus, with respect to *Arcturus*, its Latitude from the *Ecliptic* will be found $30^{\circ} 30'$, and its Longitude in the *Ecliptic* about $20^{\circ} 20'$ of *Libra*. This Problem regards either Pole, as the Stars are in the *Northern*, or *Southern Hemispheres*, respectively.

Prob. LIII. *The Right ASCENSION and DECLINATION of a Star being given, to find its Place on the Globe.**

Turn the Globe till the Meridian cuts the Equinoctial in the given Degree of right Ascension: Thus, for Example: suppose you find in the Table the right Ascension of *Aldebaran* to be $65^{\circ} 30'$, and its Declination to be 16° North; then turn the Globe about till the Meridian cuts the Equinoctial in $65^{\circ} 30'$, and under the 16° of the Meridian, on the Northern Part, you will observe the Star *Aldebaran*, or the *Bull's Eye*.

* See the Table of right *Ascension* and *Declination* of the Stars at the End of this Chapter.

Prob.

Prob. LIV. *To find the Time of the rising, southing, setting, Amplitude, &c. of any STAR in a given LATITUDE and DAY of the YEAR.*

The Precept is the same as in the Problems for the Sun. Thus, let it be required to know at what Time the *Pleiades* (or *Seven-stars*) rise, set, &c. in the Latitude of *London*, on the 11th of *May*. The Globe being rectified for the Latitude of *London*, and the Sun's Place for the given Day, turn the Globe about till you bring the *Pleiades* into the Eastern Semi-circle of the Horizon, and the Index will Point to IV. 15', the Time of their *rising* in the Morning. — Then bring the said Cluster of Stars to the Meridian, and the Index will point to about $\frac{1}{2}$ after XII for the Time of their *culminating*, or being upon the Meridian. — Lastly, bring them into the Western Horizon, and the Index will point to VIII. 30', which shews the Time of their *setting* in the Evening of that Day. — It will also appear, on the Circle of the Horizon, that they rise with about 40° of *Amplitude* to the *North*, and set with the same Amplitude from the West.

Prob. LV. *To find when a STAR RISES and SETS COSMICALLY, in a given LATITUDE.*

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Rectify the Globe to the Latitude of the Place, and bring the given Star to the Eastern Part of the Horizon, then observe what Point of the Ecliptic rises with it, and find the same Degree of the Ecliptic upon the Frame of the Horizon, against which is the Day of the Month when the given Star rises *Cosmically*. ——— Afterwards, bring the given Star to the Western Edge of the Horizon, and observe what Degree of the Ecliptic rises in the Eastern Part, then the Day of the Month in the Calendar, which answers to that Degree, is the Time when the Star sets *Cosmically*.

For Example; *Mencar*, in the *Whale's Mouth*, rises with the 10° of *Gemini*, in the Latitude of *London*, and therefore rises *Cosmically* on the first Day of *June*. Again, by bringing the Star *Mencar* to the Western Part of the Horizon, I find the 2° of *Sagittarius* rising in the East, answering to which is the 24th Day of *November*, the Time on which that Star sets *Cosmically*.

Prob. LVI. *To find the TIME when any STAR will RISE or SET ACRONICALLY, in a given Latitude.*

The Example will here be sufficient: Therefore, let *Sirius* or the *Dog-Star*, be brought to the Eastern Edge of the Horizon, and then observe what Degree of the Ecliptic is in the Western Part of the Horizon, which

which you will find to be the 18° of *Aquarius*, against which the 7th Day of *Februcry* in the Calendar, the Time when the *Dog-Star* rises *Acronically*, or at *Sun-set*, and, consequently, when it begins to be *visible in the Evening*.

Then, for the *Acronical setting* of the *Dog-star*, turn the Globe about till he is setting in the Western Horizon, and see what Degree of the Ecliptic is, at the same Time, setting with him, which you will find is the 23° of *Taurus*; and therefore, about the 13th of *May*, this Star *sets Acronically*, or with the Sun, and consequently is no longer to be seen in the Evening.

Hence it is plain, those Months of the Year which intervene between the Acronical rising and setting of the Star, is the Space of Time in which that Star may be seen above the Horizon, of the given Latitude, in an Evening.

Prob. LVII. *To find when any STAR CULMINATES, or comes upon the Meridian with the SUN.*

Bring the given Star to the Meridian, and observe what Degree of the Ecliptic comes upon the Meridian with it, and against that Degree is the Day of the Month, in the Calendar, required.

For Example: Let the given Star be *Cor Hydra*, which bring to the Meridian, and you

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you will observe the 16° of *Leo* intersected by the Meridian at the same Time; against which, in the Calendar, is the 9th Day of *August*, which is the Day required, when that Star Culminates with the Sun.

Prob. LVIII. *To find what Time of the Year a Star is upon the Meridian at Midnight.*

Bring the given Star to coincide with the *nocturnal Part* of the Meridian, and then observe what Point of the Ecliptic is intersected by the *diurnal Part* of the Meridian, and the Day when the Sun possesses that Part of the Ecliptic, which you will see, by the Calendar, is the Time required. Thus, for Example; the Star called *Deneb* in the Tip of the *Great Bear's Tail*, being brought to the *nocturnal Meridian*, the Degree of the Ecliptic lying under the South Semi-circle of the Meridian, is the 26° of *Aries*, against which is the 16th Day of *April*, the Day of the Month on which that Star will be on the Meridian at XII at Night.

Prob. LIX. *To find the OBLIQUE ASCENSION of a given Star, and thereby the Time of its being above the Horizon in a given Latitude.*

This Problem is performed in the Manner already prescribed for the Sun, Moon, and
and

and Planets. Thus, for *Aldebaran*, rectify the Globe to the given Latitude, and you find its right Ascension, by Prob. LIII, to be $65^{\circ} 30'$; by bringing the Star to the Eastern Horizon, his oblique Ascension will appear to be $41^{\circ} 30'$: the ascensional Difference therefore is 24° ; which converted into Time, is $1^{\text{h}} 36'$, which, added to 6^{h} , makes 7^{h} and $36'$, the half Time which that Star is above the Horizon in the given Latitude; and therefore the whole Time is $15^{\text{h}} 12'$.

Prob. LX. *In a given Latitude, Day of the Year, and Hour of the Night, to find the ALTITUDE and AZIMUTH of a given STAR.*

Rectify the Globe to a given Latitude, and Day of the Year, then set the Hour Index to the given Hour, and move the Quadrant of Altitude to the given Star, its *Azimuth* will then appear in the Horizon, and its *Altitude* on the Edge of the Quadrant.

For Example: In the Latitude of *London*, the 11th of *May*, at XI o'Clock at Night, I find the Altitude of *Cor Leonis*, or *Lion's Heart*, to be $26^{\circ} 50'$, and its *Azimuth* $76^{\circ} 30'$ from the South towards the West, or nearly *West by South*.

Prob. LXI. *From the observed Altitude of a Star, to find the Hour of the Night*
in

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in a given Day of the Year, and in a known
Latitude.

Rectify the Globe for the given Latitude and Day of the Year, then turn the Globe about in such a Manner that the Star may be upon the Edge of the Quadrant in the given Degree of Altitude, then will the Index point to the *Hour of the Night*. This is but the Converse of the former Problem, and therefore needs no Example.

Prob. LXI. *From the observed HOUR and MINUTE of a STAR'S RISING, or SETTING on a given Day, to find the LATITUDE of the Place.*

Rectify the Globe to the given Day, and turn it about till the Index points to the given Hour and Minute, where keeping it steady, let the Meridian be moved up and down in the Notches of the Horizon till the given Star touches the same, then will the Degrees of the Meridian, intersected by the North Part of the Horizon, shew the *Elevation of the Pole*, and consequently the *Latitude* of the Place.

For Example: Suppose, on the 11th of *May* at IV in the Morning, I observe the bright Star in *Caput Medusæ* rising; then by rectifying, and moving the Globe as above directed, the *Latitude* of the Place will be found to be $24^{\circ} 30'$ North.

Prob.

Prob. LXIII. *From an Observation of two known Stars being upon the same Azimuth in a given Latitude, to find the HOUR of the Night.*

Rectify the Globe for the Latitude, and the Sun's Place on the given Day, then turn the Globe about in such a Manner, and also the Quadrant till its Edge lies over both the given Stars precisely, then will the Index point to the *Hour of the Night.*

Thus, for Example: on the 11th of *May*, in the Latitude $51^{\circ} 30'$, the two Stars called *Lucida Lyræ*, and *Alcair*, will both be on the same Azimuth at $\frac{1}{4}$ past II in the Morning.

Prob. LXIV. *From an Observation of two known STARS, having the same ALTITUDE, to find the HOUR of the NIGHT.*

Rectify the Globe to the given Latitude and Day of the Month, then move the Globe about so that the same Degree of the Quadrant may cut both the given Stars; then will the Index point to the *Hour of the Night.*

For Example: On the 11th of *May*, in Latitude $51^{\circ} 30'$, the bright Star in *Pegasus's* Wing, and that in the Head of *Andromeda*, will both of them have an equal Altitude at Half an Hour after II in the Morning.

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N. B. This and the foregoing Problem are useful when the Quantity of the Azimuth, or the Altitude of the two Stars is not known: for, by a *Plumb-line only*, it may be known when any two Stars have the *same Azimuth*; and any Staff, &c. moved parallel to the Horizon, will give the *equal Altitude* of two known Stars with Ease.

Prob. LXV. *From an Observation of a known Star in the Meridian, and another in the East, or West Part of the Horizon, to find the LATITUDE of the PLACE.*

Bring the Star that was observed in the Meridian of the Place to the Meridian of the Globe, and keep the Globe from moving round its Axis; then slide the Globe up and down in the Notches, till the other Star is brought to the East, or West Part of the Horizon, and that *Elevation of the Pole* will shew the *Latitude of the Place*.

Thus, for Example: When *Sirius* is upon the Meridian, *Arcturus* will be upon the Eastern Part of the Horizon in the Latitude of $44^{\circ} 40'$.

Prob. LXVI. *From the observed Altitude of two Stars on a given Azimuth, to find the LATITUDE of the PLACE.*

Set the Quadrant over both Stars of the observed Degrees of Altitude, and there
keep

keep it from moving, then slide the Meridian up or down in the Notches 'till the Quadrant cuts the given Azimuth in the Horizon; then the Elevation of the Pole will be the Latitude required.

For Example: *Cor Hydræ*, and *Procyon* or the little *Dog Star*, are both on the Azimuth of $78^{\circ} 45'$ South East, one with 5° of Altitude and the other with 35° , in the Latitude of $26^{\circ} 30'$.

Prob. LXVII. To find the CIRCLE, or Parallel of perpetual APARITION, or OCCULATION of a fixed STAR in a given LATITUDE.

By rectifying of the Globe to the Latitude of the Place, and turning it round on its Axis, it will be immediately evident, that the *Circle of perpetual Apparition* is that Parallel of Declination which is equal to the Complement of the given Latitude Northward; and for the *perpetual Occulation*, it is the same parallel Southward; that is to say, in other Words, all those Stars whose Declinations exceed the Co-Latitude will always be visible, or above the Horizon; and all those in the opposite Hemisphere, whose Declination exceeds the Co-Latitude, never rise above the Horizon.

For Instance: In the Latitude of *London* $51^{\circ} 30'$, whose Co-Latitude is $38^{\circ} 30'$, gives the Parallels desired; for all those

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Stars which are within this Circle, toward the North Pole, never descend below our Horizon; and all those Stars which are within the same Circle, about the South Pole, can never be seen in the Latitude of *London*, as they never ascend above its Horizon.

Prob. LXVIII. *To represent the FACE of the HEAVENS on the GLOBE for a given HOUR on any DAY of the YEAR.*

Rectify the Globe to the given Latitude of the Place and Day of the Month, setting it due North and South by the *Needle*; then turn the Globe on its Axis till the Index points to the *given Hour* of the NIGHT: Then all the upper Hemisphere of the Globe will represent the *visible Face* of the *Heavens* for that Time; by which it will be easily seen what CONSTELLATIONS and STARS of Note are then above our Horizon, and what Position they have with respect to the Points of the Compass. In this Case, supposing the Eye was placed in the *Center* of the GLOBE, and *Holes* were pierced through the *Centers* of the STARS on its Surface, the Eye would perceive through the Holes the various *corresponding* STARS in the FIRMAMENT; and hence it would be easy to know the several Constellations at Sight, and to be able to *call all the Stars by their Names*.

The

The Use of this Problem is most extensive, as it acquaints us at any Time with the apparent Face or State of the Heavens, and shews us when the MOON, or any of the PLANETS, may be seen, or fit for Observation by the Telescope. We can also from hence learn, when any of those curious and wonderful Objects, called *Nebulous STARS*, may be seen, and which strike the Mind of the Observer with Amazement, by presenting to his View an indefinite Number of the smallest fixed Stars *through the whole Field of View* in his Telescope. — From hence also, the Position of that very extraordinary Phænomenon called the *Galaxia*, or *Milky-way*, is at any Time known; and from hence those silly and superstitious Notions of its having Relation to the Wind, with other *astrological Fooleries*, will intirely vanish. — This single Problem, therefore, may be considered in its self as sufficient to recommend the Use of the *Celestial GLOBE*, to every studious and rational Mind, as the most necessary Instrument of his Celestial Tuition, or KNOWLEDGE of the HEAVENS.

By the following TABLE, the PLACES of the most considerable *Fixed STARS* are found upon the *Celestial GLOBE* in the same Manner as Places on the Surface of the *Terrestrial GLOBE* are found by a TABLE of their LATITUDE and LONGITUDE.

A TABLE

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A TABLE of the Right ASCENSION and DECLINATION of the principal FIXED STARS.

The NAMES of the STARS, their Mark in Bayer, and their Magnitude.	Rt: Ascension.			Declination.		
	D.	M.	S.	D.	M.	S.
<i>Algenib</i> in Pegasus. ----- γ 2.	0	11	17	13	49	56 N.
The Breast of Cassiopeia. --- α 3.	6	42	51	55	11	58 N.
The Tail of the Whale. ----- β 2.	7	50	45	19	19	23 S.
The <i>Polar Star</i> . ----- α 2.	10	57	57	88	0	18 N.
The Girdle of Cassiopeia. --- γ 3.	10	33	20	59	23	37 N.
The Girdle of Andromeda. ---- β 2.	14	0	49	34	19	31 N.
In the Ear of Aries ----- γ 4.	25	1	25	18	5	40 N.
The preceding Horn of Aries. ---- β 3.	25	16	49	19	36	41 N.
The Foot of Andromeda. ----- γ 2.	27	16	15	41	9	5 N.
The bright Star of Aries. ----- α 2.	28	20	55	22	18	13 N.
The Whale's Mouth, <i>Mencar</i> . ---- α 2.	42	24	1	3	7	16 N.
<i>Medusa's Head</i> . ----- β 2.	43	6	47	40	0	0 N.
The bright Star of Perseus ----- α 2.	46	46	42	48	58	22 N.
The Bull's Eye, <i>Aldebaran</i> . ---- α 1.	65	30	3	16	0	1 N.
The Goat Star, <i>Capella</i> . ----- α 1.	74	41	38	45	43	14 N.
The Foot of Orion. ----- β 1.	75	43	15	8	30	3 S.
The northern Horn of Aries ---- β 2.	77	44	4	28	22	36 N.
The western Shoulder of Orion. ---- γ 2.	78	1	40	6	6	25 N.
The first of Orion's Girdle. ---- δ 2.	79	53	16	0	29	59 S.
The second. ----- ϵ 2.	80	58	30	1	22	39 S.
The third. ----- ζ 2.	82	7	52	2	5	30 S.
Auriga's Shoulder. --- β 2.	85	25	40	44	53	28 N.
Orion's eastern Shoulder ----- α 1.	85	30	26	7	20	21 N.
Bright Star in the Foot of Gemini. γ 2.	95	55	0	16	35	2 N.
The great Dog-Star, <i>Sirius</i> . ----- α 1.	98	36	42	16	23	57 S.
The northern Head of Gemini. ---- α 2.	109	45	49	32	23	48 N.
The little Dog-Star, <i>Procyon</i> . ---- α 2.	111	38	36	5	49	51 N.
The southern Head of Gemini. ---- β 2.	112	36	19	28	35	29 N.
<i>Hydra's Heart</i> . ----- α 2.	138	54	50	7	36	58 S.
The Lion's Heart, <i>Regulus</i> . ----- α 1.	148	51	6	13	8	44 N.
In the great Bear. ----- β 2.	161	45	0	57	40	38 N.
In the great Bear. ----- α 2.	162	7	33	63	3	21 N.
The Tail of the Lion. ----- β 2.	174	9	45	15	55	47 N.
In the Thigh of the Bear. ----- γ 2.	175	13	57	55	2	41 N.
In the great Bear. ----- δ 3.	180	49	27	58	22	59 N.
The first Star in the Tail of the Bear. ϵ 3.	190	48	48	57	16	57 N.
The Virgin's Wing. ----- ϵ 3.	192	31	7	12	16	17 N.
The Virgin's Spike. ----- α 1.	198	6	22	9	53	4 S.
The 2d Star in the Tail of the great Bear. ζ 2.	198	31	11	56	11	59 N.
The 3d Star in the great Bear's Tail. η 2.	204	29	11	50	31	58 N.

Arcturus.

The NAMES of the STARS, their Mark in Bayer, and their Magnitude.	Rt. Ascension.			Declination.		
	D.	M.	S.	D.	M.	S.
<i>Arcturus</i> , -----	<i>a</i> 1.	211	8	57	20	27 39 N.
The South Scale of <i>Libra</i> . -----	<i>a</i> 2.	219	22	8	15	0 58 S.
The first Shoulder of the Bear. -----	<i>β</i> 2.	222	55	5	75	8 53 N.
The north Scale of <i>Libra</i> . -----	<i>β</i> 2.	225	59	37	8	28 88.
The bright Star in the Crown. -----	<i>a</i> 2.	231	5	15	27	32 50 N.
The bright Star in the Serpent's Neck.	<i>a</i> 2.	233	4	56	7	12 25 N.
The northern Star in Scorpio's Forehead.	<i>β</i> 2.	237	49	39	19	7 10 S.
The Heart of Scorpio. -----	<i>a</i> 1.	243	38	17	25	52 11 S.
The Knee of Serpentarius. -----	ζ	3.	245	57	5	10 3 13 S.
The Head of Hercules. -----	<i>a</i> 3.	255	53	37	14	41 10 N.
The Head of Serpentarius. -----	<i>a</i> 2.	260	54	57	12	45 25 N.
The bright Star in the Dragon's Head.	<i>β</i> 3.	261	14	29	52	29 23 N.
The Serpent's Shoulder. -----	<i>β</i> 3.	262	52	7	4	41 23 N.
The bright Star in the Dragon's Head.	γ	3.	267	45	55	51 31 32 N.
The southern Bow of Sagittarius. -----	ε	3.	272	0	40	34 28 13 S.
Bright Star of <i>Libra</i> . -----	<i>a</i> 1.	277	10	43	38	34 17 N.
The Shoulder of Sagittarius. -----	σ	3.	280	2	46	26 34 27 S.
The bright Star of <i>Aquila</i> . -----	<i>a</i> 2.	294	43	52	8	14 43 N.
The Horn of Capricorn. -----	<i>β</i> 2.	301	49	59	15	31 49 S.
Tail of the Swan. -----	<i>a</i> 2.	308	17	13	44	35 20 N.
The preceding Shoulder of Aquarius.	<i>β</i> 3.	319	41	27	6	37 35 S.
Pegasus's Mouth. -----	ε	3.	323	3	31	8 46 22 N.
Star in the Tail of Capricorn. -----	δ	3.	323	23	58	17 12 56 S.
<i>Scheat</i> in Aquarius. -----	δ	3.	340	25	53	17 6 28 S.
<i>Fomalhaut</i> . -----	<i>a</i> 1.	341	2	32	30	54 12 S.
<i>Scheat</i> in Pegasus. -----	<i>β</i> 2.	343	0	18	26	46 7 N.
<i>Markab</i> , ditto. -----	<i>a</i> 1.	343	10	11	13	34 10 N.
Andromeda's Head. -----	<i>a</i> 2.	358	58	5	27	44 52 N.
Bright Star in Cassiope's Chair. -----	<i>β</i> 2.	359	5	0	57	48 27 N.

N. B. The *Greek Letters* *a*, *β*, *γ*, &c. are fixed to different Stars in each Constellation, for the sake of a more Particular and easy Nomination of them; thus they concisely say, *γ Draconis* for one of the bright Stars in the Head of the Dragon—Also the Digits 1, 2, 3, &c. after the Letters, denote the STARS of the First, Second, Third, &c. MAGNITUDES—In the last Column, the Letters N and S denote the DECLINATION to be North or South.—Lastly, the Method for correcting the *right Ascension* and *Declination* of the Stars is shewn in the APPENDIX to this Treatise.



C H A P. IX.

The Method of constructing the Celestial GLOBE with a moveable ECLIPTIC and EQUINOCTIAL, to render its USE Universal for all AGES of the WORLD.

IT has been shewn in a great Variety of the most useful Problems, how necessary and valuable an Instrument the *Celestial GLOBE* is; but it must, at the same Time, be considered, that as all the Stars have a slow progressive *Motion from West to East*, at the Rate of *one Degree* of right Ascension in 72 Years, the Use of a Celestial Globe, as it is commonly made, cannot be so extensive, as, in some Cases might be desired: For, since the Stars are continually moving out of their Places, we cannot represent the Face of the Heavens as they were *many Ages past*, or as they will appear to those who shall live in *future Ages*; and since the Celestial Globe is capable of a Construction that shall entirely

entirely prevent this Deficiency of its Use, by rendering it fit to represent the true State of the Appearance of the Heavens *for any AGE of the WORLD indifferently*, I thought proper here to recommend it to the Ingenious and Inquisitive in the STUDY of ASTRONOMY, by shewing wherein this *new Construction* or *Apparatus* of this Celestial Globe does consist, and then to illustrate its use by proper Examples.

The late Mr. *Senex*, amongst many other Improvements of the Globe, contrived by Means of two Bras Arms screwed at one of their Ends, upon the Poles of the Ecliptic, and in the other (at the Distance of $23^{\circ} 30'$) there were fixed Pieces of Iron-wire to represent the two Ends of the Earth's Axis, or Poles of the World; these were placed as usual in proper Grooves in the Brazen Meridian, and the Globe moveable upon, or about them, as in those of the common Construction:—From hence, it is easy to understand, that, by loosening the Screws in the Pole of the Ecliptic, any Degree of angular Motion about them might very easily be given to the Poles of the World, and consequently that the said Poles of the World might have any Position required with respect to the Poles of the Ecliptic, and thereby the *Colures* might be conceived as *moving through all the Points of the Ecliptic* in the Space of 25920 Years, in
P which

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which Period of Time all the different Phases of the Heavens will return again, and succeed in the same Order perpetually; and that, in any particular Part of this Period, the Appearance of the Stars and the Seasons of the Year will be *very different in the Heavens and in the Calendar*, from what they will be at any other considerable Distance of Time.

But, to represent this Difference in the most natural and easy Manner, I have found the following additional Parts of an Apparatus to be necessary, and therefore have added them: (1) A *moveable* equinoctial and solstitial COLURE. (2) A *moveable equinoctial Circle*. (3) A *moveable* ECLIPTIC. — These are all so connected together, that they represent the Situation of those imaginary Circles in the Heavens for any Age of the World, and the Situations, or Places of the Stars and Constellations respectively thereto, hereby rendering the *Celestial GLOBE* of *universal and perpetual* Use, as we shall now proceed to illustrate in the Solution of the following *uncommon* PROBLEMS, which we make no doubt will afford equal Pleasure and Amusement to the young ASTRONOMER.

Prob. LXIX. *To rectify the Globe for any past AGE of the World proposed.*

We are here to observe, that the LATITUDE of the PLACE is not affected by this Motion

Motion of the Poles of the World about the Ecliptic, but continues the same in every Age: Therefore, to rectify the Globe for any given Age, you have no more to do than only to *loosen the Screws of the Poles of the Ecliptic*, and thereby give the Poles of the World so much Motion as is necessary for that Distance of Time, at the Rate of *one Degree in 72 Years*; which being done, let the *Brass Arms be again screwed fast on the ecliptic Poles*; then will all the Stars, with regard to the *Colures, Ecliptic, and equinoctial Lines*, have the same Position and Appearance as they had in the given Age.

For Example: It is said, that *Hipparchus*, the first considerable Astronomer, lived about 2000 Years ago; therefore, the Globe being *rectified for that Age*, the Poles of the World must be moved forward about the Poles of the Ecliptic $27^{\circ} 30'$, and there fixed: — In Consequence of this, the *vernal equinoctial Point*, or Beginning of the Sign ν *Aries* will be carried forward in the Ecliptic $27^{\circ} 30'$, by which Means the *equinoctial Colure* will pass very near to the bright Star in the Head of *Aries*, and there, *Hipparchus* tells us, it really was in his Time. — At this Time, therefore, it plainly appears by the Globe, that all the Constellations of the *Zodiac* were seen in the *same Signs of the Ecliptic, which bear their Names*; very diffe-

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rent from the Position and Appearance of those Constellations in the *present AGE*.

Prob. LXX. *To shew the Quantity of the RECESSION, or retrograde Motion of the equinoctial Points, from AGE to AGE.*

Rectify the Globe for any distant given Age, then will the Degrees in the Ecliptic, contained between the *present equinoctial Points* and those of the *given Age*, be the Quantity of the *Recession* required.

Thus, for Example: Since the Age of *Hipparchus* there are $27^{\circ} 30'$, by which the equinoctial Points have gone backward thro' the Ecliptic, or so much are they at present distant from the Position they had in his Time.

Prob. LXXI. *To Rectify the GLOBE for any proposed FUTURE AGE.*

This is done by loosening the Screws in the Poles of the Ecliptic, and thereby giving the Poles of the World so much of their retrograde angular Motion as is required for the Age proposed, at the Rate of one Degree in 72.

Thus, for Example; Let it be required to rectify the Globe for the People who shall live 6500 Years hence, which being one fourth Part of the whole Period, it is plain the Poles of the World must have retrograded through one fourth of a Circle, or 90° :
Then

Then will the People of *that Age* observe the following Differences in the State of the Heavens from the *Present*, (1.) That the *equinoctial Points* will then be in the Beginning of *Capricorn*. (2.) The *vernal equinoctial Day* will then happen upon the 22d of *December*, which is now our *Midwinter Day*. (3.) That the Stars will all appear to have advanced forward, or *changed their Longitude* three whole Signs, or 90° in that Time. (4.) The *Constellations* of the *Zodiac* will be *removed four Signs* from the Beginning of the *Ecliptic*, *i. e.* *Aries* will be in *Leo*, and so on. (5.) As the moveable *Equinoctial Line* will then contain an Angle with the present, so the *Declination of the Stars* will be much altered thereby. (6.) For those that had none before, may now have a *Declination* of any Quantity less than 24° . (7.) Many Stars will have *changed their Declination* in that Time; Thus, in the present Age, *Cor Leonis* has 14° *Declination North*, in that Age its *South Declination* will be greater. (8.) The Stars and *Constellations* which are now *always visible* to us, will, many of them, *then rise and set*: Thus the *Greater Bear*, which at present goes not very near the *Horizon*, will, in that distant Age, be got almost wholly below it. (9.) Many Stars and *Constellations* which *now rise and set*, will then be *constantly visible*, as *Delphinus*, *Vulpecula*, *Andromeda*, &c. (10.) Stars which are at *present invisible*, will then
become

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become visible to us. (11.) The present *Pole Star* will then circulate round the *North Pole of the World.* (12.) A Point in the Heavens between the Right-hand and Head of *Cepheus* will then be the *North-Pole* of the World. (13.) Many Stars *visible* in our Age, will be wholly *invisible* to them. (14.) In that Age, very different Stars will rise, culminate, and set with the Sun, to what do now. (15.) The *Right Ascension, Altitudes,* and *Azimuths* will all undergo proportionable Changes, from what they have in the present Age.

These, and many other *Pheænomena*, may be looked upon as so many particular Problems to be wrought on this *new constructed Celestial GLOBE* alone; But when the Globe is rectified for any particular Age, the Problems are the same as those we have already specified in the Use of the common Globe for the present Age; and therefore, as the Reader can find no Difficulty in repeating them in that Case, we have, for Brevity-Sake, only just mentioned them here.

Prob. LXXII. *To find the Distance of the AGE in which any Person lived, from Celestial OBSERVATIONS recorded by him.*

Having loosened the Screws on the Poles of the Ecliptic, let such a Motion be given to the Poles of the World, and to the several moveable Circles, as will render the Globe
fit

fit for exhibiting and verifying the *given Observation upon Record*; and there screw them fast: Then find the Arch of the Ecliptic between its *Intersections* by the *Equinoctial* at that Time and the present, this, converted into Time, allowing one Degree to 72 Years, will give the Distance of Time required.

For Example: HESIOD the Poet, * tell us, that, in his Time, 60 Days after the Sun had past the *Winter Solstice*, and was, of Course, in the Beginning of *Pisces*, the Star *Arcturus* rose in the East at the Time of *Sunset*. Now, in order to qualify the Globe to exhibit the same *Phænomenon* when the Sun is in that Part of the Ecliptic, we must first rectify the Globe for the Latitude of *Ascra* in *Greece*, where *Hesiod* lived, which was in 38° N. Latitude; and having done this, the Poles of the World must be moved one Way and the other, about the Poles of the Ecliptic, 'till such Time as the Sun's Place (in the Beginning of *Pisces*) and the Star *Arcturus* shall be both at the same Time in opposite Parts of the Horizon, in which Case let the Brass Arm be fastened, and then you will observe the Equinoctial Points to have been moved forward in the Ecliptic to the 6th Degree of *Taurus*, or 36° . This, therefore, is the Space thro' which they have receded since *Hesiod's* Time, which therefore must have been at the Distance of 36 times 72, or 2592 Years

* See his Poem called WORKS and DAYS, Verse 562.

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Years from the present Time ; which proves him Contemporary with *Jebu* King of *Israel*, and *Jonab* the Prophet, according to our best Chronologers.

Again, *Hesiod* further tells * us, that at the same Time that *Arcturus* was rising, the *Dog Star*, and the Constellation *Orion*, possessed the *Middle Region* of the Heavens, and thus you will observe they appear on the Globe rectified for his Age : but in the present Age, no such *Phænomena* of those Stars appear with the setting Sun in that Part of the Ecliptic. The same Problem may be performed for other Observations, recorded by the Poets and Philosophers of ancient Times, as *Ovid*, *Virgil*, *Ptolemy*, &c. and thus the celestial Globe will be found most eminently useful in the Science of *Chronology*.

It may be proper here to mention, that I have by me, the COPY of a *very antique* GLOBE, which was found in the Ruins of ancient *Rome*, and is now in the *Musæum* of the *Farnesian* Palace, reserved as the most curious MONUMENT of ANTIQUITY : It is about 12 Inches in Diameter, and has upon it the various *Constellations* as they were depicted by the ancients, and, amongst them, those of the *Zodiac*, possessing severally the *Signs bearing their own NAMES* ; together with the EQUINOCTIAL LINE, ECLIPTIC, and COLURES : The *Equinoctial Colure* passing

* Ibid. Verse 607.

ling through the right Horn and Foot of *Aries*, not far from the Equinoctial Point, *viz.* about 5° , which shews that this Globe might probably be made 360 Years after the Colure was in the Equinoctial Point. But since this Situation of the Colure on this *antique Globe*, the Equinoctial Point has receded 25° more, which, in Time, gives 1800 Years: Which plainly shews it to have been made some Years before the BIRTH of CHRIST. Therefore, this Globe seems a Proof that the Equinoctial Colure passed through the bright Star of *Aries* near 2200 Years ago, agreeable to what we observed before, with regard to the Time and Observations of *Hipparchus*.

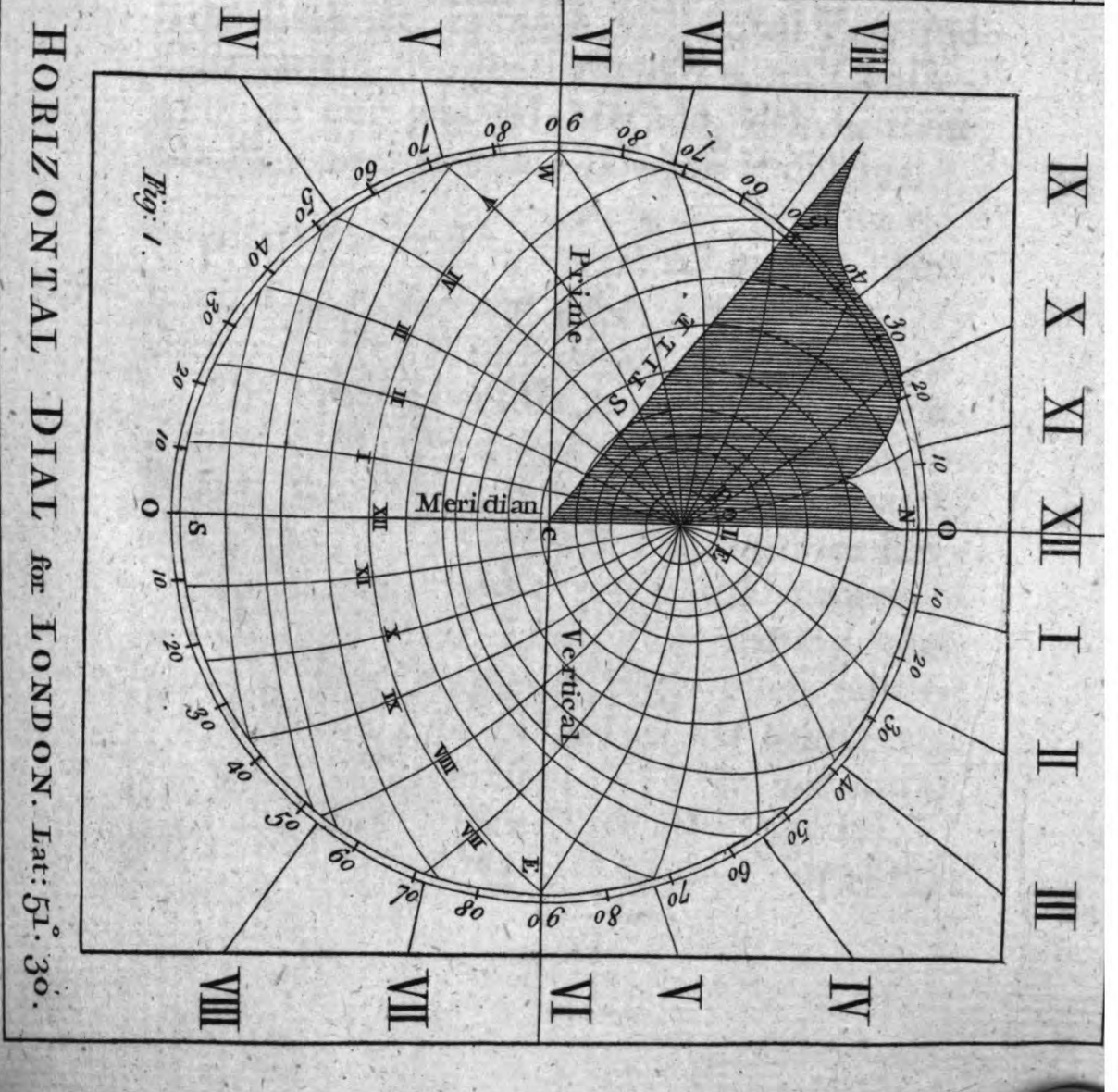
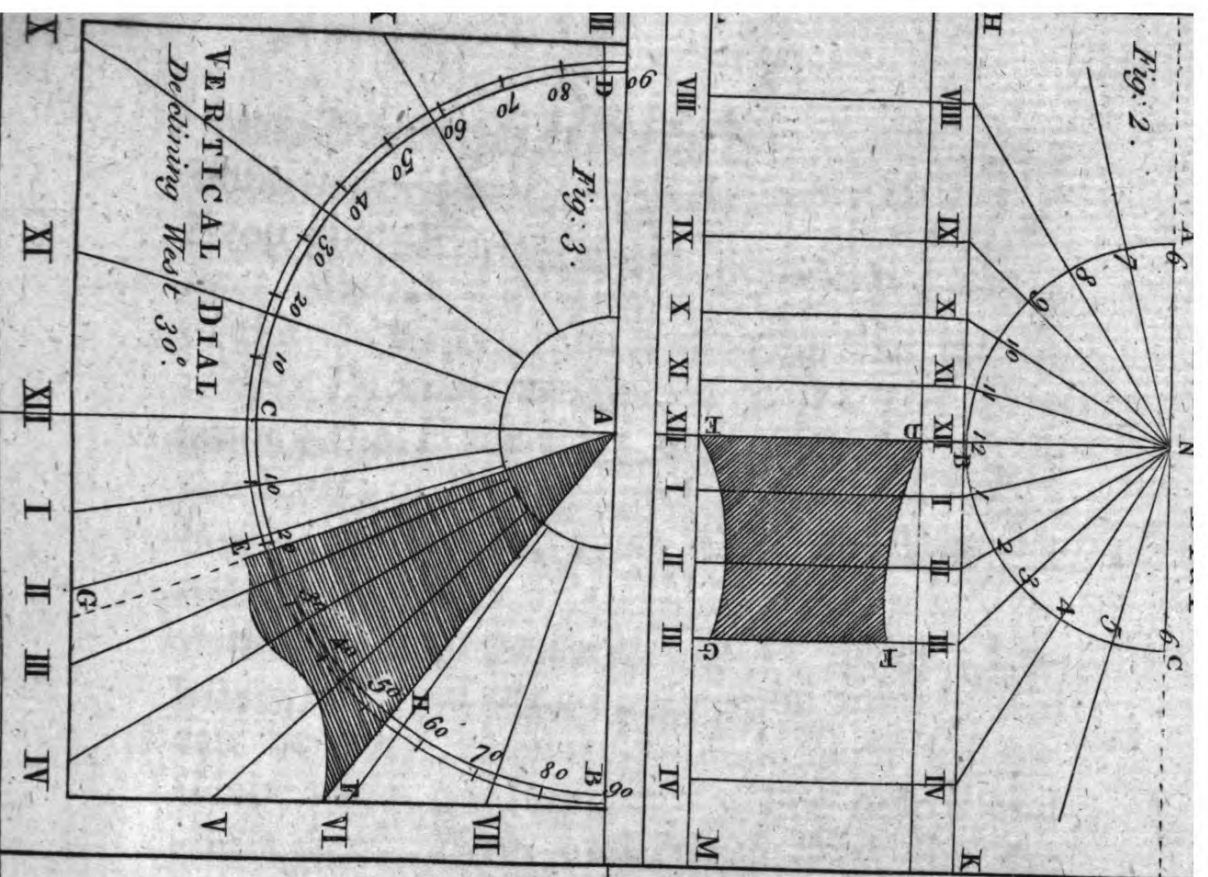


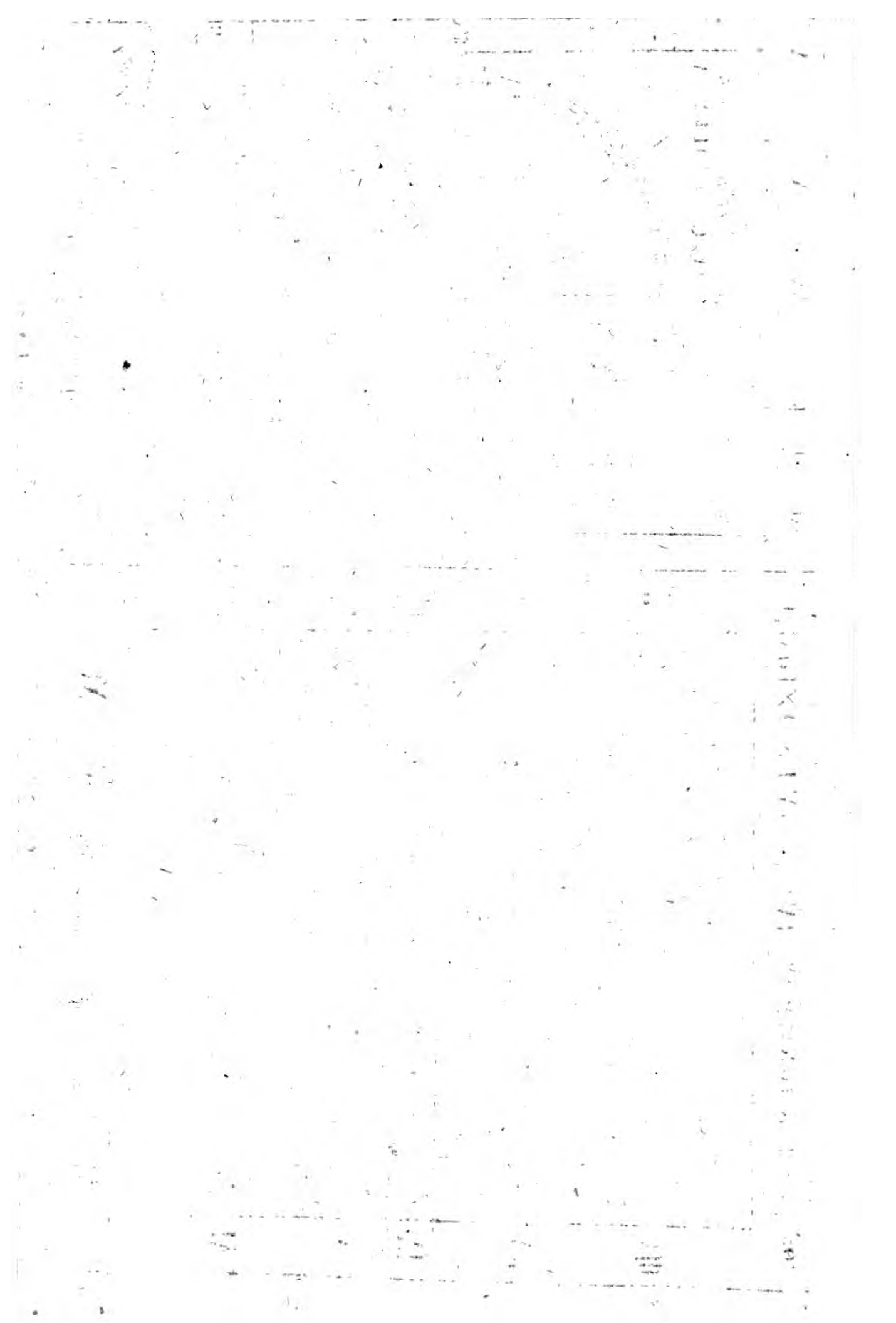


CHAP. X.

The Use of the Celestial GLOBE in
DIALLING.

THE principal Use of the Celestial
 T GLOBE in DIALLING is rather to
 give the *Rationale*, or general Reason
 of the Process in the Construction
 of different Kinds of Dials, than to give
 an accurate and practical Method of delineat-
 ing Dials universally. A Person totally un-
 acquainted with the Nature and Use of the
 Globe is wholly *mechanical* in these Opera-
 tions; he works by *Rules*, and is sure to
 succeed, which is all the Satisfaction he can
 have; but one who is skilled in the Use and
 PROJECTION of the GLOBE may be said to
construct DIALS in a *rational Manner*, having
 the LIGHT of REASON to direct and eluci-
 date all his mechanical Operations: For
 when his Globe is rectified, the whole Dial
 rises before him to his View.—The POLE
 is elevated to its proper Height:—The
 HOUR-CIRCLES all appear in their natural
 Position:





Position :—Their Intersections with the Horizon give the angular Position of the *Hour-lines*, with the Meridian :—The POSITION of the GNOMON, and SUBSTYLE in all *declining* DIALS, are shewn to be the same among the Hour-lines of the Plane, which the Rules of Practice prescribe :—To such a Person, therefore, every thing must appear natural and easy.

But since an *horizontal* DIAL for any Latitude is, of all others, the most useful, and can be very accurately made even by the Globe itself, without any other help; and also a *direct South*, and *North Dial*, for the same Latitude, is made with equal Ease and Correctness, we shall therefore, in Conformity to our general Method, deliver these Constructions in the following Problems.

Prob. LXXIII. *To construct an HORIZONTAL DIAL for any given LATITUDE, by Means of the GLOBE alone.*

The Process consists in the following Particulars : (1) On a Piece of clean Paper, or Board, which is designed for the PLANE of the DIAL, let a Circle be described (as large as can be admitted,) through the Center of which draw *two Lines*, intersecting each other at right Angles; one of these will be the *Meridian Line* of *North and South*, and the other will represent the *prime vertical* of *East and West*. (See Plate IV. Fig. 1.)

Q 2

(2) Let

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(2) Let this Circle be divided into 4 Times ninety Degrees, numbering them each Way into 10, 20, 30, 40, &c. from the North and South Parts of the *Meridian Line* towards the Points of East and West.

(3) Let the Globe be rectified and elevated to the Latitude of the given Place, as, suppose LONDON $51^{\circ} 30'$, then will the *Axis* of the Globe have the same Elevation above the Horizon as the *Gnomon*, or *Style* of the Dial, must have above the Plane thereof, viz. $51^{\circ} 30'$.

(4) Because the General Meridian of the Globe must necessarily represent the Hour-circle of XII, therefore the Meridian Diameter of that Circle must be continued out to the Border of the Dial, (the Form of which is supposed to be a Parallelogram) at the North Part of which you place the Hour XII.

(5) If your Globe has Meridians drawn on its Surface through every 15° of the *Equinoctial*, (as on *Senex's* Celestial Globes they are,) then will these *Meridians* represent the true *Hour-circles* of the Sphere, and will intersect the Horizon of the Globe in certain Points on each Side the Meridian, which you must very carefully observe, and note down upon a Piece of Paper, as in the following Table ;

Arches

Arches of the Horizon.

Hour		
12	— 00°	00'
1	— 11	51
2	— 24	19
3	— 38	3
4	— 53	36
5	— 71	6
6	— 90	0

(6) Then laying a Ruler from the Center of the Circle to each of those Points, or Divisions, you draw from the Circle strait Lines to the Border of the Dial in each North Quadrant of the Circle, and against them write the several Hours respectively, *viz.* XI, X, IX, VIII, VII, VI, on the North-West Quadrant, for the Morning Hours; and I, II, III, IV, V, VI, for the Hours of the Afternoon.

N. B. It is here supposed, that one of the Meridians on the Globe coincides precisely with the graduated Edge of the Meridian; then all the Hour-Circles, on each Side the Meridian, intersect the Horizon at equal Distances from it respectively.

(7) Again, because in *all Latitudes* the longest Day exceeds XII Hours, there must be more than XII drawn upon an *horizontal* DIAL. And, because in the Latitude of *London* the longest Day does a little exceed XVI Hours, therefore the Hour-lines on
such

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such horizontal Dials, must, at least, be *Sixteen*; therefore,

(8) Since the Hour-Circle of VII intersects the Horizon at an equal Distance from the *East Point*, as does the Hour-Circle of V, and the same may be said of the Hours V and VII in the *Morning*, on the *Western* Part of the Horizon, it is evident, a *Ruler* laid from the Hour of VII in the *Morning* thro' the Center of the Circle, will give the opposite Hour-line for VII in the *Evening* on the Eastern Side of the Dial: in the same Manner, the Ruler laid from the Hour of VIII in the Morning will give the Hour of VIII in the *Evening* upon the Dial. — On the contrary, the *Evening Hour-lines* of V and IV, continued thro' the Center, will be the Hour-lines of V and IV in the *Morning*: and thus all the Hour-lines belonging to such a Dial are drawn.

(9) But supposing that the Globe you use has not the Meridians drawn thro' every 15th Degree of the Equinoctial, you then proceed as follows: Rectify the Globe to the Latitude as before, and bring the *Solstitial Colure* to the *General-Meridian*, where, holding it steady, set the Hour-Index to the lower XII; then move the Globe till the Index points to the Hour I, and the Colure will intersect the Horizon in $11^{\circ} 51'$ from the Meridian: — Then move the Globe till the Index points to the Hour II, and the Colure will intersect the

the Horizon in $24^{\circ} 19'$ from the Meridian: And thus the Intersections for every Hour to VI will be found the same as in the foregoing Table, by which all the Hour-lines are drawn, as before directed.

(10) Whatever Globe you use, this Method of the *Colure* will be necessary for finding the Points of Intersection in the Horizon proper to the *Quarters of each Hour*; for if you move the Globe so that the Index may point to the several Quarters of each Hour, you will then observe the Degrees and Minutes in the *Intersection of the Colure with the Horizon*: These are to be marked in your Circle, and a *Ruler* laid from the Center thro' each of them will divide each Hour into its proper Quarters, between the Hours of the Dial, on the Border of the Frame respectively: and thus is the *Horizontal DIAL* completed, with respect to the HOUR-LINES.

(11) The next Thing to be done is, to give the GNOMON or STYLE its proper *Height above the Plane*, which is that of $51^{\circ} 30'$ for LONDON.

(12) This *Gnomon* must be placed truly in the *Meridian Line* of the Dial, with its elevated Part towards the *North*, and must be so fixed that it may rise precisely from the *Center of the Dial*, and then the whole is finished; and ready to be placed upon a *Pedestal*.

Prob.

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Prob. LXXIV. *To draw a direct SOUTH or NORTH DIAL, for any given Latitude, or Place, by the GLOBE only.*

Here you proceed by rectifying the Globe to the Latitude of the Place; and fixing the Quadrant of Altitude in the Zenith, you bring it to intersect the Horizon in the true East Point, to represent the *prime VERTICAL* of *East* and *West*, the *Plane* of which is evidently the *Plane of the Dial proposed*.

As this *Plane* intersects the *Plane* of the *Meridian* at *right Angles*, and stands *perpendicular* on the *Horizon*, it is very evident, from a bare View of the Globe thus rectified, that the *Axis* of the Globe contains an Angle with this *Plane*, which is just the *Complement* of that which it contains with the *Horizon*, and therefore is just equal to the *Co-Latitude* of the *Place*, which, for *London*, is $38^{\circ} 30'$

It is farther evident, since the *Plane* of the *Dial* passes through the *Center* of the *Globe*, that the *southern Part* of its *Axis* is elevated to *that Angle* on the *South Side* of this vertical *Plane*; and that on the *North Side*, the *Northern Semi-axis* is elevated to the same *Degree*.

Hence, in Case of a direct *South DIAL* for *LONDON*, the *Gnomon* must be placed in the *Meridian-Line* of the *Plane*, exactly in its *Center*, and point downward precisely to
the

the *South-Pole*, in an Angle of $38^{\circ} 30'$ with the Plane.

On the other Side of the Plane, which is the *North DIAL*, the Gnomon is elevated to the same Height, and points directly to the *North Pole*, being placed in the Meridian-Line, and exactly in the Center of the Plane.

Moreover it is evident, by a bare Inspection of the Globe, that the Sun cannot come upon the *South Side* of this *vertical Plane* before VI o'Clock in the Morning, because it meets with the Hour Circle of VI exactly in the Horizon, and then only on the *Equinoctial Days*: at all other Times of the Year it will come on the Eastern Side of the South Dial after VI, and the same may be said with Regard to its shining on this Plane after VI in the Evening. Therefore no more than XIII Hour-lines need be drawn on this Plane, *viz. six on each side of the Meridian.*

Again, with respect to the *North Side* of this *vertical Plane* it is evident, the Sun is upon it from the Time that it rises to the Time that it comes on this Vertical Plane on the *longest Day*, which is from $\frac{1}{4}$ before IV to about $\frac{1}{2}$ an Hour after VII in the *Morning*; and in the Evening from $\frac{1}{2}$ an Hour before V to about $\frac{1}{4}$ of an Hour after VIII: And consequently there will be no Need of drawing more than *ten Hour-lines* on a direct *North Dial* in our Latitude, *viz. five on the West*, and *five on the Eastern Side*; but

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none on the upper, or lower Part of the Dial.

Lastly, by considering the Globe attentively, it will appear, that the Meridians, or Hour Circles, fall in a similar Manner upon this prime *Vertical* and *horizontal* Plane, and that, therefore the Intersections made by them and the vertical Plane, are the same with those made between the said Meridian and horizontal Plane, when the Pole is elevated to no more than $38^{\circ} 30'$ in our Latitude. Consequently, by actually elevating the Pole to that Height, you will have the Points of Intersection given, through which the *Hour Lines* are to be drawn, as in the *horizontal Dial* before, and are such as are contained in the following Table :

Hours.	Arches	from the Center of the
12—	00° 00'	Circle to the Points marked
1—	9 28	off in the North-east, and
3—	31 53	North-west Quadrants, and
2—	19 45	Lines drawn quite thro',
4—	47 08	will give the Position of
5—	66 42	the Hour-lines on both
6—	90 00	Sides of the Plane at once,

those from VI to VI belonging to the *South-Dial*; and the Hours from IV to VIII belonging to the *North Side*, for a *North Dial*.

N. B.

N. B. The Quarters are here drawn by Means of the *Hour-Index* and *Colure*, as before directed, Page 114.

Prob. LXXV. *To draw the Hour Lines upon a direct South reclining Plane, by Means of the Globe.*

These Dials admit of three Varieties; for the *Reclination* from the *Zenith*, may be equal to, greater, or less than the *Distance of the Pole* from the *Zenith*.

Variety I. Suppose the Plane *reclines quite to the Pole*, or just $38^{\circ} 30'$ from the *Zenith*, in the *Latitude of London*; then it is evident the *Axis of the Earth* can have *no Elevation above the Plane*, but must lie in the Plane itself, and become the *Meridian-Line* thereof.

In order therefore to draw this Dial; on any Point N, as a Center, describe a *Semi-circle* ABC, which divide into two *Quadrants*, AB and BC, by drawing the Line NB, which must be continued out to an indefinite Length, to represent the Hour Line of XII upon the Dial Plane HKLM, whose Side HK touches the Semi-circle in the Point B; then divide each Quadrant AB and BC into *six equal Parts*, through which Points of Division lay a Ruler from the Center N, and draw straight Lines to the Plane of the Dial, and they will give the Points in the Side HK, through which, if Lines be

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drawn parallel to the Meridian Line N E, they will be the Hour Lines on the Dial Plate, as required, which must be numbered as you see in Fig. 2. of the *Plate of Dials*.

Then, on the Meridian Line of XII, you must fix a Stile, or Plate D F G E, whose Height D F must be just equal to the Distance between the Hour Lines of XII and III, which is just equal to the Radius N B; for it is evident, the Line B K is only a *Line of Tangents* to the *Radius* N B, and therefore the Distance of the Hour Lines III, or IX, must be equal to the *Tangent* of $45^{\circ} 00'$

On this Dial there cannot be placed conveniently more than *nine Hour Lines*, the Reason of which appears by Inspection; as that of VII in the Morning and V in the Afternoon would occasion the Dial to be of a very great Length. The Hours and Quarters may be put into this Dial by subdividing the Arches of the Quadrant into Halves and Quarters each.

N. B. This Dial is called the *Equinoctial* DIAL, as being peculiar to the People who live under the *Equinoctial* LINE, or have *no Latitude*.

The *Second Variety* is, when the *Reclination* is less than the *Distance of the Pole from the Zenith*; for Example: Suppose the *South Plane*

Plane reclines from the *Zenith* of London $18^{\circ} 30'$, then is the *South Pole* elevated above this Plane $20^{\circ} 00'$, and a Dial on such a Plane is evidently no other than a *South erect Dial* in the Latitude of $70^{\circ} 00'$, and therefore may be drawn as before directed for a *direct South DIAL*.

The *third Variety* is, when the *South Plane* reclines from the *Zenith* to a greater *Distance than the Pole*; as for Example: Suppose it reclines $71^{\circ} 30'$ from the *Zenith* of *London*, then will the said Plane be 20° below the *North Pole*, or the *Pole* will be elevated $20^{\circ} 0'$ above the Plane; therefore it will be evidently a *Horizontal Dial* in the Latitude of $20^{\circ} 0'$, and may be drawn as before directed in the Problems for *Horizontal DIALS*.

Prob. LXXVI. *To draw the HOUR LINES on a direct North reclining PLANE, by Means of the GLOBE.*

This Problem also admits of three Varieties:

For (1.) the Reclination may be *equal* to that of the *Equinoctial Circle*; or, (2.) it may recline *less*; and, (3.) it may recline *more* from the *Zenith* of the given Place.

In the first Variety it is evident, the Dial Plane coincides with the *Equinoctial Line*; consequently, to draw a Dial on this Plane is no more than to describe a Circle, and divide

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vide the same into 24 equal Parts; then a *Wire* being fixed *perpendicular to the Plane*, in its Center, will represent the *Axis* of the *Globe* or *World*, and become the true *Stile* of this DIAL,

N. B. This Dial, 'tis true, is a *Polar Dial*; but it is of Use in every Latitude if it be elevated to the *Equator*, or to an Angle equal to the *Co-Latitude*, and placed due North and South: According to the *Number of Hours* that the Sun can shine upon it, so many *Hour-lines* are to be drawn, the rest being useless.

In the *second Variety*, the *Reclination* of the Plane from the *Zenith*, being *less than that of the Equinoctial*, it is a *North erect Dial* in some Latitude, *viz.* that which is equal to its *Distance from the Equator*. — Thus, for Example: Suppose the *Reclination* from the *Zenith* of *London* were $21^{\circ} 30'$, then it is a *direct North Dial* in the Latitude of $30^{\circ} 0'$, which is the *Distance* between it and the *Equator*; and therefore the *Hour-lines* are drawn as before directed for such Dials.

In the *third Variety* the Plane *reclines to a greater Distance than the Equator from the Zenith*, in which Case it evidently becomes an *Horizontal Plane* in that Latitude which is the *Complement* of its *Distance from the Equator*. Thus, for Example: Suppose it
reclines

reclines from the Zenith of *London* $71^{\circ} 30'$, then will that be 20° farther than the Equator, and it becomes an *Horizontal Plane* in the Latitude of $70^{\circ} 0'$, for that is the Elevation of the North Pole above the Plane, as is evident by *rectifying the Globe to that Latitude*, as may be done in every other Case of these *reclining Dials*, because the *Horizon* may be always taken for the *Reclining Plane* with respect to the *Zenith* of any particular Place, as *LONDON* in our Examples: And this is mentioned once for all, to avoid frequent Repetitions.

Pro. LXXVII. *To draw the HOUR-LINES on any Erect declining Plane, by means of the GLOBE.*

First draw an Horizontal Line, as *D A B*, for the upper Part of the Dial Plane, and from the Center *A*, describe the Semi-circle *D C B*, which divide into two Quadrants *DC* and *CB* by a perpendicular *A C*; which will represent the Meridian of the Plane, or Hour-line of XII, and then let each Quadrant be divided into 90° , reckoned each Way from the Point *C*. (See Fig. 3. of *Dialling*.)

This being done, rectify the Globe to the Latitude of the Place, *viz. London*, and screw the Quadrant of Altitude to the Zenith, *viz. $51^{\circ} 30'$* ; then bring the *Solstitial Colure* to coincide nicely with the Meridian,
and

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and set the Hour Index to XII: Lastly, remove the Quadrant of Altitude to such a Degree from the *East or West Points* of the Horizon, towards the North, as is equal to the Plane's Declination. Thus, for Example: If the Plane declines 30° to the West, the Quadrant of Altitude must be fixed 30° from the *West Point towards the North*.

This Preparation being made, turn the Globe to the Westward till $15^{\circ} 00'$ of the *Equinoctial* pass under the Meridian, or the Hour-Index points to I in the Afternoon; then will the Colure intersect the Edge of the Quadrant in a Point which shews the Number of Degrees, as will give the Distance of the Hour-line of I to be set off in the Quadrant, from C towards B; then, by revolving the Globe till the Index points to II, the Intersection of the Colure with the Quadrant will give the Number of Degrees from the Meridian, which must be set off in the Circle from C towards B, for the Hour-line of II. And thus you proceed for the several Hour-lines for the Afternoon, as long as the Sun can shine on such a Plane, which will not be quite till VIII.

Then moving the Quadrant to the eastern Side of the Meridian, place it to $30^{\circ} 0'$ from the *East Point towards the South*, and, turning the Globe Eastward, place the Index at XI, X, IX, &c. Hours exactly, the *Intersection of the Colure with the Quadrant* at those

those respective Hours, will be the Distances in Degrees and Minutes, to be set off from the Point C toward D in the Circle, by which those Hour-lines, for the Forenoon, may be drawn so far as they are required, which will be but to VIII in the Morning.

In such Dials, the Stile stands not in the Meridian, or Hour-line of XII, but somewhere among the Hour-lines of the Afternoon in *West-Decliners*; but *vice versa*, in those whose *Declination is Eastward*.

To find the Distance of the *Sub-stile*, or Line in which the *Stile* or *Gnomon* is to be placed, you turn the Globe about 'till the *Colure intersects the Horizon* at $30^{\circ} 0'$ from the Meridian, and there hold it fast; then, as in this Case the Colure is at *right Angles* with the Verticle Circle, or Quadrant of Altitude, it will represent the *Meridian of the Plane*, and the *brass Meridian* must be considered as the *Sub-stile* of the Plane; therefore the *Number of Degrees* that is contained in the Quadrant of Altitude *between the Colure and the Zenith*, which you will find to be $21^{\circ} 40'$, is the *Distance of the Sub-stile from the Meridian Line, A C*; which, therefore, set off in the Circle B C D from C to E, will give the Distance of the Sub-stile or Line A G from the Meridian A C of the Dial,

Then, to find the *Height of the Pole*, or *Gnomon*, above the Plane of the Dial, you

S

count

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count the *Number of Degrees on the Colure between the Verticle Circle and the Pole*, which you will find to be $32^{\circ} 36'$; therefore from the Point E, where the Sub-stile crosses the Circle, set off $32^{\circ} 36'$ to H, through which Point draw A F for the *Gnomon of the Dial*: And thus is the Dial compleated. And after this Manner may any Dial be drawn, *declining any Number of Degrees towards the East*.

But when the Dials *decline just to the East or West Points*, or when their Plane coincides with the Plane of the Meridian, then the Pole has no Elevation on such a Plane, and the *Axis of the World* becomes now the *Hour-line of VI*; and the other Hour-lines are drawn by describing a Semi-circle and dividing it into 12 equal Parts as before directed for *Equinoctial Dials*; and the Gnomon, or Stile, is, in these, placed perpendicularly on the Hour-line of VI, as it is there on the Hour Line of XII; and the *Height of the Stile* is here equal to the Distance of the Hour-line of IX or III, from the Hour-line of VI, or to the *Radius of the Circle*: And thus are these *direct EAST and WEST DIALS* constructed, in the same Manner with the *Equinoctial Dials*.

I might next proceed to shew how Dials, *both declining and reclining*, may be made by the GLOBE; But as they are seldom required, and the *Apparatus* to the Globe for this

this Purpose will require an *additional Semi-circle* it will scarcely be worth while to attempt it in this Way. However, by Means of the Globes the *Rationale* even of this Sort of Dials will be best of all explained and comprehended; but the young *Diallist* will find the easiest *Mechanical Methods* of constructing all Sorts of DIALS, deduced from the *Geometrical THEORY*, in my *Horologia Nova*, or *NEW ART of DIALLING*, lately published.





T H E
U S E
O F T H E
T E R R E S T R I A L G L O B E .

P A R T I I .

C H A P . I .

*The SOLUTION of Geographical
P R O B L E M S by the Terrestrial
G L O B E . **

Prob. I.

*Find any particular PLACE on the
Globe, from a Table of given LA-
TITUDES and LONGITUDES.*

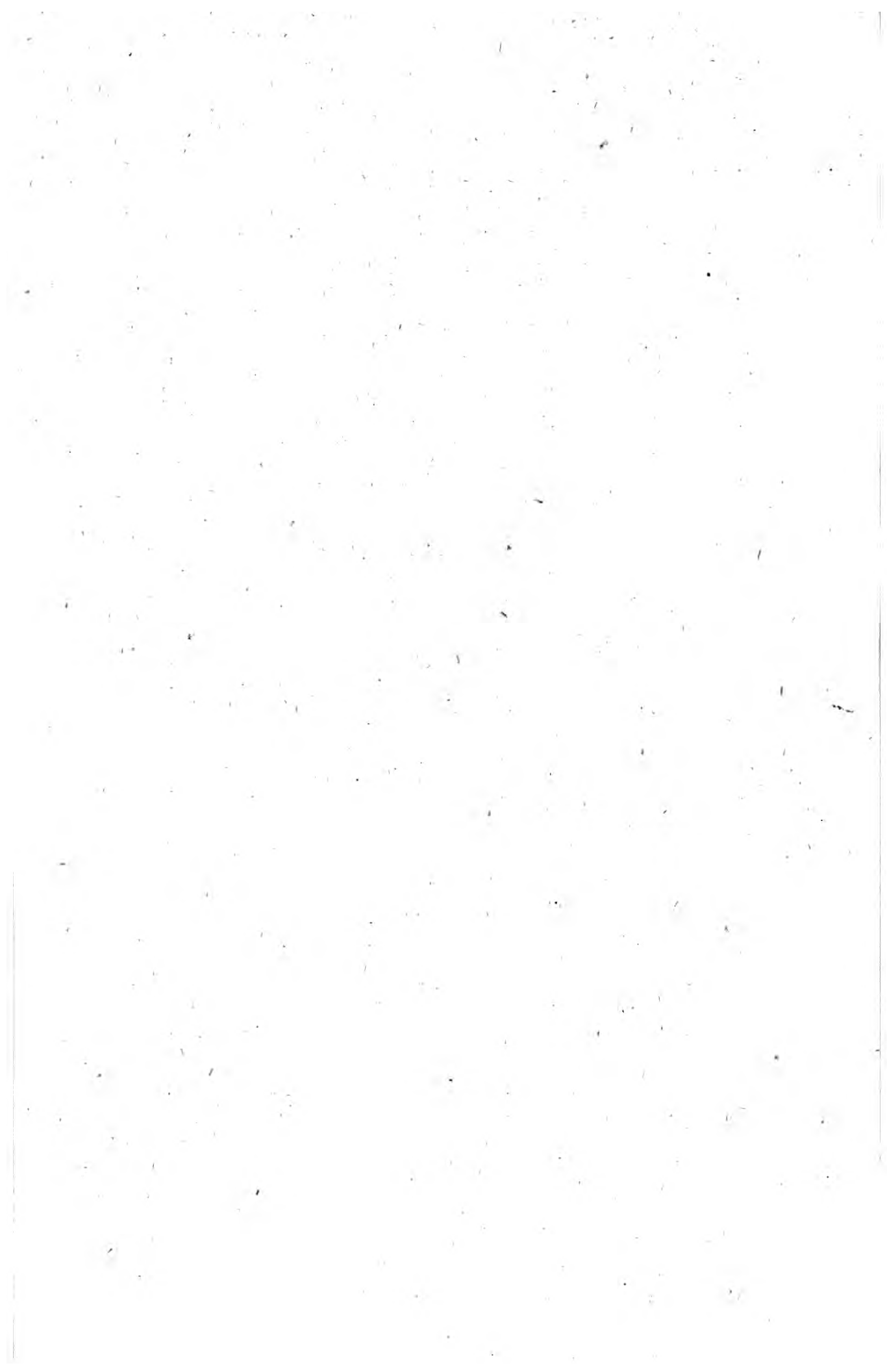
*Bring the Degree and Minute
of Longitude to the General Meridian, and
look for the given Latitude, whether North
or*

* In my *Physico-Geology*, or TREATISE of *Philosophical
GEOGRAPHY*, the Reader may meet with all the *New
DISCOVERIES* that have been made in this SCIENCE, toge-
ther with a SET of MAPS of a *New Form*, adapted to the
True FIGURE of the EARTH, and in which the DEGREES of
LATITUDE are divided into *Minutes*, with many other IM-
PROVEMENTS.

The TERRESTRIAL GLOBE.

Plate III.





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or South, on the said Meridian, and just under it will be the Place required. For Example, let it be required to find LONDON, whose Longitude is 0, and Latitude $51^{\circ} 30'$; then supposing the first Meridian of Longitude, in the Table, to pass through *London*, and using Mr. *Senex's* Globe of 12 Inches Diameter, bring the Beginning or 0° of Longitude, (which you will find on the under Side of the Equator,) to the Meridian, and exactly under $51^{\circ} 30'$ on the Meridian, you will see the City of *London* on the Globe.

Again: Suppose, in the Table, you find the Longitude of *Constantinople* to be $28^{\circ} 55'$, and the Latitude $41^{\circ} 6'$; then, bring $28^{\circ} 55'$ of the Equator to the Meridian, and under $41^{\circ} 6'$ on the North Part of the Meridian, you will observe the City of *Constantinople* on the Globe.

Prob. II. *To find the LATITUDE and LONGITUDE of any Place observed on the Surface of the Globe.*

Let the given Place be *Constantinople*, then, turning the Globe about, bring that City to lie under the Graduated Meridian, and you will observe the Degree just over it to be $41^{\circ} 6'$ N. Latitude: Then, without moving the Globe, observe the Degree on the under Side of the Equator cut by the Meridian, and you will find it to be $28^{\circ} 55'$. Again: Let the given Place be *Port Royal*
in

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in *Jamaica*, which bring to the Meridian, and you will find it to lie under the 18° of North Latitude, and 78° of West Longitude.

N. B. By this Problem the *Difference of Latitude* and *Difference of Longitude* between any two Places are given. Thus the Difference of Latitude between *London* and *Constantinople* is $10^{\circ} 24'$, and the Difference of Longitude between *Constantinople* and *Port Royal* in *Jamaica* is found to be $105^{\circ} 55'$.

Prob. III. *To find all the PLACES of the same LATITUDE and LONGITUDE with those of any given PLACE.*

Bring the given Place to the Meridian, then all those Places which lie under the Meridian have the *same Longitude* with the given Place; and, turning the Globe on its Axis, you will observe all those Places which pass under the same Degree of the Meridian with the given Place, will have the *same Latitude* with it.

Prob. IV. *To find the DISTANCE between any two Places on the Globe in English MILES.*

Bring one of those Places to the Meridian, then, if the other Place lies under the Meridian also, the Distance between them will easily appear in Degrees of the Meridian; but if the other Place is not under the Meridian, fix a Quadrant of Altitude over one Place

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Place upon the Meridian, and then bring it to lie over the other given Place, and the Difference between them, in Degrees of a great Circle, will be shewn on the Edge of the Quadrant, which, multiplied by the Number $69\frac{1}{2}$, (the MILES in *one Degree*) will give the Distance in *English Miles*: Thus the Distance between *London* and *Rome* will be found to be about 13° , which reduced, will give $903\frac{1}{2}$ *English Miles*, or 780 *Geographical Miles*, reckoning 60 to a Degree.

Prob. V. *To find all those PLACES that are at the same DISTANCE from any given Place, as LONDON, for Instance.*

Bring the given Place, or *London*, to the Meridian, and fix the Quadrant of Altitude precisely over it, then turning the Quadrant about upon the Surface of the Globe, you will observe all those Places over which the same, or a given Degree of the Quadrant, passes, and they will be *all equidistant* from *London*; for, by this Means, the *Parallels of equal Distance* will be described from the *Zenith* to the *Horizon*.

Prob. VI. *To find the ANGLE of POSITION, or the BEARING of any one Place from another given, as London.*

Rectify the Globe for the Latitude and Zenith of one of the given Places, *viz.*
London,

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London, and fix the Quadrant of Altitude over it; then bring the said Quadrant to lie over the other given Place, and it will shew, in the Horizon, the *Point* of the COMPASS on which it bears from *London*; and the Angle, which is contained between the Quadrant of Altitude and the Meridian, is called the *Angle of Position*: Thus let the two given Places be *London* and *Port Royal* in *Jamaica*; then, by rectifying the Globe for the City of *London*, let the Quadrant of Altitude (fixed over *London*) be laid upon *Port Royal*, and it will cut the Horizon in the *Western Point* very nearly; and thereby shews that *Port Royal* bears almost WEST from LONDON.

But if the Globe be rectified for *Port Royal*, and the Quadrant of Altitude be laid over the City of *London*, it will cut the Horizon in about $40^{\circ} 30'$ from the North Point *Eastward*, which shews that *London* bears nearly *North-east* from *Port Royal*, or the Angle of Position is $40^{\circ} 30'$ from the North towards the East.

Hence it appears, that the *geographical Bearing* of Places is very different from a *Bearing* taken in a *Nautical Sense*; for, with Navigators, if one Place A bears *West* from another Place B, the Place B will bear *East* from the Place A, because they estimate the Bearing in a *Rhumb Line*, but the Geographers in the Arch of a *Great Circle*.

And

And again, if one Place A bears *North-East* from another Place B, the same Place B will bear *South-west* from the Place A, as being both on the same RHUMB, or artificial Curve, which cuts every Meridian under the same Angle; but neither of those Cases can be true in a *Geographical Sense*, as appears from the two Places of *London* and *Port Royal* in the above Problem.

Prob. VII. *When it is NOON in a given Place, to find what Hour of the Day it is at any other Place proposed.*

Bring the given Place to the Meridian, and set the Hour-Index to the upper XII, then turn the Globe about till the Place proposed comes to the Meridian, and the Index will point to the Hour required.

Let the Example be for *London* and *Pekin* in *China*: Then placing *London* under the Meridian; and the Index to XII, you revolve the Globe and bring the City of *Pekin* to the Meridian, when the Index will point to 40' after VII in the *Evening* for the *Hour there*, when it is *Noon* with us.

But if the Place proposed has West Longitude from *London*, as *Jamaica*, for Instance: Then turn the Globe Eastward 'till *Port Royal* comes under the Meridian, and the Index will point to about 45' after VI in the *Morning*, the Hour of the Day with them, when *Noon* with us.

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Prob. VIII. *To find all these PLACES where it is NOON at any given Hour of the Day, at a given PLACE.*

Bring the given Place to the Meridian, set the Index to the *given Hour*, then turn the Globe about till the said Index points to the upper XII: Then observe *all those Places* which lie under the brass *Meridian*, for to them it is *Noon at that Time*.

For Example: Let *London* be the given Place; and let it be required to find all those Places where it is *Noon* when it is $\frac{1}{2}$ an Hour after VII in the *Morning* at *London*: Then proceeding as above directed, you will find the brass Meridian lie over *Muscovy* in *Asia*, and Part of the Mogul's Empire, in all which Places it is *Noon* at that Time. By the same Method it will be found, that when it is IV o'Clock in the *Afternoon* with us, it will be *Noon* at *Martinico*, *Antigua*, and other of the Windward Islands; also at *Louisbourg* in *North America*, and over all the Middle Part of *South America*.

Prob. IX. *For any GIVEN HOUR of the Day in the Place where you are, to find the HOUR of the Day in any other PLACE proposed.*

Bring the Place where you are to the Meridian, and set the *Index to the given Hour*, then turn the Globe 'till the Place proposed comes to the Meridian, and the Index will shew

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Shew the *Hour of the Day there*, as required.

Thus, for Example: When it is IV o'Clock in the Afternoon with us, it is $\frac{3}{4}$ after XI at Night at the City of *Pekin* in *China*.

Prob. X. *For any GIVEN HOUR at a given PLACE, to find all those PLACES where it is any other given HOUR of the Day.*

Bring the given Place to the Meridian, and set the Index to the given Hour, then revolve the Globe till the Index points to the other given Hour: Then all those Places which lie under the Meridian have that Hour of the Day. *This Problem is so plain as to need no Example.*

Prob. XI. *To find all those Places to which the Sun is VERTICAL for any given Day.*

Bring the *Sun's Place* for the given Day to the Meridian, and observe the *Degree of its Declination*: Then turn the Globe quite round, and *all those Places that pass under the same Degree of the Meridian* are those required, or to whom the Sun will be *vertical* for *that Day*.

Thus, for Example: On the 10th of May, when the Sun's Declination is $17^{\circ} 30'$, all those People who live under that Parallel

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of North Latitude have the *Sun in their Zenith that Day at Noon*: Amongst these you will find the Inhabitants of *Porto Rico, Hispaniola, Jamaica, &c.* in the Western Hemisphere; the Midland Parts of *Africa*, the Southern Part of the *Mogul's Empire*, and the Kingdom of *Pegu* in the farther *India*.

Prob. XII. *To find what DAY of the Year the SUN will be vertical in the torrid Zone to any given PLACE.*

Bring the given Place to the Meridian, and mark the *Degree exactly over it*; then turn the Globe round and observe the *two Points* of the *Ecliptic* which pass under that Degree of the Meridian: Lastly, see on the wooden Horizon on what *Day of the Year* the Sun is in those Points of the *Ecliptic*, for those are the *Days required*.

For Example: Let the given Place be *Jamaica*, which bring to the Meridian, and observe the Degree under which it lies; then, revolving the Globe, the two Points of the *Ecliptic* which pass under the same Degree of the Meridian will be the 20° of *Taurus*, and 10° of *Leo*, and therefore the *two Days* in which the Sun possesses those *two Degrees* of the *Ecliptic* will be the 9th of *May* and the 2d of *August*, which will be the two *Mid-summer Days* to the People of that Island.

Prob.

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Prob. XIII. *To find those PLACES in the North Frigid ZONE where the Sun begins to shine constantly, without setting, on any given Day between the vernal EQUINOX and MID-SUMMER.*

Find the Sun's Place in the Ecliptic for the given Day; bring it to the general Meridian, and observe the *Degrees of Declination*; then all those Places which are the *same Number of Degrees distant from the Poles*, are the *Places required* to be found,

Thus, for Example: On the 10th of *May* the Sun's Declination is $17^{\circ} 30'$, which deducted from 90° , the Remainder is $72^{\circ} 30'$: Therefore all those Places whose Latitude is equal to $72^{\circ} 30'$ will have the Sun in the Northern Part of the Horizon at XII o'Clock at Night.—The Reason of all which is evident by a bare Inspection of the Globe, rectified to the Latitude $72^{\circ} 30'$.

Prob. XIV. *To find on what DAY the SUN begins to shine constantly, without setting, in any given Place in the North Frigid ZONE, and how long.*

Rectify the Globe to the Latitude of the Place, and, turning it about, observe what Points of the Ecliptic between *Aries* and *Cancer* cut the *North Point* of the Horizon; then find, by the Calendar, (on the Horizon,) what *Days* the Sun will enter those

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those Degrees of the Ecliptic, and they will
satisfy the Problem.

Thus, for Example: Rectify the Globe for the Midland Parts of *Nova Zembla*, whose Latitude is 75° , and then turning the Globe about its Axis, you will see the 15° of *Taurus* and the same Degree of *Leo* both touch the North Point of the Horizon; therefore, on the 4th of *May* the Sun begins to shine without setting, and so continues till the 8th of *August* following:— At the same Time it appears, that in this very Place, when the Sun has more than 15° of *South* Declination, it ceases to rise above their Horizon, in the *Winter Half* of their Year, and continues just as long *invisible*.

Prob. XV. *To find the PLACE, or Part of the SURFACE of the Terraqueous GLOBE, over which the Sun is vertical on any given DAY, HOUR, and MINUTE.*

Find the *Sun's Place* and *Declination* for the given Moment of Time; then find (by Prob. IX.) those Places which have the Sun on the Meridian at that Time; and, among them, that which lies under the given *Degree of Declination* is the Place desired, or that in whose *Zenith* the Sun then is.

Thus,

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Thus, for Example : On the 10th of *May* at VIII o'Clock in the Morning, admit the *Sun's Declination* be $17^{\circ} 30'$, then, proceeding as above directed, we shall find it to be Noon in all those Places from the Middle of *Nova Zembla* to the Middle of the Southern Part of the *Persian* Empire, and, amongst them, that Part which is exactly under the Degree of the Sun's Declination is a Point of the *Arabian* Sea, over which the Sun is vertical at the given Time.

Prob. XVI. *To find, for any given DAY and Hour, those PLACES wherein the Sun is then rising or setting, or on the Meridian; also those Places which are enlightned, and those which are not.*

Find the Place to which the Sun is vertical at the Time given, and bring the same to the Meridian, and elevate the Pole to the Latitude of the said Place, then all those said Places which are in the *Western Semi-circle* of the Horizon have the *Sun rising*; and those in the *Eastern Semi-circle* see it *setting*: And to those *under the Meridian* it is *Noon*. Lastly, all Places above the Horizon are enlightned, and all below are in *Darkness*, or *Night*.

Thus, for Example : Let the Place be that Part of the *Arabian* Sea which was found in the last Problem, to which the Sun
is

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is *vertical* on the 10th of *May* at VIII in the Morning, and having rectified the Globe for that Place, (which is always equal to the Sun's Declination,) bring the said Place to the Meridian, and there let the Globe rest: Then it is evident, that all those Places that lie *under the Meridian* have their *Noon Day*: Then all those Parts of the Earth, lying under the *Western Semi-circle* of the Horizon, will see the Sun *rising*, as they are all of them at 90° distance from it; and the Motion of the Globe carrying them towards the Sun, he will appear to *rise gradually* above their Horizon.— On the Contrary, those Parts of the Globe under the *Eastern Semi-circle* of the Horizon, being also every where 90° distant from the Sun, will see him *setting*, being carried by the Motion of the Globe out of the enlightened into the *dark*, or *nether Hemisphere*.

Prob XVII. *The Day and Hour of an ECLIPSE of the SUN or MOON, or TRANSIT of the PLANETS or other Phænomenon in the Heavens being given, to find all those Places on the Surface of the Globe, where the Beginning, Middle, or End thereof will be visible.*

Find the Place to which the Sun is vertical at the given Instant, for the *Beginning, Middle, or End* of the TRANSIT or ECLIPSE: Then will those Phases be visible
at

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at all those Places which are above the Horizon at those Instants of Time.

We shall exemplify this curious Problem by the late most remarkable TRANSIT of *Venus* over the Sun, *viz.* on the 6th of *June*, 1761.

The BEGINNING of this TRANSIT was about 5' after 11 o'Clock in the Morning, the Place of the Sun in $15^{\circ} 30'$ of *Gemini*, and its Declination 22° . Then rectify the Globe to a Latitude equal to the Sun's Declination, *viz.* 22° ; bring the given Place of Observation, *London*, for Instance, to the Meridian; and place the Hour Index to 5' after 11 in the Morning: Then turn the Globe about till the Index points to XII at Noon, and the Place under the 22° of the Meridian will be that to which the Sun is vertical at the Time that the Planet *Venus* appears to touch his Eastern Limb; and therefore all that Hemisphere which is illuminated by the Sun, or above the Horizon, will shew those Places of the Earth where the Beginning of the Transit is visible. Thus the People in all these Parts which *lie under the Meridian* will see the BEGINNING of the TRANSIT just at NOON: All those Places which lie in the *Western Part* of the Horizon will see the *Beginning* of the *Transit* at *Sun-rising*: ——— And those Parts of the Earth which lie under the *Eastern Semi-circle* of the Horizon, see the *Beginning* at *Sun-set*.

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From whence it appears, that the Beginning of the Transit was seen in the *Forenoon* by the vast Continent of *Asia*, a small Part of *Arabia* in *Africa*, and the North-East Parts of *Europe*; but not in *Great-Britain*.

The MIDDLE of the TRANSIT happening at about $\frac{1}{2}$ an Hour after V in the Morning, the City of *London* must be again brought to the Meridian, and the Index placed to $\frac{1}{2}$ after V; then turn the Globe about 'till the Index points to the upper XII, and there let it rest. — The Part of the Earth's Surface which is now under the 22° of the Meridian, *viz.* a Part of the *Indies*, Eastward of *Bengal*, will then observe the *Sun in their Zenith*; and all the Parts of the World which lie under the *diurnal Meridian* are those which see the MIDDLE of the TRANSIT at NOON: — Those in the *Western Part* of the Horizon view it at *Sun-rising*, and those in the *Eastern Part* at *Sun-set*. — From whence it appears, that all *Europe*, almost all *Africa*, and Half the Continent of *Asia* saw the *Middle of the Transit in the Forenoon*, and the *Eastern Part* of *Asia* viewed it in the *Afternoon*; but *England* saw it not.

Lastly, for the END of the TRANSIT, bring *London* to the Meridian, and set the Hour Index to 20' after VIII, and turn the Globe till it points to XII: Then will nearly the *Middle Part* of the *Red Sea* be that to
which

which the *Sun is vertical* at the EGRESS of *Venus*, and all the Parts lying under the Meridian will see her go off from the *Sun's Disk* at Noon. — In the *Western Parts* of the Horizon, the Countries appear where the *Transit* is seen to end at *Sun-rising*. — These are a few of the *most Easterly Parts* of North and South *America*: — The Countries lying under the *Eastern Semi-circle* see the *End* of the *Transit* at *Sun-set*: — All *Africa* and *Europe* observed *this Phase* in the *Forenoon*, and all *Asia* in the *Afternoon*. — Upon the whole it appears, that this *extraordinary Phænomenon* was almost wholly invisible to the Continent of *America*; but it will be their Turn to have their Curiosity satisfied, in this Respect, by the *next Transit* of the same PLANET, which will happen in the Year 1769, and which will be as little seen and observed by us. After the same Manner, it may be shewn where the *Beginning*, *Middle*; or *End* of any ECLIPSE will be visible, or not so.*

Prob. XVIII. To find in what LATITUDE the longest DAY is of a given Length.

Bring the *solstitial Points* to the Meridian, and set the Index to XII at Noon, then turn

* If the Reader be desirous of being instructed in the ASTRONOMY and GEOGRAPHY of TRANSITS, he may consult my TREATISE on that subject. He may likewise see in my SURVEY of the Solar SYSTEM, how all its DIMENSIONS are discovered by these TRANSITS.

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the Globe Westward 'till the Index points at *Half the Number of Hours* given, which being done keep the Globe from turning round its Axis, and slide the Meridian up or down in the Notches 'till the *solstitial Point* comes to the Horizon: Then that *Elevation of the Pole* will be the *Latitude* required.

For Example: Suppose the Latitude be required in which the Day is 14 Hours; by proceeding as above directed, the Latitude will be found near the *Parallel* of 40° , and for the *longest Day* of 20 Hours the *Latitude* will be something more than 63° .

Prob. XIX. *To exhibit a general Representation of the Lengths of DAYS and NIGHTS throughout the YEAR, in any given Latitude.*

Elevate the Globe to the *given Latitude*, and bring the *Solstice* to the Meridian, where let it rest: Then will the *Parallels of North Latitude*, from the Equator to the Tropic of *Cancer*, represent the diurnal Arches, or Length of Days in the Summer Half Year, from the *Mean Day* when the *Sun* is in the Equator, to the *longest Day*, which is represented by the *Tropic itself*. Then, for the *Winter Half Year*, the same *Parallels of South Latitude* above the Horizon do represent the *decreasing Length of Days*, from the *Mean Day* in the Equator, to the *shortest* in the *Tropic of Capricorn*. — Indeed nothing

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thing can be more amusing or instructive, than to shew how instantaneously, by the Globe, *all the Variety of different* LENGTHS of DAYS and NIGHTS, for *every Part* of the YEAR, and for *every Latitude* of Place, are represented to the View by a Motion of the Meridian up and down in the Notches of the Horizon:—It gives us a transient, and, as it were, simultaneous View of all the *Phænomena* and VICISSITUDES of all the SEASONS in the *whole Year*, and throughout the WORLD, at once, and in every *different Position* of the GLOBE.

Prob. XX. *To find those* INHABITANTS of the Earth called the PERIOECI with respect to LONDON.

Bring *London* to the Meridian and set the Hour Index to the upper XII, then turn the Globe about till the Index points to the lower XII, and that Part of the Globe under $51^{\circ} 30'$ of the upper Meridian, is that required, which, being the Northern Part of the great *Pacific Ocean*, it appears there are no Inhabitants of that Denomination with Respect to *London*; but the greatest Part of *China* in *Asia*, and the *Gulph* of *Mexico* in *America*, or what is usually called the *West-Indies* are very nearly *Periæci*, to each other.

Prob.

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Prob. XXI: *To find those INHABITANTS of the Earth that are called ANTOECI.*

These are found by counting equal Degrees of Latitude from the Equator upon the Meridian on either Side:

Thus, for Example: *Tripoli*, on the Northern Coast of *Africa*, and the *Cape of Good Hope*, on the Southern Point, lie nearly in the *same Parallel of Latitude*, and under the *same Meridian*, are *Antæci* to each other, having the *same Length of Days*; and *Nights*; and the *same Vicissitudes of Seasons*; but at *opposite Times of the Year*.

Prob. XXII. *To find the ANTIPODES to any given Place; as LONDON, for Instance.*

Bring *London* to the upper or diurnal Semi-circle of the Meridian, then, in the nether Semi-circle of the Meridian, reckon the *same Number of Degrees Southward* from the Equator as is equal to the North Latitude of *London*, viz. $51^{\circ} 30'$; the Point of the Globe lying under this Degree of the lower Meridian, is that *diametrically opposite to London*, and therefore they are *Antipodes* to each other: This appears to be a Part of the *Southern OCEAN*, near *New-Zealand*: thus the Midland Parts of *Tartary* and Southern Parts of *America*, called *Terra Magellanica*, are *Antipodes* to each other, as is easily seen by the Globe.

Prob.

Prob. XXIII. To find those PLACES in the Torrid Zone, to whom the Sun will appear twice in the Forenoon or Afternoon upon the same AZIMUTH.

Let the Sun be in the Beginning of *Cancer* on the longest Day, and then there are many Latitudes in the Torrid Zone in which this Phænomenon may be observed. Thus if we take the Latitude of *Jamaica* 18° , and rectify the Globe thereto, the Quadrant of Altitude will, in one certain Azimuth, touch the Parallel, or Tropic of *Cancer*; but if removed a little more *Southward*, it will cut the said Parallel in two Points, and continue to do so till it coincides with the said Parallel in the Horzion: Therefore bring the Beginning of *Cancer* to the Meridian, and set the Hour-Index to XII, then turn the Globe about till the Beginning of *Cancer* be in the *Eastern Horizon*, and the Hour-Index will point to $\frac{1}{2}$ after V, which is the Time of Sun-rising in that Latitude on their *longest Day*.——Again, place the Quadrant of Altitude to the same Point of the Horizon, where the *Ortive Amplitude* is 25° ; and then will the *Quadrant* be the *Azimuth* in which the Sun rises for that Morning; and as the Sun advances, it will gain *Azimuths* more and more *Southward*, 'till about IX o'Clock, and afterward return over them to the *North*, where it will be at XII.

Thus,

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Thus, for Example: At VII o'Clock it will be nearly upon the Azimuth of 70° from the North; at VIII o'Clock it will be on the Azimuth of 72° , and about $45'$ after VIII it will attain its *most Southern Azimuth*, which is about 73° , at the *Altitude* of about 45° above the Horizon: On this Azimuth it will appear for *some Time*, viz. till about IX o'Clock, and at the *Altitude* of 50° it will begin to go off upon *Azimuths more and more Northern*. Thus at X o'Clock it will be again upon the Azimuth of 72° from the North; at $\frac{1}{2}$ after X it will be upon the Azimuth of 69° ; at $50'$ after X it will again get upon the *Azimuth equal to the Amplitude*, and then proceed through all less Degrees of Azimuths to the North.

N. B. In this Method of solving this very curious Problem, the *Rationale* of this odd Phænomenon will more plainly appear, as also the Reason why it can be seen only by the *Inhabitants* of the *Torrid Zone*; and most evidently to those between 15 and 20° of Latitude.—It may be farther observed, that this very Problem is a remarkable Case of the *Ambiguity* of *spherical Triangles*, since, in a given *Latitude*, *Declination*, and *Azimuth* of the SUN, if the *Hour* of the *Day* be required, it is very evident from hence there may be two Answers given, and it will be uncertain which is the *right*, unless

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unless from some *particular Conditions* of the *Problem*.

Prob. XXIV. *To find all those Places of the Earth where an ECLIPSE of JUPITER'S SATELLITES will be visible.*

We have already shewn when *Jupiter* may be seen in any particular Place, or Latitude; but it may be necessary, on many Accounts, to give a more general Solution to this Problem, and to shew how, by the Globe, it will be easy to know all those Places of the Earth's Surface where Eclipses of *Jupiter's* Moons may be observed at any Time of the Year, which will be very useful to *Navigators, Astronomers, &c.*

If *Jupiter* be in *Consequentia*, or follows the Sun, and sets after him in the Evening, then proceed thus: Find that Part of the Earth's Surface to which the Sun is vertical, (by Prob. XV.) and rectifying the Globe to the Sun's Declination, bring that Place to the Meridian which will then be in the Zenith, and place the Hour-Hand to XII; holding the Globe fast in this Position, with a *Black-lead Pencil* or *Chalk*, draw a Line on the Surface of the Globe, along the *Eastern Semi-circle* of the Horizon, and that will denote all those Places to whose Inhabitants the Sun is *setting at that Time*, as we have shewn in the fore-mentioned Problem,

X

Then

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Then find the Difference of the *Sun's Right Ascension*, and *that* of Jupiter, in TIME ; and turn the Globe *Westward*, 'till the Index points to that Difference ; and then rectifying the Globe to the *Declination* of Jupiter, hold it fast, and draw *another Semi-circle* on the Globe by the *Eastern Side* of the Horizon : Then the Space between these two *Semi-circles* will include all those Places on the Earth's Surface, where Jupiter will be seen *after Sun-set*.

In the same Manner, if Jupiter be in *Antecedentia*, or rises before the Sun, you proceed as before for the Place to which the Sun is vertical, and having brought it to the Meridian and fixed the Index to XII, you draw a Line by the *Western Edge* of the Horizon, to shew the Places where the *Sun is Rising* ; then rectify the Globe for *Jupiter's Declination* ; and turning it *Eastward* till the Index points to the Difference of the *Right Ascension* of the Sun and Jupiter, and there holding it fast, draw another Line by the *West Side* of the Horizon ; and the Places between this and the former *Semi-circle*, are those to whom Jupiter will be *visible before Sun-Rising*.



C H A P. II.

*The USE of the ANALEMMA on the
Terrestrial GLOBE.*

THE *Analemma* is a small SLIP of
 T PAPER, pasted on the Surface of
 all Mr. *Senex's* Terrestrial Globes;
 the *Length* of it is just equal to the
Breadth of the Torrid Zone, or Distance be-
 tween the two Tropics. It contains the
 CALENDAR of *Months* and *Days* in two
 Parts, beginning from the Day of the *Win-
 ter Solstice*, and proceeding to that of the
Summer-Solstice on one Part, and from thence
 it returns again to the Winter Solstice. The
 Months and Days are so laid down and di-
 vided as to *correspond exactly with the Declin-
 ations North or South*, which the Sun has
 on each respective Day through the Year.
 — This will evidently appear if the said
Analemma be brought to lie under the Gene-
 ral Meridian, and from thence the following
 Problems may easily be deduced.

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Prob. XXV. *To find the SUN'S DECLINATION on any Day of the Year, by the ANALEMMA, without knowing its Place.*

Bring the *Analemma* to the Meridian, and thereon, over the given Day of the Month, the *Sun's Declination* may be seen.

Prob. XXVI. *To find by the ANALEMMA the SUN'S PLACE in the Ecliptic, and RIGHT ASCENSION, for any given Day of the Year.*

Bring the *Analemma* to the Meridian, and hold a Pin or Wire against it over the given Day; then turn the Globe about 'till a Point of the Ecliptic comes under the Wire, which will shew the *Sun's Place* in that Quarter of the Ecliptic which corresponds to the Quarter of the Calendar, in which the given Day is. Its *right Ascension* is shewn in the Equinoctial Line, at the same Time.

Prob. XXVII. *To find by the ANALEMMA the Time of the SUN'S RISSING and SETTING, with its AMPLITUDE, for every Day in the Year by Inspection, in a given LATITUDE.*

Rectify the Globe for the given Latitude of the Place, and bringing the middle Part of the *Analemma* to the Meridian, set the Hour-Index to XII, then turn the Globe about to the East 'till the *most Southern Part* of the *Analemma* coincides with the Horizon, then will the Index point to about $\frac{1}{4}$ after
VIII

VIII in the Morning for the Time of *Sun-rising* on the *shortest Day*. — Then bring any other Day between the 20th of *January* and the 20th of *March*, to the Horizon, and the Index will shew the Time of the Sun's rising for that Day. — Also from the 20th of *March* to the 20th of *June*, any given Day of the ANALEMMA being brought to the Horizon, the Index will shew the Time of its rising on that Day also; — Consequently, the *Time of the Sun-rising and Sun-setting*, from one End of the six Months to the other, is seen for every Day respectively, by the Motion of the *Analemma* through the various Parts of the Horizon; and its *Amplitude* for every Day is shewn by Inspection, from 38° of *South Amplitude* to 38° of *North*. — And all that has been said about its *rising* is the same with regard to its *setting*. By this Means a general Idea may be formed, as it were, instantaneously, of the various *Length of Days and Nights throughout the Year*.

Prob. XXVIII. *To find, by the ANALEMMA, the Sun's ALTITUDE and AZIMUTH, for any given DAY and HOUR.*

Rectify the Globe for the Latitude and for the *Analemma*, then turn the Globe 'till the Index points to the given Hour, and bring the *Quadrant of Altitude* to lie over the given *Day of the Month*, and that Day will shew,

on

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on the Edge of the Quadrant, the *Altitude* of the Sun; and, in the Horizon, the *Azimuth* is shewn (by the QUADRANT) from the *South*, or *North Points*.

For Example: On the 10th of *April* at IX in the Morning, the *Sun's Altitude* is found about 33° , and its *Azimuth* 56° from the *South*.

Prob. XXIX. *At a given Hour in the Morning, or Afternoon, to find all the different ALTITUDES and AZIMUTHS the SUN can have for every DAY in the YEAR.*

Rectify the Globe to the Latitude and *Analemma*, then revolve the Globe till the Index points to the given Hour, and there keep it steady; then bring the Quadrant of Altitude to lie over the Southern Part of the *Analemma*, and it will shew the *Sun's Altitude* and *Azimuth* on the *shortest Day* of the Year at that given Hour: Then removing the Quadrant of Altitude gradually over all the Length of the *Analemma* till it comes upon the *most Northern Part*, and there the *greatest Altitude and Azimuth* will appear on the Edge of the Quadrant in the *Analemma* and Horizon.

For Example: Let the Hour given be IX in the Morning, then will the Altitude on the *shortest Day* be 4° only, and the *Azimuth*

muth 44° ; and on the longest Day the Altitude will be 43° , and the Azimuth, 73° ; so that the *Altitude* will vary at that Hour no less than 39° , and the *Azimuth* 29° .

Prob. XXX. To find all the different Times of the DAY, througout the YEAR, on which the SUN will be upon a given AZIMUTH, and its ALTITUDE for those Times, on every DAY respectively.

Let the given Azimuth be that of 45° or *South East*, and the Globe being rectified for the Latitude and *Analemma*, bring the *Quadrant of Altitude* to the given *Azimuth*; then move the Globe about till the *Southern Part* of the *Analemma* comes to the *Edge of the Quadrant*, then will the Time be shewn, by the Index, when the Sun comes to the given *Azimuth* on the *shortest Day*, and is a little before IX in the Morning, with an *Altitude* of little more than 3° : Then revolve the Globe *Westward* till the most *Northern Part* of the *Analemma* touches the *Edge of the Quadrant*, (remaining still in the given *Azimuth*,) then will the *Index* shew the Time in which the Sun is upon *that Azimuth* on the *longest Day*, which will be about $35'$ after X, and the *Altitude* then will appear to be $55^{\circ} 30'$:—The Time of it's being on that *Azimuth* for any intermediate Day, and it's Height at that Time, will appear by *stopping*
the

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the Globe when the given Day comes to the
Edge of the Quadrant.*

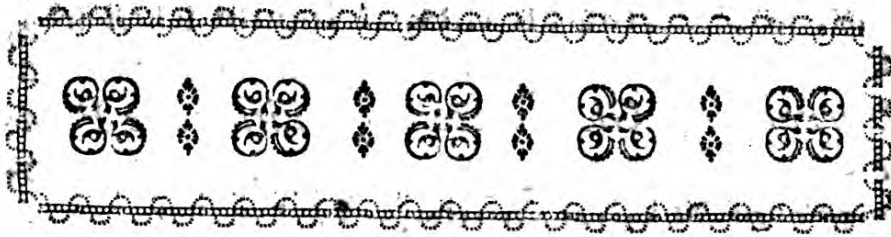
Prob, XXXI. *From the observed Altitude
of the SUN, to find the HOUR and AZIMUTH
in the given Latitude by the ANALEMMA.*

Having rectified the Globe, as before directed, move the Globe and Quadrant of *Altitude* so together that the *given Day* of the Month may coincide with the given Degree of *Altitude* on the Edge of the Quadrant.

Thus, for Example : Suppose on the 20th of *April* in the Morning, you observe the *Sun's Altitude* 23° , then proceeding as directed, you will find the Index point to VIII in the Morning for the Time required, and the Quadrant will cut the Horizon in $77^{\circ} 30'$ at that Time.



CHAP.



C H A P. III.

*Of the Use of the Terrestrial GLOBE
in HYDROGRAPHY and NAVIGATION.*

A
S
 the *Terrestrial GLOBE* has ever been very justly held in the highest Esteem, for its Use in conveying the Ideas relative to the PRINCIPLES of *Geographical SCIENCE* with the greatest Perspicuity and Facility, and for the SOLUTION of all such *Problems* in a *direct* and *natural Manner*, it may be a Wonder to many People, why it should be thought of no more Consequence in HYDROGRAPHY, and *so little in Use at SEA*, when the most *natural Representation* and *easy Solution* of all the CASES of SAILING, or PROBLEMS of NAVIGATION, are *so readily exhibited* and *performed by it*—We may add to the above Consideration, that since *Three Parts in Four* of the *whole Surface of the Globe* is covered with *Water*, and the Necessity that Mankind are under of traversing all Parts of this vast extended aqueous Surface, without any other *Guide* but the *Compass* and *Stars*, I

Y

say,

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say, considering all this, it should seem as if the principal Design and Use of the artificial *Terraqueous Globe* were to *facilitate the Principles of HYDROGRAPHY*, and the *PRACTICE of NAVIGATION*.

It must be confessed by every one, that though there be Methods invented of representing a Case of Sailing *in Plano*, and solving the same with great Accuracy; yet such an Invention is altogether *artificial*; whereas, the Idea we have of such a *Case of Sailing on the SURFACE of a Globe*, is altogether *natural*; and whereas one requires great Skill in *Mathematical Science* to comprehend the Principles on which it depends, the Method of *SAILING by the GLOBE* is so simple and plain, that the *Rationale* of every Case of Sailing is evident by Inspection only.

It must be allowed, that small Globes are not so well fitted to answer this End; but a Globe of 17 Inches Diameter has its Degrees so large as to give any Distance failed to 10' or Miles, and, by the Application of a *Vernier*, even to a Minute or two, which is as much Accuracy as is ever required, and is much more than is often had, by the *common Methods* in a *CASE of SAILING*.

But when we consider the Size of a 28 Inch Globe, and that each Degree is $\frac{1}{4}$ of an Inch in Length, all Hesitation or Difficulty about solving Problems with Accuracy must vanish: for Distances there may be measured to 5', or Miles, without any Trouble
of

of a *Vernier*, and all the other *Quæſita* of Sailing obtainable without the leaſt Degree of Trouble; And as the *Terreſtrial Globe* only would be neceſſary in this Caſe, and there is Room enough in the Cabins of all large Ships to diſpoſe of ſuch a Globe with Conveniency, it is a Wonder that any *Maſters, Captains, or Commanders* of SHIPS, ſhould ever go to Sea without them.

But to return to Mr. *Senex's* Globe of 17 Inches Diameter, which ſeems to have been deſigned in a peculiar Manner for anſwering the *Purpoſes of Navigation*, by having a great Number of *Rhumb Lines* drawn in all the convenient Parts of the Surface of the Globe repreſenting the *Oceans* and Seas, ſo that if a Ship is departing from any Port, it is at once evident upon what *Rhumb* or *Coarſe* ſhe muſt be ſteered to reach the Port or Coaſt ſhe is bound for.—And when we conſider, with how little Accuracy and Certainty the *Way of a Ship* can be meaſured at Sea, or the Angle of her Coarſe can be eſtimated, and the *Departure, Difference of Latitude, Longitude, &c.* found by the *common Methods* of Obſervation, we ſhall find no room to object againſt the Size of the Globe, which is more than ſufficient to repreſent them in a far ſuperior Degree of Truth: Such a Globe therefore ought to be eſteemed the moſt *neceſſary Piece of Furni- ture in the Cabin of a Ship*; and as this

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may be justly recommended for common Use, I shall now proceed to shew in what Method the *common CASES of SAILING* are represented upon it, and how they are resolvable by it.

In a Case of Sailing on the Globe, there are but four things properly to be considered, which are all found in one *Loxodromic Triangle*, *viz.* (1.) The DIFFERENCE of LATITUDE, (2.) The DIFFERENCE of LONGITUDE, (3.) The ANGLE of the COURSE, and (4.) The DISTANCE Sailed.—Any two of these being given, or known, the other two when required, may be found; and from hence there will arise *five different CASES of SAILING*, according to the Method we take, which is two fold, *viz.*

ORTHODROMICS, or *Great Circle Sailing*: For it is to be considered, that the Way or Course of a Ship being upon a Globular Surface, the nearest Distance between any two Places is the *Arch of a great Circle*; and therefore the *shortest and most direct Way* for a Ship to proceed is in such an Arch; but the Arch of a great Circle does not intersect the Meridians it passes obliquely over in *equal Angles*, and therefore it will be required, very often, to *change the Direction of a Ship's Course*, in steering of her most directly, or the nearest Way from one Port to another: Hence a second Method of Sailing

ing, or steering of a Ship's Course has been invented, *viz.*

LOXODROMICS, so called from its Sailing on an OBLIQUE *Course*, or upon a Curve of such a Nature or Kind as to make equal Angles every where with the Meridian; such a Curve is called a *Rhumb*; *eight* of which are generally drawn in every Quadrant, or Quarter of a Circle, which are those Lines you observe so frequently crossing each other on the aqueous Surface of the Globes. This *artificial Method of sailing* is by Means of the *Magnetical Needle*, which, as it makes a constant Angle with the Meridian where you are, points out to the Mariner, at the same Time, the *Angle* which his *Ship's Course* is to make with the Meridian daily.

Now, either of these Methods of Sailing are performable by the Globe, and would be almost equally easy, if, to qualify the Globe for answering such Purposes, there were added to it, a *Moveable Meridian* on the Surface, and *Globular PROTRACTOR*.

For tho' one might very well shift without the *Moveable Meridian*, as the Meridian on the Surface of this Globe are drawn thro' every 10 Degrees, yet the Solution of a Problem would be more accurate with it, and the Expence not extraordinary:—The *Globular Protractor* we might make a shift without likewise; but it would, in many Cases, be found very useful, especially in *Loxodromic Sailing*,

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Sailing, by which, to delineate the *Rhumb*
more accurately.*

We proceed now to the Problems by which
the *Cases of sailing* are solved on the GLOBE,
which we shall first do in a general Manner,
and then afterward more particularly with
Regard to the Curve on which the Course
of the Ship is to be directed, in *great Circle*
SAILING,

Prob. XXXIII. Case I. *Given the Difference*
of LATITUDE and Difference of LONGITUDE,
to find the COURSE and DISTANCE sailed.

Example: Admit a Ship sails from a Port
A in Latitude 38° to another Port B in La-
titude 5° , and finds her Difference of Longi-
tude 43° .

Let the Port A be brought to the Meri-
dian and elevate the Globe to the given La-
titude of that Port 38° , and fixing the Qua-
drant of Altitude precisely over it on the
Meridian, move the said Quadrant to lie
over the second Port B, (found by the given
Difference of Latitude and Longitude) then
will it cut in the Horizon $50^{\circ} 45'$ for the
Angle of the *Ship's Course* to be steered from
the Port A. Also, count the Degrees in the
Quadrant between the two Ports, which you

* This *Loxodromic PROTRACTOR* is only a *moveable Spheri-
cal COMPASS*, with its 32 Points, formed in Brass, and
furnished with a proper *Index*; and Means to apply and fix
it to any Part of the Brass Meridian.

will

will find 51° : This Number multiplied by 60, (the nautical Miles in a Degree,) will give 600 for the *Distance run*.

Prob. XXXIV. Case II. *Given the Difference of LATITUDE and COURSE, to find the Difference of LONGITUDE and DISTANCE sailed.*

Example: Admit a Ship sails from a Port A in 25° North Latitude, to another Port B in 30° South Latitude, upon a *Course* of 43° .

Bring the Port A to the Meridian, and rectify the Globe to the Latitude thereof 25° , where fix the Quadrant of Altitude, and place it so as to make an Angle with the Meridian of 43° in the Horizon, and observe where the Edge of the Quadrant intersects the Parallel of 30° South Latitude, for that is the *Place of the Port B*. Then count the Number of Degrees on the Edge of the Quadrant intersected between the two Ports, and there will be found 73° , which multiplied by 60, gives 4380 Miles for the *Distance sailed*.——As the two Ports are now known, let each be brought to the Meridian, and observe their *Difference of Longitude in the Æquator* respectively, which will be found 50° .

N. B. Had this Problem been solved by *Loxodromics*, or *sailing on a Rhumb*, the Difference of Longitude would then have been $52^{\circ} 30'$ between the two Ports.

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Prob. XXXV. Case III. *Given the DIFFERENCE of LATITUDE and DISTANCE run, to find the DIFFERENCE of LONGITUDE and ANGLE of the COURSE.*

Example: Admit a Ship sails from a Port A in Latitude $50'$, to another Port B in Latitude $17^{\circ} 30'$; and her Distance run be 2220 Miles: Rectify the Globe to the Latitude of the Place A, then the Distance run, reduced to Degrees, will make 37° , which are to be reckoned from the End of the Quadrant lying over the Port A under the Meridian; then is the Quadrant to be moved till the 37° coincides with the Parallel of $17^{\circ} 30'$ North Latitude, and the *Angle of the Course* will appear in the Arch of the Horizon intercepted between the Quadrant and the Meridian, which will be $32^{\circ} 40'$; and by making a Mark on the Globe for the Port B, and bringing the same to the Meridian, you will observe what Number of Degrees pass under the Meridian, which will be 20° , the *Difference of Longitude* required.

Prob. XXXVI. Case IV. *Given the DIFFERENCE of LONGITUDE and COURSE, to find the Difference of LATITUDE and DISTANCE sailed.*

Example: Suppose a Ship sails from A, in the Latitude 51° , on a Course making an Angle with the Meridian of 40° , till the
Diffe-

Difference of Longitude be found just 20° ; Then rectifying the Globe to the Latitude of the Port A, place the Quadrant of Altitude so as to make an Angle of 40° with the Meridian; then observe in what Point it intersects the Meridian passing through the given Longitude of the Port B, and there make a Mark to represent the said Port; then the Number of Degrees intercepted between that Place and the Port A will be 28° , which will give 1680 Miles for the *Distance run*:—And the said Mark for the Port B, being brought to the Meridian, will have *its Latitude* there shewn to be $27^{\circ} 40'$.

Prob. XXXVII. Case V. *Given the Course and Distance sailed to find the Difference of Longitude and Difference of Latitude.*

Example: Suppose a Ship sails 1800 Miles from a Port A $51^{\circ} 15'$ South West, on an Angle of 45° to another Port B.

Having rectified the Globe to the Port A, fix the Quadrant of Altitude over it in the Zenith, and place it to the South West Point in the Horizon: then upon the Edge of the Quadrant under 30° (equal to 1800 Miles from the Port A) is the Port B; which bring to the Meridian, and you will there see the *Latitude*; and at the same Time, its *Longitude* in the Equator in the Point cut by the Meridian.

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In all these Cases, the Ship is supposed to be kept upon the *Arch of a great Circle*, which is not difficult to be done, very nearly, by Means of the Globe, by frequently *observing the Latitude, measuring the Distance sailed, and (when you can) finding the Difference of Longitude*; for one of these being given, the Place and Course of the Ship is known at the same Time; and therefore the preceding Course may be altered, and rectified without any Trouble, through the whole Voyage, as often as such Observations can be obtained, or it is found necessary. Now if any of these *Data* are but of the Quantity of *four or five Degrees*, it will suffice for correcting the Ship's Course by the Globe, and carrying her directly to the intended Port, according to the following Problem.

Prob. XXXVIII. *To steer a SHIP upon the ARCH of a GREAT CIRCLE by the given Difference of Latitude, or Difference of Longitude, or DISTANCE sailed in a given TIME.*

Admit a Ship sails from a Port A, to a very distant Port Z, whose *Latitude and Longitude* are given, as well as its *Geographical Bearing* from A; then,

First, having rectified the Globe to the Port A, lay the Quadrant of Altitude over the Port Z, and draw thereby the Arch of
a Great

a *Great Circle* through A and Z; this will design the intended Path or Tract of the Ship.

Secondly, Having kept the Ship upon the *first given Course* for some Time, suppose by an Observation you find the Latitude of the *present Place* of the Ship, this added to, or subducted from the Latitude of the Port A, will give the *present Latitude* in the Meridian; to which bring the Path of the Ship, and the Part therein, which lies under the new Latitude, is the true Place B of the Ship in the great Arch. To the Latitude of B rectify the Globe, and lay the Quadrant over Z, and it will shew in the Horizon, the *new Course* to be steered.

Thirdly, Suppose the Ship be steered upon this Course till her Distance run be found 300 Miles, or 5° ; then, the Globe being rectified to the Place B in the Zenith, laying the Quadrant from thence to make the given Course, make a Mark at the 5th Degree from B, and that will be the *present Place* of the Ship, which call C; which being brought to the Meridian, its *Latitude* and *Longitude* will be known. Then rectify the Globe to the Place C, and laying the Quadrant from thence to Z, the *new Course* to be steered will appear in the Horizon.

Fourthly, Having steered some Time upon this new Course, suppose, by some Means or other you come to know the Difference of

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Longitude of the present Place of the Ship, and of any of the preceding Places, C, B, A, as B, for Instance; then bring B to the Meridian, and turn the Globe about, 'till so many Degrees of the Equator pass under the Meridian as are equal to the discovered *Difference of Longitude*, then the Point of the *Great Arch* cut by the Meridian is the present Place D of the Ship, to which the new Course is to be found as before.

And thus, by repeating these Observations at proper Intervals, you will find future Places E, F, G, &c. in the great Arch; and by *rectifying the Course at each*, your Ship will be conducted on the *Great Circle* or the *nearest Way* from the Port A to Z, by the *Use of the Globe* only.

And were the Globe properly fitted up with all the useful Apparatus; it would convey the clearest Notions of *Spherical Trigonometry* in general, and its Application to ASTRONOMY, GEOGRAPHY, DIALLING, NAVIGATION, &c. of any Instrument whatsoever. But, for more general Instructions on this Head, I must refer the Reader to the MARINER'S MIRROR, where every *Species* of NAVIGATION is taught according to the *newest Discoveries*, by Mercator's CHART, a New *Marine* PLAIN-TABLE, *Nautical* SLIDING-RULE, &c. with several Improvements of *Davies's* and *Hadley's* QUADRANTS.

CHAP.



C H A P. IV.

A NEW CONSTRUCTION of the Terrestrial GLOBE by CLOCK-WORK, exhibiting all the Phænomena of the annual and diurnal MOTIONS of the EARTH, in the most natural and general MANNER.

HAVING dispatched the *geographical Problems* of the *Terrestrial GLOBE*, according to the usual Form thereof, I must here beg Leave to observe, that this Globe is capable of a much more genuine and natural Construction, and its Use in a Solution of geographical Problems will be found much more rational and easy, as the *Position of this Globe* and its *Motions* will be always *similar and exactly correspond with that of the large GLOBE of EARTH* itself.—It is true, this Disposition of the Globe is more expensive than the common one, as requiring a Sort of *Clock-work* to give it Motion: But then the very Globe itself, when furnished with its proper

proper Circles and Appendages, gives, by Inspection, without any Trouble to the Student, a most natural Solution to all this Kind of Problems; so that after such a Globe is rectified, it becomes an AUTOMATON, being always in Motion, and *exhibiting the same Phænomena* as he would observe on the *very Earth itself*, if situated at a Distance from it.

For the Sake, therefore, of such as may chuse to indulge a rational Curiosity, and take the most direct and demonstrative Way to Knowledge, I shall give a brief Description of this Machine, and its Uses, as in this Way the *Rationale* of Geography, rather than a practical Solution of Problems, is the principal Object in View.

First, By the Mechanism of this Globe, the *Axis* has a *conical Motion* on its Center, by which it makes *one Revolution* in the Space of *one whole Year*, by which Means the Poles of the World describe round the Poles of the Ecliptic a Circle of 47° in Diameter, the Axis of the Ecliptic being always perpendicular to the Horizon with respect to this annual Motion.

Secondly, Upon the lower Part of the Foot is placed a silvered horizontal Circle, containing the *Ecliptic* with its Signs and Degrees, and a *Calendar* with its Months and Days correspondening thereto.

Thirdly,

Thirdly, In a Part of the Stem, or Foot which supports the Globe, is an Index moving over the aforesaid Circle, indicating the *Time or Season of the Year*, which is shewn in the *Calendar*; and the *Sun's Place* in the *Ecliptic*.

Fourthly, By another Part of the Machinery, another Motion is communicated to the Globe, by which it is carried once round upon its Axis in the Space of a *natural Day*, or 24 Hours. In this *diurnal Motion*, the Poles of the *Ecliptic* revolve every Day about the Poles of the World, at the Distance of $23^{\circ} 30'$.

Fifthly, To estimate any Part of this diurnal Motion of the Earth, there is a *horary Circle* or *moveable Dial-plate* annexed, with its proper *Nonius* for shewing the *Hour*, and *Minutes*.

Sixthly, At a convenient small Distance is fixed a Circle called *the Circle of Illumination*, which divides the Globe into two Hemispheres, *viz.* one *always illumined* by the Sun Beams, and the other *wholly dark*.

Seventhly, At a proper Distance from the Surface of the Globe, corresponding to the middle Point of the enlightened Hemisphere, is fixed a small brass Ball to represent the *SUN*; but at Night, a *small Lamp*, or wax Candle will be necessary. These are the principal Parts without the Globe; but on the Surface of the Globe itself, the following Circles are contained.

Eighthly,

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Eighthly, Two great Circles intersecting each other, at Right Angles in the Poles of the World, and moveable thereon to any Part of the Earth's Surface.

Ninthly, On the middle Point of one of these is placed *another great Circle*, moveable, to make any given Angle therewith, and consequently is properly adapted to represent the *Horizon* of any given Place, the *Meridian* of which is represented by the other great Circle of the Two before mentioned.

Tenthly, At 18° distant from the horizontal Circle is fixed another, called the *Crepuscular Circle*; shewing the Beginning and End of Twilight at any particular Place.

There are other Parts of Machinery which are appropriated to the Nature of *Solar* and *Lunar* ECLIPSES, TRANSITS of the PLANETS, &c. but as these Things are rather Appurtenances than what necessarily belong to the Globe, and the Subjects of *Astronomy* rather than *Geography*, I shall here pass them by, and shall refer the Reader to the *Young Gentleman and Lady's Philosophy*, * where he will find a full Account of them and their Uses.

In order to rectify this Globe for Use, the first Thing to be done is, to put the *Axis* of the *Globe* into a *Position* similar to that of the *real Globe*, by moving the Machine till

* A second Edition of this Work is lately published, very correct, in 2 Vols. 8vo.

the Index comes to the given Day of the Month, when you use it: Then the horizontal Circle is to be adapted to the Place where you are, suppose the City of *London*, for Instance:—*Lastly*, Move the *Dial-plate* 'till the *present Hour and Minute* of the horary Circle comes to the *Nonius*, then will the Globe, or any Part of the Surface, have the same Situation with respect to the Solar Ball or Lamp, as the real Globe of the Earth has itself at that Time to the Sun:— And if now you hang on the *Weight*, the Globe will be put into Motion, and all the Phænomena of Days and Nights, Season of the Year, &c. will appear in *one natural View*.

Thus, for Example: To rectify the Globe for the first Day of *April*, you bring that Day in the Calendar to the annual Index and because it then appears that the Sun is in the 12° of *Aries*, therefore you will see that Point of the Ecliptic, upon the Globe, stand under the Solar Ball, or artificial Sun; then move the Globe about till the Meridian of the given Place, as *London*, passes through the Sun, where letting the Globe rest, move the Hour Circle till the Hour of XII comes to the *horary Index*: Then let the Horizon of *London* have its proper Position given it, and the Machine being put into Motion, you will observe *all the Phænomena of that Day and Night* to follow each other, in a natural

Manner, in the Space of one Revolution of the Globe on its Axis:—Particularly you will see the North Pole a little Way within the enlightened Hemisphere, and the Southern Pole as far in the dark one.—By this Means you will observe, that all the Parts in Northern Latitudes are turned more directly to the Sun, whose Beams are therefore stronger:—Also you observe, that the Tract which each Place in North Latitude describes in the enlightened Hemisphere is manifestly longer than that which is described in the dark one. Therefore the Season of the Year, in the Parallel of the City of *London*, must be warmer and more light-some than in any Place of an equal Latitude South, where the Days are evidently as much shorter than the Nights, as they are longer with us; for the Alteration of Days and Nights, according to the Latitudes North or South, does here equally, and at once appear. — If you look on any particular Place, as the Island of *Great Britain*, you see it enter the enlightened Hemisphere at Sun-rising, because then the Sun is in the Horizon upon the Globe; for when any Place is under the Circle of Illumination, the Sun must necessarily be in the Horizon at that Place, because the Sun, being in the Zenith of the enlightened Hemisphere, must be 90° from the Place——From hence it will also appear, that when the City of *London*,

London comes on the other Side of the *Circle of Illumination*, then likewise the Sun appears again in its Horizon, and consequently you have here a most natural View of those great Phænomena of the Rising and Setting of the Sun in any given Place, and on any given Day of the Year.— At the same Time, you see it is Noon when the Meridian of the Place comes just under the Sun, and that it is Midnight when the opposite Part of that Meridian comes to the Sun; because then the Place is exactly in the middle Part of its Path in the dark Hemisphere.

But that all these Things may appear in their greatest Quantity, you may move the annual Index to the Beginning of *Cancer*; then it will appear, that the *Circle of Illumination* just touches the *Arctic Circle*, or that the North Pole is within the enlightened Hemisphere just $23^{\circ} 30'$, and, consequently, that, by putting the Globe into Motion, it will appear, that *all the Space contained within the Arctic Circle* is intirely illumined that Day, and *all within the Antarctic Circle* wholly contained in the dark Hemisphere.—The Places in North Latitude have now their nearest Position to the Sun's perpendicular Beams, and, consequently, his Rays will fall most directly upon them, and of Course a *greater Number of Rays* will fall upon any given Place than at any other Time:

The Sun Beams also pass now through *a less Quantity of the Earth's Atmosphere* in Northern Latitude. To all which if we add, that the Length of Days now greatly exceed the Length of the Nights, it will shew this to be the hottest and most lightfome Season of the Year to all the Northern Latitudes; and just the contrary appears in all the Southern Latitudes. In the same View, you have their Depth of Winter, arising from just contrary Causes, *viz.* the Shortness of Days, and the Obliquity of the Sun Beams falling on those Parts of the Earth, now at their greatest Remove from the Sun's perpendicular Rays.

With respect to the TWILIGHT for any particular Place, you will observe, that while that Place is describing its natural Arch, the *Crepuscular Circle* will naturally succeed the Horizon, and at Length come upon the Sun; then will the *Twilight end*, and the Time shewn upon the Hour-Circle, subtracted from the Time of Sun-setting, will leave the *Length of the Twilight* for the Evening of that Day:—Then, as the Globe revolves, the upper Part of the Circle of Twilight will come upon the Sun, and the Index will shew the Time of Day-break, or Beginning of Twilight for that Morning.—In this View of the Globe it will also appear, what Places in North Latitude can have no dark Night at *Midsummer*, *viz.*
all

all those which are contained between $48^{\circ} 30'$ of North Latitude and the Arctic Circle; for in the Midnight Situation of the Globe the Sun will be seen between the Horizon and the Crepuscular Circle.——For Instance: *London*, in the Middle of its Nocturnal Path, will not be more than 15° from the Circle of Illumination: therefore, the Sun at Midnight will be more than 15° below its Horizon.

If we now remove the annual Index to point to the Beginning of *Aries*, or *Libra*, we shall then observe all the *Phænomena* of the *Equinoctial Seasons*:——The Sun appears now *in the Equator*:——The Poles of the World are both under the Circle of Illumination:——Consequently, as the Globe revolves, every Place, from Pole to Pole, will describe an equal Arch in the enlightened and dark Hemispheres:——For they will enter into, and go out of each, exactly at VI o'Clock, as shewn by the Hour-Circle.——All Parts have now their mean Inclination to the Sun Beams; their Effects will therefore be of a mean Degree, and consequently produce a *temperate Season*, between the Extreams of *Summer's Heat* and *Winter's Cold*.

Lastly, By turning the annual Index to point to the Beginning of *Capricorn*, we observe the North Pole turn from the Sun, and, at length, wholly included in the dark
Hemi-

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Hemisphere:—The South Pole is now seen in the enlightened Hemisphere just as far. —All the Parts in Northern Latitudes now have their *Winter Season*, as those in Southern Latitudes have their *Summer*.—The Lengths of Days and Nights are now just inverſely what they were when the Sun entered *Cancer*.—The City of *London*, in the Miſt of its diurnal Path, is now but 15° within the enlightened Disk, or from the Circle of the Illumination at Noon; and therefore the Sun, of Courſe, can aſcend no higher above his Horizon on the Mid-winter-Day, or its Meridian Altitude will then be but 15° .—All the other Appearances for this Season are obvious in the Space of one Revolution, and need not be repeated.

To conclude: If, by CLOCK-WORK, both the *annual* and *diurnal Motions* were given to a Globe of this Conſtruction, (as they eaſily might be) the *Phænomena* of every Day and Night, and all the SEASONS of the YEAR, would be conſtantly ſhewn as they return in Nature: And thus the *artificial Globe* might keep Pace with the *Natural*, in all its Motions and Appearances, and ſo prove an *Automaton* demonſtrative of the *Rationale* of all the PRINCIPLES of GEOGRAPHY; and therefore the moſt compleat INSTRUC-TOR in that moſt uſeful and delightful SCIENCE.

A TABLE



C H A P. V.

A TABLE of the LATITUDE and LONGITUDE of all the remarkable CITIES and TOWNS in the WORLD, mostly corrected by Astronomical OBSERVATIONS.

Towns.	Provinces.	Countries.	Quar- ters.	Longi- tude.	Latitude.
				D. M.	D. M.
A.					
A Berdeen,	Marr,	Scotland,	Europe	1-45 W.	57-12 N.
Abo,	Finland,	Sweden,	Europe	21-30 E.	60-30 N.
Agra,	Agra,	East-India,	Asia	79-00 E.	26-20 N.
Aix-la-Cha- pelle,	Juliers,	Germany,	Europe	5-50 E.	50-45 N.
Aleppo,	Syria,	Turkey,	Asia	37-40 E.	36-30 N.
Alexandria,	Lower Egypt,	Turkey,	Africa	31-15 E.	30-40 N.
ALGIERS,	Algiers,	Barbary,	Africa	3-20 E.	36-40 N.
Amiens,	Picardy,	France,	Europe	2-30 E.	49-53 N.
AMSTERDAM,	Holland,	Netherlands,	Europe	4-30 E.	52-22 N.
Antwerp,	Brabant,	Netherlands,	Europe	4-15 E.	51-15 N.
Archangel,	Dwina,	Russia,	Europe	40-12 E.	64-34 N.
Astracan,	Astracan,	Russia,	Asia	52-00 E.	47-00 N.
Athens,	Achaia,	Turkey,	Europe	24-15 E.	38-00 N.
B.					
Bagdat,	Eyraca Arabic	Turkey,	Asia	43-00 E.	33-20 N.
Barcelona,	Catalonia,	Spain,	Europe	2-00 E.	41-26 N.
Bafil,	Bafil,	Switzerland,	Europe	7-40 E.	47-40 N.
BATAVIA,	Java Isle,	East-India,	Asia	106-00 E.	6-00 S.
Belgrade,	Servia,	Turkey,	Europe	21-20 E.	45-00 N.
Bencoolen,	Sumatra,	Island,	Asia	101-00 E.	4-00 S.
Bergen,	Bergen,	Norway,	Europe	6-00 E.	60-00 N.
					BERLIN,

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Towns.	Provinces.	Countries,	Quar- ters.	Longi- tude.		Latitude.
				M. D.	M. D.	
BERLIN,	Brandenburg,	Germany,	Europe	14-50 E.	52-31 N.	
Bern,	Bern,	Switzerland,	Europe	7-20 E.	47-00 N.	
Bologna,	Romania,	Italy,	Europe	11-40 E.	44-29 N.	
Bombay,	Bombay Isle,	East-India,	Asia	72-00 E.	18-30 N.	
Borneo,	Borneo Isle,	East-India,	Asia	111-30 E.	4-30 N.	
BOSTON,	Massachusetts,	N. England,	Amer.	71-00 W.	42-24 N.	
Bordeaux,	Guienne,	France,	Europe	00-40 W.	44-50 N.	
Brandenburg,	Brandenburg,	Germany,	Europe	13-00 E.	25-52 N.	
Breda,	Brabant,	Netherlands,	Europe	4-40 E.	51-40 N.	
Breslaw,	Silesia,	Bohemia	Europe	17-00 E.	51-15 N.	
Brest,	Bretany,	France,	Europe	4-30 W.	48-25 N.	
Bristol,	Somerfet,	England,	Europe	2-40 W.	51-30 N.	
Bruges,	Flanders,	Netherlands,	Europe	3- 5 E.	51-16 N.	
Brunswic,	Saxony,	Germany,	Europe	10-30 E.	52-30 N.	
BRUSSELS,	Brabant,	Netherlands,	Europe	4- 6 E.	51-00 N.	
BUENOS- AYRES.	La Plata	South	Americ.	60-00 W.	34-35 S.	
C.						
CADIZ,	Andalusia,	Spain,	Europe	6-40 W.	36-30 N.	
CAIRO	Lower	Egypt,	Africa	33-00 E.	30-00 N.	
GRAND, Cambray,	Cambray,	Netherlands,	Europe	3-15 E.	50-15 N.	
N. Cambridge	Massachusetts,	N. England,	Amer.	70- 4 W.	42-00 N.	
Candia,	Candia	Island,	Asia	25-00 E.	35-30 N.	
Candy,	Ceylone	Island,	Asia	79-00 E.	8-00 N.	
CANTON,	Canton,	China,	Asia	112-30 E.	23-25 N.	
Cape of Good Hope,	Caffraria,	Hottenttos,	Africa	16-20 E.	33-55 S.	
Cape Horn,	Delfuego Isle,	Patagonia,	S. Am.	80-00 W.	57-30 S.	
CARTHA- GENA,	Carthagera,	Terra-firma,	S. Am.	77-00 W.	10-26 N.	
Carthage,	Tunis,	Barbary,	Africa	9-00 E.	36-30 N.	
CHARLES- TOWN,	Carolina,	North	Amer.	79-00 W.	32-30 N.	
Civita Vecch.	Pope's Territ.	Italy,	Europe	12-30 E.	42-05 N.	
Cochin,	Malabar,	East-India	Asia	75-00 E.	9-30 N.	
Cologn,	Cologn,	Germany,	Europe	6-40 E.	50-55 N.	
CONSTANTI- NOPE,	Romania,	Turkey,	Europe	29-15 E.	41-01 N.	
COPENHA- HAGEN,	Zeland,	Denmark,	Europe	13-00 E.	55-40 N.	
Corinth,	Morea,	Turky,	Europe	23-00 E.	37-30 N.	Cork,

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Towns.	Provinces.	Countries.	Quar- ters.	Longi- tude.	Latitude.
				D. M.	D. M.
Cork,	Munster,	Ireland,	Europe	8-25 W.	51-40 N.
Cracow,	Little Poland,	Poland,	Europe	19-30 E.	50-10 N.

D

D Amascus,	Syria,	Turky,	Asia	37-20 E.	33-15 N.
Dant- zick,	Prussia,	Poland,	Europe	19-00 E.	54-22 N.
Delft,	Holland,	Netherlands,	Europe	4- 5 E.	52- 6 N.
DELLY,	Delly,	East-India,	Asia	79-00 E.	28-00 N.
Delphos,	Achaia,	Turky,	Europe	22-15 E.	38-30 N.
Dettingen,	Wetteravia,	Germany,	Europe	8-45 E.	50- 8 N.
Dieppe,	Normandy,	France,	Europe	1-15 E.	49-55 N.
DOMINGO St.	Hispaniola	Island,	Americ.	70-00W.	18-20 N.
Dover,	Kent,	England,	Europe	1-25 E.	51-10 N.
DRESDEN,	Saxony,	Germany,	Europe	13-36 E.	51-00 N.
Drontheim,	Drontheim,	Norway,	Europe	10-30 E.	67-00 N.
DUBLIN,	Leinster,	Ireland,	Europe	6-25W.	53-16 N.
Dunkirk,	Flanders,	Netherlands,	Europe	2-20 E.	51-00 N.

E.

E EDIN- BURGH,	Lothian,	Scotland,	Europe	3-00W.	56-00 N.
Embden,	Embden,	Germany,	Europe	6-45 E.	53-40 N.
Erzerum,	Turcomania,	Turky,	Asia	41-00 E.	40-00 N.
Exeter,	Devonshire,	England,	Europe	3-40W.	50-44 N.

F

F E, St.	New	Mexico,	Amer.	109-00W.	36-00 N.
Ferrol,	Gallicia,	Spain,	Europe	8-40W.	43-30 N.
FEZ,	Fez,	Morocco,	Africa	6-00W.	33-30 N.
FLORENCE	Tuscany,	Italy,	Europe	12-15 E.	43-46 N.
Franckfort,	Weteravia,	Germany,	Europe	7-30-E.	50-10 N.
Friburg,	Friburg,	Switzerland,	Europe	6-55 E.	46-50 N.

G

G ENEVA,	Savoy,	Italy,	Europe	6-00 E.	46-12 N.
GENOA,	Genoa,	Italy,	Europe	9-30 E.	44-30 N.
Gibraltar,	Andalusia,	Spain,	Europe	6-00W.	36-00 N.
Glasgow,	Clyfdale,	Scotland,	Europe	4- 8W.	55-50 N.
		B b			Goa,

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Towns.	Provinces.	Countries.	Quar- ters.	Longi- tude. D. M.	Latitude. D. M.
Goa,	Malabar,	East-India,	Asia	73-20 E.	15-31 N.
Gottenburg,	Gothland,	Sweden,	Europe	11-30 E.	57-42 N.
Grenoble,	Dauphine,	France,	Europe	5-28 E.	45-12 N.

H.

H AGUE,	Holland,	Netherlands,	Europe	4-00 E.	52-10 N.
H AM- burgh,	Holstein,	Germany,	Europe	9-40 E.	54-00 N.
HANOVER,	Saxony,	Germany,	Europe	9-35 E.	52-32 N.
Havanna,	Cuba	Island,	Amer.	84-00W.	23-00 N.
Heidelberg,	Palatinate,	Germany,	Europe	8-40 E.	49-20 N.
Helena, St.	Helens	Island,	Africa	6-30W.	16-00 N.

I

J AMES- TOWN,	James County,	Virginia,	Amer.	76-00W.	37-30 N.
JERUSALEM,	Palestine,	Turky,	Asia	36-00 E.	31-50 N.
Ingoldstadt,	Bavaria,	Germany,	Europe	11-30 E.	48-45 N.
Inspruc,	Austria,	Germany,	Europe	11-26 E.	47-12 N.
ISPAHAN,	Iracagem,	Perfia,	Asia	50-00 E.	32-25 N.

K.

K ingston,	Jamaica,	American Isle,	—	77W.	17-30 N.
Konings- burgh,	Prussia,	Poland,	Europe	21-50 E.	5-40 N.

L.

L eghorn,	Tuscany,	Italy,	Europe	11-00 E.	43-30 N.
Leipfic,	Saxony,	Germany,	Europe	12-40 E.	51-19 N.
Lepanto,	Achaia,	Turky,	Europe	30-00 E.	38-00 N.
Leyden,	Holland,	Netherlands,	Europe	4-00 E.	52-09 N.
LIEGE,	Liege,	Westphalia,	Europe	5-36 E.	50-39 N.
LIMA,	Lima,	Peru,	S. Am.	76-00W.	12- 1 S.
Lille,	Flanders,	Netherlands,	Europe	3-00 E.	50-38 N.
LISBON,	Eitremadura,	Portugal,	Europe	9-25W.	38-42 N.
LONDON,	Middlesex,	England,	Europe	00-00	51-31 N.
Londonderry,	Ulster,	Ireland,	Europe	7-40W.	54-52 N.
Loretto,	Pope's Territ.	Italy,	Europe	15-00 E.	43-15 N.
LOUISBOURG,	Cape Breton	Island,	Amer.	61-30W.	46-54 N.

Lubeck,

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Towns.	Provinces.	Countries.	Quar- ters.	Longi- tude. D. M.	Latitude. D. M.
Lubeck,	Holstein,	Germany,	Europe	10-35 E.	54-20 N.
Lyons,	Lyonois,	France,	Europe	4-45 E.	45-46 N.
M.					
M ADRID,	New Castile,	Spain,	Europe	4-15 W.	40-25 N.
Mag- deburg,	Saxony,	Germany.	Europe	12-00 E.	52-25 N.
Mahon Port	Minorca	Island,	Europe	4-06 E.	39-51 N.
Majorca,	Majorca Isle,	Spain,	Europe	2-30 E.	39-30 N.
Malo, St.	Bretany,	France,	Europe	2-00 W.	48-40 N.
Malacca,	Malacca,	East-India,	Asia	100-00 E.	02-12 N.
Malaga,	Granada,	Spain,	Europe	4-45 W.	36-40 N.
Malta,	Malta Isle,	Mediterranean,	Europe	15-00 E.	35-54 N.
MANTUA,	Mantua,	Italy,	Europe	11-15 E.	45-20 N.
Marfeilles,	Provence,	France,	Europe	5-20 E.	43-15 N.
Martinico,	Martinico Isle,	West-Indies	Amer.	61-00 W.	14-30 N.
MECCA,	Mecca,	Arabia,	Asia	3-30 E.	21-20 N.
Mentz,	Mentz,	Germany,	Europe	8-00 E.	49-07 N.
Messina,	Sicily	Island,	Europe	15-40 E.	38-30 N.
MEXICO,	Mexico,	North	Amer.	105-00 W.	20-00 N.
MILAN,	Milanese,	Italy,	Europe	9-30 E.	45-28 N.
Mocho,	Mocho,	Arabia Felix,	Asia	45-00 E.	13-00 N.
MODENA,	Modena,	Italy,	Europe	11-20 E.	44-34 N.
Montpelier,	Languedoc,	France,	Europe	3-50 E.	43-36 N.
MOSCOW,	Moscow,	Russia,	Europe	38-00 E.	55-45 N.
Munster,	Westphalia,	Germany,	Europe	7-10 E.	52-00 N.
MUNICH,	Bavaria,	Germany,	Europe	11-32 E.	48-02 N.
N.					
N Amur,	Namur,	Netherlands,	Europe	4-50 E.	50-30 N.
NANCY,	Lorraine,	Germany,	Europe	6-00 E.	48-41 N.
Nanking,	Nanking,	China,	Asia	118-30 E.	32-00 N.
NAPLES,	Lavora,	Italy,	Europe	15-00 E.	40-50 N.
Naifau,	Upper Rhine,	Germany,	Europe	7-25 E.	50-21 N.
Norwich,	Norfolk,	England,	Europe	1-26 E.	52-40 N.
Nuremberg,	Franconia,	Germany,	Europe	11-00 E.	49-27 N.

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Towns.	Provinces.	Countries.	Quar. Longi- ters. tude.	Latitud D. M. D. M.
O				
Oczacow,	Tartary,	Turky,	Europe 35-00 E.	46-00 N.
Orange,	Provence,	France,	Europe 4-46 E.	44-10 N.
Osnabrug,	Westphalia,	Germany,	Europe 7-40 E.	52-31 N.
Ostend,	Flanders,	Netherlands,	Europe 2-45 E.	51-15 N.
Oxford,	Oxfordshire,	England,	Europe 1-15 E.	51-45 N.
P				
Padua,	Venice,	Italy,	Europe 12-25 E.	45-22 N.
Paita,	Peru,	South	Amer. 80-00 W.	5-00 S.
PALERMO,	Mazara,	Sicily Isle,	Europe 13-00 E.	38-30 N.
Palmyra,	Syria,	Turky,	Asia 39-00 E.	33-00 N.
Panama,	Darien,	Terra-firma,	Amer. 82-00 W.	9-00 N.
PARIS,	Ile of France,	France,	Europe 2-25 E.	48-50 N.
PARMA,	Parmefan,	Italy,	Europe 11-00 E.	44-45 N.
Pavia,	Milaneze,	Italy,	Europe 9-40 E.	45-15 N.
PEGU,	Pegu,	East-India,	Asia 97-00 E.	17-30 N.
PEKING,	Peking,	China,	Asia 111-00 E.	39-54 N.
St. PETERS- BURG,	Ingria,	Russia,	Europe 31-00 E.	60-00 N.
PHILADEL- PHIA,	Pensylvania,	North	Amer. 74-00 W.	40-50 N.
Pisa,	Tuscany,	Italy,	Europe 11-15 E.	43-43 N.
Plata,	Plata,	South	Amer. 66-30 W.	22-30 S.
Plymouth,	Devon,	England,	Europe 4-27 W.	50-26 N.
Pondicherry,	Coromandel,	East-India,	Asia 80-00 E.	11-56 N.
Port l'Orient,	Bretany,	France,	Europe 3-15 W.	47-42 N.
Porto, or Oporto,	Entreminho Douro,	Portugal,	Europe 9-00 W.	41-10 N.
Porto Bello,	Darien,	Terra-firma,	Amer. 82-20 W.	9-33 N.
Porto Rico,	Porto Rico	Island,	Amer. 65-00 W.	18-00 N.
PORT ROYAL	Jamaica	Island,	Amer. 77-00 W.	17-30 N.
Portsmouth,	Hampshire,	England,	Europe 1-6 W.	50-48 N.
Potosi,	Los Charcas,	Peru,	Amer. 67-00 W.	22-00 S.
PRAGUE,	—————	Bohemia,	Europe 14-20 E.	50-00 N.
PRESBURG,	Upper	Hungary,	Europe 17-30 E.	46-40 N.
Pyrmont,	Lyppe,	Germany,	Europe 9-00 E.	52-00 N.
Q				
QUEBEC,	French	Canada,	N. Am. 74-00 W.	47-35 N.
Quito,	Quito,	Peru,	S. Am. 78-00 W.	00-13 S.
				Ramillies,

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Towns.	Provinces.	Countries.	Quar- ters.	Longi- tude.	Latitude.
				D. M.	D. M.
R.					
R Amillies,	Brabant,	Netherlands,	Europe	4-50 E.	50-46 N.
Ratifbon,	Bavaria,	Germany,	Europe	12- 5 E.	49-00 N.
Ravenna,	Romania,	Italy,	Europe	13-00 E.	44-30 N.
R HODES,	Rhodes	Island,	Asia	28-00 E.	36-20 N.
Rochelle,	Orleanois,	France,	Europe	1- 5W.	46- 9 N.
Rotterdam,	Holland,	Netherlands,	Europe	4-20 E.	52-00 N.
Rouen,	Normandy,	France,	Europe	1- 6 E.	49-26 N.
Rome	Pope's Territ.	Italy,	Europe	13-00 E.	41-54 N.
S.					
S ALANKA- MEN	Ratfcia,	Sclavonia,	Europe	21-00 E.	45-20 N.
Salisbury,	Wiltshire,	England,	Europe	551-W.	51- 6 N.
Salonichi,	Macedon,	Turky,	Europe	24-00 E.	41-10 N.
S AMACRAND,	Ushc	Tartary,	Asia	66-00 E.	40-00 N.
Samos,	Samos Isle,	Turky,	Asia	27-30 E.	37-30 N.
Saragoffa,	Arragon,	Spain,	Europe	1-15W.	41-32 N.
Scanderoon,	Syria,	Turky,	Asia	37-00 E.	36-15 N.
Seville,	Andalusia,	Spain,	Europe	6-00W.	37-15 N.
Sheerness,	Kent,	England,	Europe	00-50 E.	51-25 N.
S IAM,	Siam,	East-India,	Asia	101-00 E.	14-18 N.
Smyrna,	Natolia,	Turky,	Asia	27-00 E.	38-28 N.
Spaw,	Liege,	Germany,	Europe	5-50 E.	50-32 N.
S TOCKHOLM,	Uplandia,	Sweden,	Europe	18-00 E.	59-20 N.
S TRASBURG,	Alface,	Germany,	Europe	7-35 E.	48-35 N.
Suez,	Suez,	Egypt,	Africa	34-30 E.	30-00 N.
S URAT,	Cambaya,	East-India,	Asia	72-20 E.	21-10 N.
S URINAM,	Surinam,	South	Amer.	56-00W.	6-30 N.
Syracuse,	Sicily	Island	Europe	15- 5 E.	37-25 N.
T.					
T Angier,	Fez,	Morocco,	Africa	7-00W.	35-40 N.
T EME- SWAER,	Temefwaer	Bannat,	Europe	22-00 E.	45-55 N.
Tetuan,	Fez,	Morocco,	Africa	6-35W.	35-40 N.
Thoulon,	Provence,	France,	Europe	6-00 E.	43- 5 N.
Tinmouth,	Northumber- land,	England,	Europe	1-00W.	55-00 N.
T OBOLSKI,	Siberia,	Russia,	Asia	63--00 E.	58-12 N.
T OLEDO,	New Castile,	Spain,	Europe	4-12W.	39-50 N.
Tornez,	Torne,	Lapland,	Europe	22-45 E.	65-51 N.
Tortofa,	Catalonia,	Spain,	Europe	00-15 E.	40-45 N.
T RENT,					

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Towns.	Provinces.	Countries.	Quar- ters.	Longi- tude.		Latitude.
				M. D.	M. D.	
TRENT,	Trent,	Italy,	Europe	11-00 E.	46-5 N.	
TRIERS, Treves,	or Treves,	Germany,	Europe	6-10 E.	49-55 N.	
TRIPOLI, Tripoil,	Tripoli, Syria,	Barbary, Turkey,	Africa	14-30 E.	32-54 N.	
Troy Ruins,	Natolia,	Turkey,	Asia	36-15 E.	34-30 N.	
TUNIS,	Tunis,	Barbary,	Asia	26-30 E.	39-30 N.	
TURIN,	Piedmont,	Italy,	Africa	10-00 E.	36-20 N.	
Tyre,	Palestine,	Turkey,	Europe	7-16 E.	45-04 N.	
			Asia	36-00 E.	32-32 N.	

V.

Valencia,	Valencia,	Spain,	Europe	00-35 W.	39-20 N.	
VENICE,	Venice,	Italy,	Europe	13-00 E.	45-25 N.	
Vera Cruz,	Tlafcala,	Mexico,	Amer.	100-00 W.	18-30 N.	
Verona,	Venice,	Italy,	Europe	11-15 E.	45-26 N.	
Verfailles,	Isle of France,	France,	Europe	2-15 E.	48-48 N.	
VIENNA,	Austria,	Germany,	Europe	16-20 E.	48-13 N.	
ULM,	Swabia,	Germany,	Europe	10-00 E.	48-24 N.	
Upfal,	Upland,	Sweden,	Europe	17-30 E.	60-00 N.	
Utrecht,	Utrecht,	Netherlands,	Europe	5-00 E.	52-7 N.	

W.

WAR- SAW,	Warfovia,	Poland,	Europe	21-5 E.	52-14 N.	
Waterford,	Waterford,	Ireland,	Europe	7-00 W.	52-12 N.	
Weymouth,	Dorsetshire,	England,	Europe	2-34 W.	50-40 N.	
Whitehaven,	Cumberland,	England,	Europe	3-16 W.	54-30 N.	
WILLIAMS- BURG,	—————	Virginia,	Amer.	76-30 W.	37-20 N.	
Wittenburgh,	Saxony,	Germany,	Europe	12-20 E.	53-20 N.	
Worms,	Palatinate,	Germany,	Europe	8-05 E.	49-38 N.	

Y.

YARMOUTH, YORK, NEW,	Norfolk, York,	England, North	Europe	2-00 E.	52-45 N.	
			Amer.	72-30 W.	41-00 N.	

Z.

ZELL,	Saxony,	Germany,	Europe	10-50 E.	52-52 N.	
ZURICH,	Zurich,	Switzerland,	Europe	8-30 E.	47-52 N.	

CHAP.



C H A P. VI.

*Concerning the True FIGURE, and
MAGNITUDE of the EARTH, with
the Proportion of LAND and WATER
on its SURFACE.*

I T appears to me necessary to say something concerning the *true* FIGURE of the EARTH; for tho' the Form of it be very nearly *spherical* or *globular*, yet it is not really so, but is of that Figure which is produced by a *Semi-ellipsis* revolving about its *shortest Diameter*; and which is usually called an *Oblate Ellipsoid*; so that it is to be understood from hence, that the *Axis* of the Earth is less, or shorter, than the *Diameter* of the EQUATOR, whereas in a *Globe*, all the *Diameters* are equal.

As the *true* FIGURE of the EARTH is the very FIRST PRINCIPLE of GEOGRAPHY, so as an Article of SCIENCE, it is fit the young Student should have proper Ideas of it, especially as in former Ages it was not known at all;

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all; and in the present Century it has been so compleatly discovered as to have left scarce a Possibility of Improvement therein by any of our *Posterity*. It is also necessary to exhibit an Idea of the proper *Figure of the Earth*, to prevent any wrong Conclusions from a constant View of the *Terrestrial Globe* in a true *spherical Figure*. To these we may add the very interesting Consequences of knowing the real Figure of the Land and Sea, for perfecting the Sciences of *Geodesia*, *Astronomy*, and *Navigation*, as they are intimately connected therewith.

It is very surprizing to consider how universally all the Ancients supposed the Earth to be only a *plain Surface of Land and Water*, extended every Way indefinitely; a Form which common Sense revolts against on every Account; for (1.) The *globular Figure* of the *Ocean* presents itself notoriously to the View of every Person upon the Sea-Beach. (2.) The *gradual Disappearance* of all Objects on the Sea, as they are viewed from the Shore; as first the *Hull of a Ship*, then the *Masts*; and lastly, the *Streamers* and *Pennants*; whereas, if the Ship moved on a plain Surface, all Parts would become indistinct and vanish from the Sight at once, and that at a vastly greater Distance than where the Ship disappears. (3.) The same thing is observed of Objects on Land by the *Sailors* at SEA, in their *gradual Loaming*,
Disap-

Disappearing, &c. (4.) The *Section of the Earth's Shadow* on the Surface of the Moon in a *Lunar Eclipse*, being *circular*, plainly proves it must proceed from a Body of a *globular Form*. (5.) The *Distance of two Hundred Million of Miles* on a *plain Surface*, would cause no sensible Alteration in the *Height of a Star*, as we know by the *North Pole Star* being of the same Altitude in the 20th of *June* and *December*; whereas if you go but $69\frac{1}{2}$ Miles on the *Meridan* of the EARTH, you alter the Star's Altitude *one whole Degree*; an indisputable Proof of the Earth's *Rotundity*, or *spherical Figure*. How these, and many other *obvious and natural Demonstrations* of the *Earth's Figure* could escape the Notice not only of the *Vulgar*, but even the *Sages of ancient Times*, is equally amazing, as it is perfectly ridiculous to make the *Earth's true Figure* (much more the *false one*) an *Article of Faith necessary to Salvation by the Decrees of modern Councils*.

The *physical CAUSE* which produces a Figure of the Earth a little different from that of a SPHERE or *perfect GLOBE*, is the *Centrifugal FORCE* arising from the great *Velocity* of the Parts of the Earth about the *Axis of Motion*; it is the same Force which a Stone in a Sling is known to acquire by being swiftly whirled round in a *circular Manner*, and by which it has a strong

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Endeavour to recede or fly from the *Hand,*
or *Center of Motion.*

Just so all the Parts of the Earth endeavour to fly off from the Axis of Motion, and would actually do so if they were not kept together by a far superior Force, viz. that of GRAVITY; by which they constantly *tend towards the Earth's Center*, and is therefore called the *Centripetal FORCE*.

When a strong and a weak Force act against each other, the Effect of the former will be lessened by the latter; and as the *Centrifugal Force* is greatest in Parts about the Equator, where the Distance from the Axis is greatest of all, so the Force of Gravity will there be most of all abated by it, and consequently all those Parts *receded farther from the Center* when the Earth was first put into Motion; and all the Parts of the Earth being connected by a *mutual Cohesion*, as the *Equatoreal Parts* receded, the *Polar Parts* would *accede towards the Center*; and so the extreme Parts of the Earth must indue a *Figure or Shape* somewhat different from that of a *Globe or Sphere*, that is, it must be a SPHEROID.

It is well known from the PRINCIPLES of *Physical GEOMETRY*, that the Proportion of *Gravity to the Centrifugal Force*, is as 289 to 1, under the Equator; and the latter decreases towards the Poles in Proportion

and MAGNITUDE of the EARTH. 185
tion to *the Squares of the Cosines of the Latitudes*; and therefore under the Poles it destroys nothing of the Power of Gravity, which has there its full Force.

Now because Gravity encreases from the *Equator to the Poles*, it will sensibly influence the Motion of long *Pendulums* by *encreasing and diminishing their Weight*, as they are carried toward the Poles or the Equator; for their Weight being greater, they vibrate quicker, and *vice versa*; therefore a Clock whose Pendulum vibrates *Seconds* here at *London*, will not do so at the Equator, where Gravity is less, for there it will vibrate slower, and the Clock will *lose Time of Course*.

Indeed, it was the *stiff going* of a *Pendulum Clock*, which first gave a Hint of the *variable Force of Gravity* in different Latitudes; for in the Year 1672, Mr. *Richer* carried a Clock from *Paris* to *Cayenne*, in North Lat. $4^{\circ} 56' 17''$, where he found that in order to its beating *Seconds of mean Time*, he was obliged to shorten the Pendulum *one Line and a Quarter*, or a little more than a *Tenth of an Inch*; which plainly proved, that Gravity was sensibly less there than at *Paris* or *London*.*

The PHILOSOPHERS and MATHEMATICIANS being at Length sufficiently appri-

* See my INSTITUTIONS of CLOCK-WORK, Chap. xiv. and xv, in Vol. II. of *Mathematical INSTITUTES*.

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sed that the Earth was not truly a *Sphere*, were determined to be satisfied, if possible, how much it differed from that Figure, by actual MENSURATION; for they well knew if the Figure was not *spherical*, the *Degrees of the Meridian could not be equal in different Latitudes*, but must be less near the Equator, and larger towards the Poles, where the Earth was flatter.

Accordingly, the arduous and unprecedented Task was undertaken, and a Degree was measured in many different Parts of the Meridian, with such Success as fully answered Expectation; and that the Reader may have some Idea of their Measurements, I shall just mention the principal Ones, which were the following:

In the Year 1718, the famous CASSINI measured the *Length* of the *Meridian* thro' FRANCE, which gave the *Length of a Degree* in the Parallel of $49^{\circ} 22'$ equal to 57183 *Toises*.

In the Year 1735, by the joint Order of the KINGS of FRANCE and SPAIN, a DEGREE was measured at *Quito* in PERU, in Lat. $1^{\circ} 10'$, and was found there equal to $56767\frac{4}{5}$ *Toises*.

In the Year 1736, by the *French KING's* Order, a Degree was measured at the *Arctic Circle*, and found to contain 57438 *Toises*. Note, 824 *Toises* are equal to an *English Mile*.

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From these several Measures of a Degree in the different Parts of the Meridian, it is found by Calculation*, that the Ratio of the *Axis of the Earth* to a *Diameter of the Equator* is as 1019 to 1024. And it is from thence also found, that the *Axis of the Earth* is 7932 Miles, and a *Diameter of the Equator* 7971, which therefore exceeds the *Axis* by 39 Miles.

By the same Calculation it is also found, that a Degree at the Pole exceeds a Degree at the Equator by 830 Toises, or a little more than an *English Mile*. It thereby also further appears, that a Degree of the Meridian in the Parallel of $54^{\circ} 44'$ is equal to a *Degree in the Equator*, which exceeds the *first Degree of the Meridian* by 546 Toises, or $\frac{2}{5}$ of a Mile.

If we add the Toises in the two *extreme Degrees* of the Meridian, half the Sum will be 57041, the Length of a *Mean Degree*, or Degree in the Meridian of a GLOBE just equal in Bulk to our *ellipsoide Earth*. Then divide 57041 by 824, and the Quotient $69 \frac{227}{1000}$ will be the Length of a Degree in a Great Circle of such a Globe; which multiplied by 360 will give 24922 Miles for the Circumference of a Globe equal to the Earth; whose Diameter therefore will be 7933 *English Miles* †.

* See MARINER'S MIRROR, Part I. Pages 15, 16, 17.

† In my SURVEY of the SOLAR SYSTEM, Page 5. This Diameter (by a different *Calculus*) comes on $17951\frac{1}{2}$.

The

186 Concerning the True FIGURE,

The DIAMETER of the Earth being known, the *Square Miles* contained in its Surface will be 197706226 ; and its Solid Content in *Cubic Miles* will be upwards of 26139500000, or near 26140 Millions.

Our EARTH is called the *Terraqueous GLOBE*, because its *Surface* consists of LAND and WATER. As the LAND appears in very unequal and irregular Parcels, under the Names of *Continents, Islands, Capes, Isthmus, &c.* and the same may be said of the WATER, the Method of estimating the Quantity of each will appear something problematical, as it can be subject (under such Circumstances) to none of the common RULES of *Mathematical COMPUTATION*.

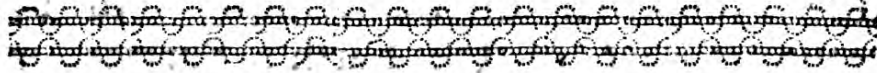
But this is only one Case out of many, where PHILOSOPHY approves itself the *genuine and most universal GEOMETRY*, for the *Weight* of Bodies *more truly* than their *Dimensions* gives us the Measure, and consequently the *Ratio* of their Quantities. Thus in the present Case, suppose, in the Papers that cover the *Artificial Globe*, those Parts which represent *Land* were carefully cut out with a Pair of Scissars, and their Weight in *Grains* taken in a nice Ballance ; and afterwards, the Weight of all the Parts remaining denoting *Water*, the Number of Grains which each Parcel weighed would exactly express the Ratio of the Quantity of Matter in the Paper ; and consequently give
the

and MAGNITUDE of the EARTH. 187

the Proportion of the *terrestrial* to the *aqueous Part* of the Earth's Surface, as far as they have been hitherto discovered. This I have carefully performed with my own Hands in the Papers which make the Surface of Mr. Senex's 28-Inch Globe, and the Paper representing all the *Continents, Islands, &c.* weighed 367 Grains, and the Residue for the *Ocean, Seas, Gulphs, &c.* weighed 1125 Grains. The Weight therefore of the whole was 1492 Grains, a fourth Part of which is 373 Grains, which is more than the Weight of the Land 367, though very near it. Therefore the Ratio of the *Land to Water* is as 1 to 3, or the *Land* is $\frac{1}{4}$ of the *Earth's Surface* very nearly.

This Distribution and Proportion of *Land* and *Water*, is a most signal Instance of the WISDOM of GOD in the WORKS of CREATION. For thus the EARTH is rendered a fit Habitation for *rational, social, and Commercial Agents*; the Oceans and Seas affording a free Intercourse between the most distant nations; at the same Time that they supply a just Quantity of VAPOURS, for the Formation of CLOUDS, to *water the Surface of the Earth*, for the Purposes of every *Species* of LIFE and VEGETATION that the infinitely wise AUTHOR of NATURE has made necessary.

CHAP.



C H A P. VII.

The DESCRIPTION *and* USE *of a New*
 MANUAL ORRERY, *or* PLANETARIUM.

THE Price of *Orreries* (as they
 are usually made) being very
 great, is one Reason why this
 most useful MACHINE is not so
 common, as one might wish, on
 Account of its great Service in convey-
 ing an easy and adequate Idea of the *true*
 CONSTITUTION of the SYSTEM of the
 WORLD, and, of Course, the First PRIN-
 CIPLES of ASTRONOMY and GEOGRAPHY
 so essential a Part of *Education* which our *Eng-
 lish* Youth should have. In order to remove
 this Difficulty, I have contrived a *Manual*
 ORRERY, that shall come at a small Price,
 and will readily shew what is, and what is
 not the true System of the World, with its
 various *Phænomena*, or Appearances of DAY
 and NIGHT, Vicissitude of the SEASONS,
 Nature of ECLIPSES, &c. as will be easy to
 apprehend from an Account of its Structure
 and various Uses, as follows.

I. This Machine is made to represent the
 **Ptolemaic System*, or such as is vulgarly re-

* So called from *Ptolemy*, a celebrated Astronomer of *Alex-
 andria*, in EGYPT, who died A. D. 147.

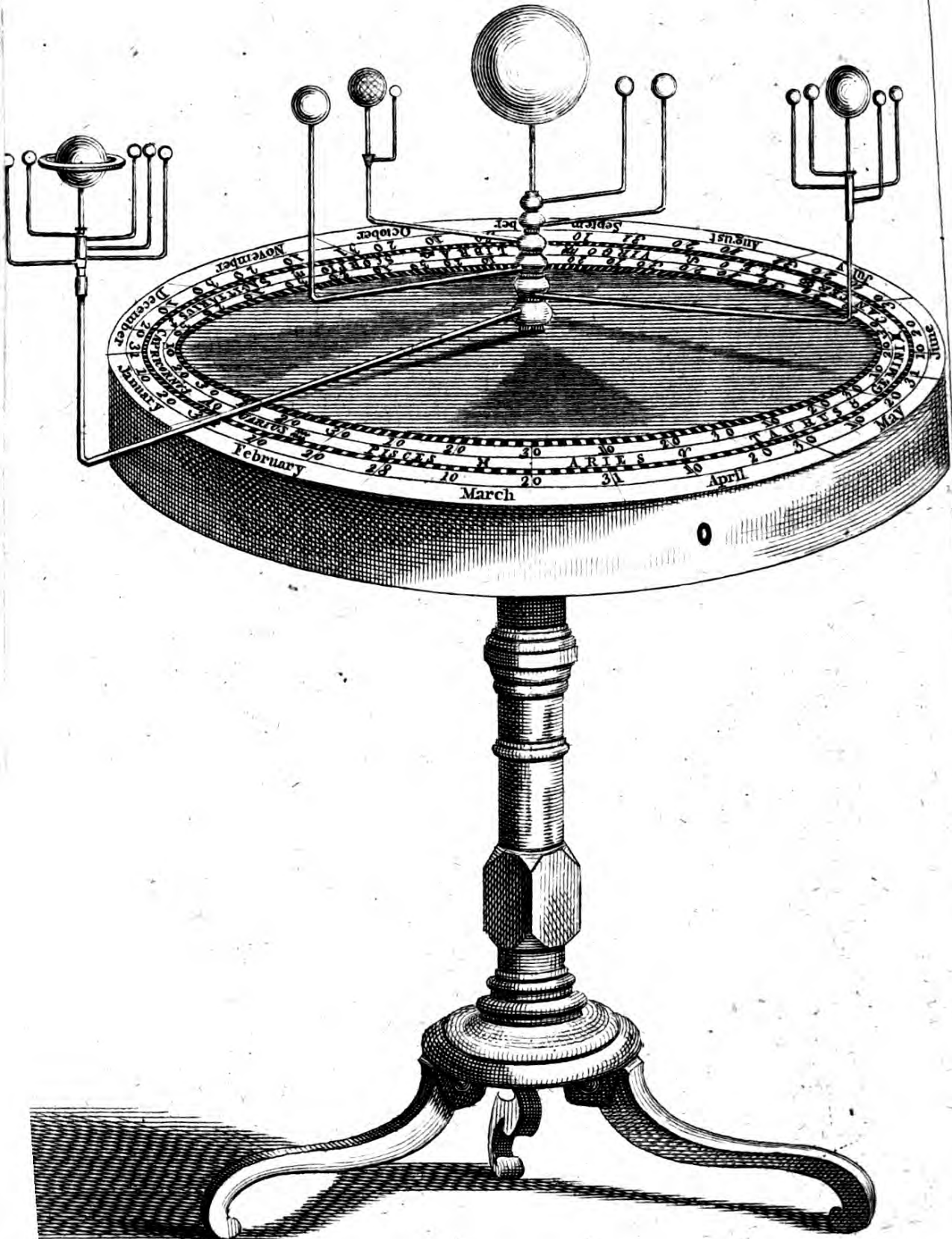
ceived,

THE UNIVERSITY OF CHICAGO

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A NEW ORRERY by CLOCK-WORK.

Plate V.



ceived, which places the Earth in the Center, and the Planets and Sun revolving about it. And at the same Time affords a *most manifest Confutation* of it. For you plainly see, in this Construction, (1.) That the Planets *Mercury* and *Venus*, being both *within the Orbit of the Sun*, cannot be seen at any Time to go behind it; whereas we observe them as often to go behind, as before the Sun, in the Heavens. (2.) It shews, that as the Planets move in *Circular Orbits* about the Central Earth, they ought at all Times to be of the *same apparent Magnitude*; whereas, on the contrary, we observe their apparent Magnitude in the Heavens to be very variable, and so far different, that (for Instance) *Mars* will sometimes appear as big as *Jupiter* nearly, and at other Times you will scarce know him from a *fixed Star*. (3.) It shews, that any of the Planets might be *seen at all Distances* (from the Sun) in the Heavens, or, in other Words, that when the Sun is setting, *Mercury* or *Venus* may be seen not only in the *South*, but even in the *East*; which Things were never yet observed. (4.) You see, by the *Planetarium*, that the Motions of the Planets should always be *regular* and *uniformly the same*; whereas, on the contrary, we observe them always to move with a variable Velocity; sometimes *faster*, then *slower*, and sometimes *not at all*. (5.) By the Machine you see

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the Planets move all the *same Way*, viz. from *West to East* continually. But in the Heavens we see them move sometimes *direct* from *West to East*; sometimes *Retrograde*, from *East to West*, and at other Times to be *Stationary*. All which *Phænomena* plainly prove this System to be a *false and absurd Hypothesis*.

II. The Truth of the *Copernican*,* or SOLAR SYSTEM of the WORLD, which places the Sun in the Center, and the Earth among the Planets, is hereby most clearly represented. For taking the *Globe of the Earth* from the Center, and placing thereon a *large gilt Ball* for the SUN, and restoring the Earth to its proper Situation among the Planets, then every Thing will be right, and agree exactly with celestial Observations. For turning the Winch, (1.) you will see the Planets *Mercury* and *Venus* go both *before* and *behind the Sun*, or have two Conjunctions. (2.) You will observe *Mercury* never to be more than 21° , and *Venus* 47° , from the Sun. (3.) That the Planets, and especially *Mars*, will be sometimes *much nearer to the Earth* than at others, and therefore must appear *much larger* at one Time

* So called from NICHOLAS COPERNICUS, a most learned ASTRONOMER of *Russia-Royal*, who revived this System (formerly taught by the School of *Pythagoras*) and proved the Truth of it beyond all Dispute, and to the entire Satisfaction of the Pope and Cardinals. See *Biographia Philosophica*.

than

than at another. (4.) You will see that the Planets cannot appear at the Earth to move with an *uniform Velocity*; for when *nearest*, they appear to *move faster*; and *slower*, when most *remote*. (5.) You will observe the Planets will appear at the Earth to move sometimes *directly* from *West* to *East*; and then to become *retrograde* from *East* to *West*; and between both, to be *Stationary*, or without any apparent Motion at all. Which Things all correspond exactly with Observations, and fully prove the TRUTH of this excellent System.

III. All the *Primary* PLANETS are here disposed about the Sun, and all the *Secondaries* or *Satellites*, about their *Primaries*, in such Order as we see them in the Heavens. Again, you may here represent the System in two Parts, *viz.* of the *inferior Planets*, and of the *superior*; and then the true comparative Distances of each Planet from the Sun, and among themselves, may be seen; and many very curious Things observed, which depend thereon; as the true *Heliocentric*, and *Geocentric Places*, the *Parallatic Angle*, the *Elongation*, and the true Proportion of *Distance* from the Sun, &c. which are the very *Fundamentals* of ASTRONOMY; and are here known, as it were, by Inspection only.

IV. By this Machine you at once see all the Planets in Motion about the Sun with

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the same respective *Velocities*, and *Periods of*
Revolution which they have in the Heavens.
The Work being calculated to a *Minute of*
Time, from the latest *Discoveries*.

Thus	}	<i>Mercury</i>	}	3600000	}	87.	23.	16
		<i>Venus</i>		6700000		224.	16.	49
		<i>Earth</i>		9300000		365.	6.	9
		<i>Mars</i>		14200000		686.	23.	27
		<i>Jupiter</i>		48600000		4332.	12.	20
		<i>Saturn</i>		89100000		10759.	6.	36

And here also the Great and General Law of the Planetary Motions may be observed, *viz.* That every where the Squares of the Periodical Times are proportional to the Cubes of the Distances respectively.

V. You will see here a Demonstration of the *Earth's Motion* about the SUN, as well as those of the Rest of the Planets; for if the Earth were to be at Rest in the Heavens, then the Time between any two *Conjunctions* of the same Kind, or *Oppositions*, would be the same with the *Periodical Time* of the Planets, *viz.* 88 Days in *Mercury*, 225 in *Venus*, &c. Whereas you here observe, this Time instead of being 225 Days, is no less than 583 Days in *Venus*; occasioned by the Earth's moving in the mean Time about the Sun the same Way with the Planet. And this Space of 583 Days always passes between two like *Conjunctions* of *Venus* in the Heavens,

Heavens. Hence the most important Point of Astronomy is satisfactorily demonstrated.

VI. The *Diurnal Rotation* of the Earth about its Axis, and a *Demonstration of the Cause of the different Seasons of the Year, and different Lengths of Day and Night*, are here answered by placing the Earth in the Center on an Axis inclined to that of the Ecliptic in an Angle of $23 \frac{1}{2}$ Degrees, and making the Sun move about it through all the Signs of the Ecliptic; then will all the Variety of Seasons appear from the same Causes as in the common Orreries, *viz.* from the *different Inclination of the Sun's Rays*; (2.) the *different Quantity* thereof which falls on a *given Space*; (3.) the *different Quantity of the Atmosphere* they pass thro'; and (4.) the *different Continuance of the Sun above the Horizon* at the same Place in different Times of the Year; which Particulars constitute the Difference betwixt *Heat and Cold* in SUMMER and WINTER SEASONS.

VII. As the Glóbe of the Earth is moveable about its inclined Axis, so by having the Horizon of *London* drawn upon the Surface of it, and one half (*viz.* that opposite the Sun) always covered with an Hemisphere of *black Crape*; you will here (more *naturally* than in any *other Orrery*;) see the Cause of the *different Lengths of DAY and NIGHT*, by observing the unequal Portions of the Circle which the Island of *Great Britain*,

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tain, or the City of LONDON (or any other Place) describes in the light and dark Hemispheres, at different Times of the Year, by turning the Earth on its Axis with the Hand.

VIII. As to the ECLIPSES of the *Sun* and *Moon*, the true Causes of them are here very clearly seen; for when the Moon is placed in a right Line between the Centers of the Sun and Earth, her *Shadow* (by Candle-light) will fall on the Earth, and all who live on that Part over which the Shadow passes will see the *Sun eclipsed* more or less. On the other Side, the Moon passes (in the aforesaid Case) through the *Shadow* of the *Earth*, and is by that Means *eclipsed*. And the Mechanism of this Orrery is such, that any one who has a Mind to do it, may easily represent the due POSITION and NODES of the *Moon's Orbit*; and thence shew when there will or will not be an *Eclipse* of either *Luminary*; and what the Quantity of each will be; but this Affair I leave to the Purchaser, as it will encrease the Price.

IX. While the Moon is moving about the Earth in the Center; if a *Candle*, or rather a *glass Lamp*, be placed at a proper Distance to enlighten the Earth and Moon, you will see all the Phases of the Moon, as *new*, *dichotomized*, *gibbous*, *full*, *waning*, &c. just as they appear in the Heavens. You will moreover

A New MANUAL ORRERY. 195

moreover observe all the same Phases of the Earth as they appear at the Moon.

X. The SATELLITES of JUPITER and SATURN are moveable only by the Hand; yet may all their *Pbænomena* be easily represented excepting the true relative Motions and Distances, thus: If that gilt *Globe* which before represented the SUN, be made now to denote *Jupiter*, and four of the Primary Planets only be retained, then will the *Jovian* System be represented; and by Candle-light you will see (the Machine being in Motion) the *Immersion*s and *Emersion*s of the Satellites into and out of *Jupiter*'s Shadow. You will see plainly the Manner in which they *transit* *his Body*; and their *Occultations* behind it. You will observe the various Ways in which *one or more* of those Moons may at Times *disappear*. And if the Machine be set by a white Wall, &c. then, by the *Projection* of their *Shadows*, will be seen the Reasons why those Moons always appear on each Side *Jupiter* in a *Right Line*; why those which are *most remote may appear nearest*, and *è contrario*. And the same may be done for *Saturn*'s Five Moons, and his Ring. And the Expence would be but trifling to have Arms of a proper Length for the true Proportional Distances of the Satellites.

XI. The Machine is not only ornamented, but rendered more generally useful, by the Plate I some Years ago published under the
Title

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Title of SYNOPSIS SCIENTIA COELESTIS; which is here made the Basis of the Orrery, having the SOLAR SYSTEM in the Center; the Earth in eight different Positions about the Sun; the Circular CALENDAR of MONTHS and DAYS for the *Old and New Stile*; over which the Planets move, and by which their Motions may be compared and estimated. Then follow various Astronomical Circles, viz. *Right Ascension, Declination, Amplitude, Equation of Time, Twilight, Phases of Saturn's Ring during his whole Period, &c.* with their several Uses in the Sphere, all in one View; and, lastly, a large and beautiful ECLIPTIC of the *Twelve SIGNS* here makes the *Solar Horizon*, wherein the Place of the Sun, and Heliocentric Places of all the Planets are at any Time to be shewn.

XII. Lastly, That *Grand Phænomenon*, the *Revolution of the Pole of the World* about the *Pole of the Ecliptic* in a retrograde Manner, in the Space of 25920 Years, (called the *Great PLATONIC YEAR**) may here also be represented; and, of Course, the *Recession of the Equinoctial Points*, the *Motion of the Stars* apparently forward through all the Degrees of the Ecliptic; the *Anticipation or Precession of the Equinoctial Days*,

* So call'd from PLATO, the Disciple of SOCRATES, who is said to have first observed this *apparent Motion of the Stars*; he died in the first Year of the 108th Olympiad, on his *Birth-Day*, in the 81st Year of his Age.

and

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and the *Mutation of Seasons* through all the Calendar, with many other Particulars, will by this Means be shewn, and the *Rationale* of those otherwise mysterious Subjects will evidently appear.

The Inquisitive Reader will see much more on this Subject in my DESCRIPTION and USE of an ORRERY of a *New CONSTRUCTION*, lately published. Also in my SURVEY of the SOLAR SYSTEM, he will find all the DIMENSIONS thereof reduced to ENGLISH STATUTE MILES. And in my LECTURE on the ORRERY, the *Mundane SYSTEM* in all its Parts, is represented and illustrated by SEVEN *different MACHINES*, which conduce more to form a just Idea thereof than any Reading can do.



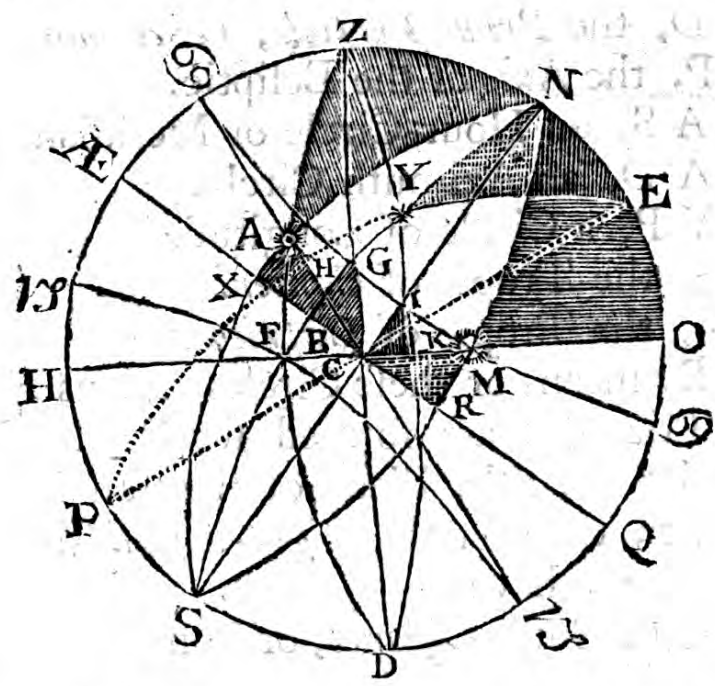


C H A P. VIII.

The METHOD of forming all Kinds of Spherical TRIANGLES on the SURFACE of the GLOBE, used in the SOLUTION of the most considerable PROBLEMS in GEOGRAPHY, ASTRONOMY, DIALLING, NAVIGATION, &c. with the Rationale of the same.

1. *AS* Spherical TRIGONOMETRY is the Ground-work of all the Practice and Calculations in the above-mentioned most useful Sciences, so by the SPHERE or GLOBE, the Origin, Nature, and Formation of *this Kind* of TRIANGLES become most evident, and easy to be understood; and consequently the *Rationale* of this, the noblest of all Sciences, will most readily result from a *bare Speculation* of the Nature and various POSITIONS of the CIRCLES of the SPHERE and GLOBES.

2. By MERIDIANS from the *Poles* of the *World*, CIRCLES of LATITUDE from the *Poles*



Poles of the Ecliptic, and the QUADRANT of ALTITUDE, as a general Verticle Circle, various Interfections are produced, and thereby numerous spherical TRIANGLES will be formed, as will be evident from the annexd PROJECTION of the SPHERE in Plano for the Latitude of LONDON ; wherein

Z is the Zenith of the Observer.

N, S, the North and South Poles of the World.

E, P, the Poles of the Ecliptic.

A, Y, Z, the Places of the Sun, Star, City, Ships, &c.

Æ N Q S, the General Meridian.

N S, the Axis of the Sphere.

Æ Q, the Equinoctial Line.

H O, the Horizon of London.

⊗ C ∨, the Ecliptic, or Sun's Path.

E e 2

Z, D,

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Z D, the *Prime Verticle*, or *Azimuth*.

E P, the Axis of the *Ecliptic*.

N A S, an *Hour-Circle* or *Meridian*.

Z A D, an *Azimuth Circle*.

E Y P, a *Circle of Longitude*.

☉☉, the *Tropic of Cancer*.

♊♊, the *Tropic of Capricorn*.

3. By means of these Circles various spherical Triangles are formed for Calculation. Thus let A be the Place of the Sun in the *Ecliptic*; then in the *Right-angled Triangle* A X C, we have

CA, the Sun's *Distance*, or *Longitude* from the *Equinox* C.

A X, the Sun's *Declination* North.

C X, the Sun's *Right Ascension*.

A C X, the *Angle of Obliquity* of the *Ecliptic*.

4. And supposing the *Sun-rising in the Horizon* at M on the Day of the *Summer Tropic*, and NMS, an *Hour-Circle*; then there is formed the *Right-angled Triangle* NOM, in which we have

N O, = \angle Z, = the *Latitude* of the *Place* Z.

M O, the *Amplitude* from the *North*.

N M, the *Complement* of the Sun's *Declination* R M.

O N M, the *Angle* of the *Hour* from *Midnight*.

O M N, the *Angle* of the Sun's *Position*.

5. On

5. On the same *Tropical Day* the Sun is at I at *Six o'Clock*, because the *Hour-Circle* of Six is projected upon the Axis NCS; therefore in the *Right angled Triangle* ICK, we have

IK, the Sun's *Altitude* at Six.

CK, the *Azimuth* from the East at Six.

CI, the *Declination* North.

ICK, the *Latitude* of the Place.

6. Again; when the Sun on the same Day comes to the *Prime Vertical* ZCD, his Place when due *East* and *West* is at G; therefore in the *Right-angled Triangle* GBC, we have

GB, the Sun's *Declination* North.

GC, the Sun's *Altitude* when East or West.

BC, the *Hour* of his being due East or West.

BCG, the *Latitude* of the Place.

7. Suppose the *Sun in the Horizon* at M once more; then in the *Right-angled Triangle* MRC, we have

CM, the *Amplitude* from East or West.

MR, the *Declination* North.

CR, the *Ascensional Difference*.

RCM, the *Co-Latitude* of the Place.

RMC, the *Angle of Position*.

8. In the *oblique Triangle* AZN, we have

ZN, the *Co-Latitude* of the Place Z.

AN, the *Co-Declination*.

AZ, the *Complement* of the *Altitude* AF.

ANZ, the *Hour* from Noon, equal to
 AX. AZN,

A Z N, the *Azimuth* from the North.

And the same may be done for *any Star*, at A, or any other Place.

9. Again; let Y be any *Star*, then in the *oblique Triangle* Y N E, we have

Y E, the *Co-Latitude* of the Star.

V N = *Co-Declination*.

N E, = $\text{Æ} \text{ } \ominus$ = the *Obliquity* of the Ecliptic.

N E Y, the Star's *Longitude* in the Ecliptic.

E N Y, the *Hour* from Midnight.

10. With respect to *Geographical Problems*, let Z, and A be two CITIES, then in the *oblique Triangle* A Z N, we have

Z N, the *Co-Latitude* of the Place Z.

A N, the *Co-Latitude* of the Place A.

A N Z, the *Difference of Longitude* of A and Z.

A Z N, the *Bearing* of A from Z.

A Z, the *Distance* of the two Places.

Z A N, the *Angle of Position*.

11. Lastly, In NAVIGATION, Problems of *oblique Sailing* do frequently occur, and require the Solution of Cases depending upon the *spherical oblique Triangle* A Z N, in which

Z N, is the *Co-Latitude* of the Port, or Ship Z.

A N, the *Co-Latitude* of the Port A.

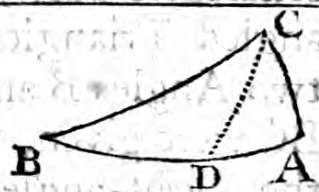
A Z, the *Distance sailed*.

A N Z, the *Difference of Longitude*.

A Z N, the *Angle of the Course*.

12. In all *Right-angled Spherical Triangles* ABC, any two Parts being known, the rest are easily found by the following Analogies, wrought by the common *Gunter*, or *Sliding-Rule*.

Cases	Given Parts	Parts Sought	Analogies
I.	AB B	AC BC C	*R : sBA :: tB : tAC. R : csB :: ctAB : ctBC. R : csAB :: sB : csC.
II.	AC B	AB BC C	tB : tAC :: R : sAB. sB : sAC :: R : sBC. csAC :: R :: csB : sC.
III.	BC B	AB AC C	R : csB :: tBC : tAB. R : sBC :: sB : sAC. csBC : R :: ct B : tC.
IV.	AB AC	BC B C	R : csCA :: csAB : csBC. sAB : R :: tAC : tB. sAC : R :: tAB : tC.
V.	BC AC	AB B C	csAC : R :: csBC : csAB. sBC : R :: sAC : sB. tBC : R :: tAC : csC.
VI.	C B	AB AC BC	sB : csC :: R : csAB. sC : csB :: R : csAC. tC : ctB :: R : csBC.



13. An *Oblique Angled Spherical Triangle* BCD, is reduced to two Right Angled

* In these Analogies, s stands for *Sine*, cs for *Co-sine*; t for *Tangent*, and ct for *Co-tangent*.

ones ABC , and ACD , by letting a Perpendicular AC , fall from an Angle C to the opposite Side BD , and then if *three Parts* of such a Triangle be given, the *other three* may be found by the foregoing Table of Analogies duly applied to these two Right-angled Triangles; for Instance, suppose the two Angles B and D , together with the Side BC were given, to find the Side CD ; then in the Right-angled Triangle BCA , there is given the Angle B , and Side BC , whence the Perpendicular AC is found by the second Analogy of Case III above. And now in the Right-angled Triangle ACD there is known the Angle at D , and the Side AC , to find the Side DC , which is known by the second Analogy of Case II. And thus you proceed for any other Parts given or sought.

14. But this Chapter is intended only for such Readers as would be well acquainted with the Uses of the GLOBE or SPHERE in *its fullest Extent*; and have been instructed in the first PRINCIPLES of *Spherical GEOMETRY*. To such, nothing here delivered will be mysterious or difficult; but if they desire a further *Eclaircissement* on this Subject, I shall take the Liberty of referring them once more to my INSTITUTIONS of *Mathematical SCIENCES*, lately published in 3 Vols. 8vo.



C H A P. IX.

*Of the various A S T E R I S M S and
C A T A L O G U E S of S T A R S, in the
Z O D I A C, and in the Northern and
Southern H E M I S P H E R E S.*

T H E Surface of the C E L E S T I A L
G L O B E may be esteemed a just
and adequate Representation of
the *concave Expanse of the Hea-
vens*, notwithstanding the Objections of
Shickardus and others to its *Convexity*, for it is
easy to conceive the Eye, placed in the Cen-
ter of the Globe, and viewing the Stars on its
Surface, supposing it made of Glass, as some
of them are; or if *Holes* were made in the
Center of each Star, then, as I said, the Eye
in the Center of the Globe, would view
through each of those Holes the *very Stars*
in the Heavens represented by them.

Because it would be impossible to have

F f any

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any distinct or *regular Ideas or Notions* of the Stars in respect of their *Number, Magnitude, Order, Distances, &c.* without first reducing them to proper Classes, and arranging them in certain *Forms*, which therefore are called ASTERISMS or CONSTELLATIONS; this was done in the early Ages of the World by the first Observers of the Heavens, and those who made Spheres or Delineations; of whom Sir ISAAC NEWTON reckons *Chiron*, the fabled Centaur, the first who formed the Stars into Constellations, about the Time of the *Argonautic Expedition*, or soon after; and that the several Forms or *Asterisms* were, as it were, so many symbolical Histories, or Memorials of Persons and Things remarkable in that Affair. Thus *Aries*, the Ram, is commemorated for his *Golden Fleece*, and was made the first of the Signs, being the Ensign of the Ship in which *Phryxus* fled to *Colchis*. *Taurus*, the Bull, with brazen Hoofs, tamed by *Jason*; *Gemini*, the Twins, *viz. Castor and Pollux*, two of the *Argonauts*; the Ship *Argo*, and *Hydrus* the Dragon, &c. which all manifestly relate to the Affairs of that Expedition, which happened about forty or fifty Years after SOLOMON'S Death; or 34 Years before the *Trojan War*.

By this Means they could make Catalogues of the Stars, record their Places in the Heavens, and call them all by their Names. *Hipparchus* is said to be the first
who

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who framed a Catalogue of the Stars, which was afterwards copied by *Ptolemy*, and adjusted to his own Time, *A. D.* 140. The Number in this was 1026. After this *Ulugh Beigh* made a Catalogue of 1022, reduced to the Year 1437. *Tycho Brahe* rectified the Places of 1000 Stars; but his Catalogue, published by *Longomontanus*, contains but 777, for the Year 1600. *Bayer* published a Catalogue of 1160. *Hevelius* composed a Catalogue of 1888 Stars, adjusted to the Year 1660. But the largest, and most compleat of all, is the *British CATALOGUE* by Mr. FLAMSTEED, containing about 3000, of which scarce 1000 can be seen by the naked Eye in the clearest and darkest Night. They are rectified for the Year 1689. They are distinguished into *seven Degrees of Magnitude* in their proper Constellations; whose Names, together with the Number of Stars in each, and of each particular Magnitude, here follow, as I have taken them from the third Volume of the *Historia Cælestis*.

The Constellations of the TWELVE SIGNS.

Names.	N ^o .	Magnitude.						
		1	2	3	4	5	6	7
<i>Aries.</i> ————	65	0	1	2	5	6	28	23
<i>Taurus.</i> ————	135	1	1	4	13	21	44	51
<i>Gemini.</i> ————	79	1	2	4	6	12	32	22
<i>Cancer.</i> ————	71	0	0	0	6	7	39	19
<i>Leo.</i> ————	95	2	2	6	15	10	50	10
<i>Virgo.</i> ————	89	1	0	5	10	19	45	9
<i>Libra.</i> ————	49	1	2	7	5	11	21	2

F f 2

Scorpio.

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<i>Scorpio.</i> ———	51	0	2	2	12	5	25	5
<i>Sagittarius.</i> ———	50	0	1	5	6	11	23	4
<i>Capricornus.</i> —	51	0	0	3	3	9	34	2
<i>Aquarius.</i> ———	99	1	0	4	7	31	50	6
<i>Piscis.</i> — — —	109	0	0	1	6	27	54	21

The Constellations of the NORTHERN HEMISPHERE.

<i>Andromeda.</i> —	66	0	3	2	12	13	34	<i>2 neb.</i>
<i>Aquila cum</i> } <i>Antinoe.</i> }	70	1	0	10	7	15	32	5
<i>Anser cum Vulpe.</i>	34	0	0	0	4	12	18	0
<i>Auriga.</i> ———	68	1	2	1	10	18	31	5
<i>Bootes.</i> ———	55	1	0	8	10	11	17	8
<i>Cassiopeia.</i> ———	56	0	0	5	7	9	30	5
<i>Camelopardus.</i>	58	0	0	0	4	18	27	9
<i>Cepheus.</i> ———	35	0	0	3	7	8	14	3
<i>Coma Berenices.</i>	40	0	0	0	8	14	14	4
<i>Corona Septen.</i>	21	0	1	0	6	8	6	0
<i>Cygnus.</i> ———	107	0	1	6	21	31	48	0
<i>Delphinus.</i> ———	18	0	0	6	0	2	9	1
<i>Draco.</i> ———	49	0	1	7	8	13	19	1
<i>Equuleus.</i> ———	10	0	0	0	4	1	5	0
<i>Hercules.</i> ———	95	0	0	11	15	31	38	0
<i>Leo Minor.</i> ———	53	0	0	1	5	11	33	3
<i>Lacerta.</i> ———	16	0	0	0	3	6	7	0
<i>Lynx.</i> ———	44	0	0	0	3	12	21	8
<i>Lyra.</i> ———	21	1	0	2	2	5	11	0
<i>Perseus.</i> ———	67	0	2	5	11	15	28	6
<i>Pegasus.</i> ———	93	0	4	3	10	13	58	5
<i>Sagitta.</i> ———	23	0	0	0	4	1	18	0
<i>Serpens Ophiu-</i> } <i>chi.</i> }	59	0	1	7	6	3	32	10
<i>Scutum.</i> ———	7	0	0	0	2	4	1	0
<i>Serpentarius,</i> } <i>or Ophiucus.</i> }	69	0	1	7	15	13	26	7
<i>Triangulum.</i> —	15	0	0	0	3	1	7	4
<i>Ursa Major.</i> —	215	0	6	5	35	58	91	20
<i>Ursa Minor.</i> —	24	0	0	4	3	5	6	6
<i>Canes Venatici.</i>	25	0	1	0	2	5	14	3

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Constellations in the SOUTHERN HEMI-
SPHERE.

<i>Ara cum Thu- ribulo. — }</i>	9	0	0	1	6	2	0	0
<i>Argo, or Navis</i>	25	0	0	4	6	6	9	0
<i>Apus. —</i>	11	0	0	0	4	3	4	0
<i>Canis major. —</i>	32	1	7	1	4	11	5	3
<i>Canis minor. —</i>	15	1	0	1	0	3	9	1
<i>Cetus. —</i>	78	0	2	6	13	9	44	4
<i>Centaurus, cum Lupo. }</i>	13	0	1	0	5	6	1	0
<i>Cameliontis, —</i>	10	0	0	0	0	9	1	0
<i>Columba Noachi.</i>	10	0	2	0	1	6	1	0
<i>Corona Austr. —</i>	12	0	0	0	1	3	8	0
<i>Corvus. —</i>	10	0	0	3	2	2	3	0
<i>Crater. —</i>	11	0	0	0	8	2	2	0
<i>Eridanus. —</i>	68	0	0	12	15	20	20	1
<i>Grus. —</i>	3	0	0	0	2	1	0	0
<i>Hydrus. —</i>	10	0	0	4	2	3	1	0
<i>Lepus. —</i>	19	0	0	3	7	3	6	0
<i>Musca. —</i>	4	0	0	0	2	2	0	0
<i>Monoceros. —</i>	19	0	0	0	10	7	2	9
<i>Orion. —</i>	80	2	4	4	25	20	25	0
<i>Pavo. —</i>	14	0	1	3	5	4	1	0
<i>Phœnix. —</i>	13	0	1	5	6	1	0	0
<i>Piscis volans. —</i>	8	0	0	0	0	7	1	0
<i>Robur Carolinæ.</i>	12	0	1	2	7	2	0	0
<i>Sextans —</i>	41	0	0	0	1	7	32	1
<i>Toucan. —</i>	9	0	0	4	2	3	0	0
<i>Triangulum —</i>	5	0	1	2	0	2	0	0
<i>Xiphias. —</i>	6	0	0	1	2	1	2	0

7. In the Zodiac,
In the Northern Hemisph.
In the Southern Hemisph.
Sum of all the STARS.

Num	1	2	3	4	5	6	7
943	7	11	43	94	169	445	174
1511	4	23	93	227	356	695	113
547	4	20	56	136	145	176	10
3001	15	54	192	457	670	1316	297

8. The

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The Use of such a Catalogue of Stars is very great; for from hence we learn, (1.) If any *new Stars* at any time appear, which have never been observed before. (2.) If any Star, which *now appears*, shall in Time to come *disappear*. (3.) If the *new Star* which shall appear be the same with a Star that has *disappeared* formerly; and therefore, 4.) If the Stars have any *periodical Times of Apparition*. Hence (5.) The Means or Method of *predicting the Appearing or Disappearing of Stars*. (6.) By a Catalogue of the Stars we compare their respective *Places, Situations, and Distances* with Ease. (7.) By this Means we also compare and determine the true Places and Motions of the heavenly Bodies in general, and of the *Sun, Moon, Planets, and Comets* in particular, with many other useful Purposes.

Now it is actually Fact, that some *new Stars appear*, and that *others disappear*; yea, that they *change their apparent Magnitude, and disappear by degrees*. *Hipparchus* the first of Men observed a *new Star*, (120 Years before *Christ*) which occasioned his making a Catalogue of the Stars. Another is said to have appeared *A. D.* 130; another *A. D.* 389; one exceeding bright in the 9th Century, and another in the Year 1264.

But the first *new Star*, of which we have any good Account, is that in the Chair of *Cassiopeia*, first observed by *Cornelius Gemma*,

ma, on the 9th of *November* 1572, and by *Tycho Brahe* on the 18th. Sir ISAAC NEWTON says it equalled *Venus* in Brightness at its first Appearance, and gradually declined in its Lustre, till it totally disappeared in the *March* following. This Star is supposed to be the same that appeared in the Years 945 and 1264, having its Period about 310 or 320 Years.

In *Aug.* 13, 1596, *D. Fabricius* observed another *new Star* in the *Neck of the Whale*; and through the 17th Century this Star was observed to *appear and disappear periodically*, its *Period* being equal to 333 Days. The *Phænomena* of this, and the like Stars, are supposed to be owing to the Spots on their Surface, which sometimes increase and sometimes decrease, in the manner as we have observed they do on the Surface of our Sun; for at some Times the *Solar Spots* are so large as to be visible to the *Naked Eye*, and very numerous at the same time; at other Times, no Spot at all has appeared on the Sun for two or three Years together.

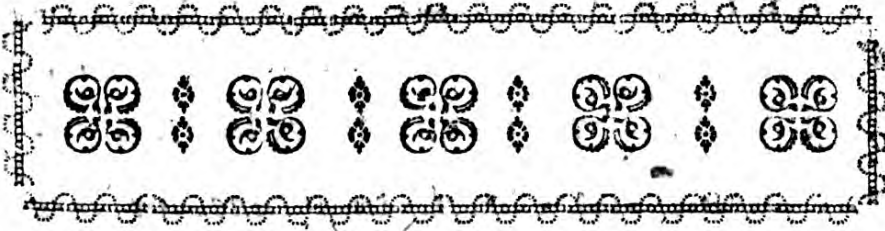
The *different apparent Magnitudes* of the Stars are owing to their *different Distances* from us. Had we *Telescopic Eyes*, we should see many more. *Seventy Stars*, and more, have been discovered in the *Pleiades*, commonly called the *Seven Stars*; and all that Tract of the Heavens called the *Milky Way* (or *Galaxy*) is well known to be owing to the
the

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the Refulgence of a prodigious Multitude of Stars diffeminated through those Parts of the Universe; though at so great a Distance as to be invisible to the naked Eye; yet are they discernable in great Numbers through a Telescope, and more in Proportion as the Instrument is better. But for the almost infinite (at least, inconceivable and immense) Distance of the nearest fixed Star, the Reader may see a Calculation in the *Philosoph. Britan.* Vol. 3. P. 263, Edit. 3d. Also in my SURVEY of the SOLAR SYSTEM, P. 121.


Hence likewise we account for that particular Phænomenon we call a *nebulous Star*, or cloudy faintish light Spots that appear like Stars in an indirect View; for in order to this you have no more to do than to direct a good Telescope to any one of them, and you will be agreeably surprized with a View of a *great Multitude of very small Stars*, which were the Cause of the *luminous Spot* to the naked Eye.

To the very small apparent Magnitude of the Stars we owe their constant *Twinkling*; for being but lucid Points, every *opaque Corpuscle* or *Atom* floating in the Air, will be big enough to cover and *eclipse them*, when they get in the Right Line connecting the Star and the Eye; which *Alternations of momentary Occultations and Apparitions* make the *Twinkling of the Stars* we now speak of.



C H A P. X.

An EXPLICATION *of the* ETYMOLOGIES
of the ARABIC NAMES *of the* CIRCLES
and POINTS *of the* SPHERE, *and of*
the CONSTELLATIONS *and* Principal
 STARS.


 SHOULD not have made the least
 I mention of the *Manázil Al Kamar*,
 or the MANSIONS of the MOON,
 so celebrated among the ancient
Arabians, were it not that they are the
 oldest Specimen of Astronomy extant, and
 plainly shew the vague and uncertain Me-
 thods which were used for observing the
 Moon's Motions in the early Ages of the
 World; as also that we may have Occa-
 sion to refer to them in what follows upon
 these Subjects.

It is reasonable to suppose, this Doctrine
 G g of

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of the *Lunar Manâzil*, was originally derived from the ancient *Chaldeans* and *Babylonians*; for in the *Syriac Tongue*, the ZODIAC, or CIRCLE of the *Twelve Signs*, was called ܡܢܙܘܠܐ , i. e. *Manzolo*, *Inclination*; from ܢܙܠܐ *Nazel*, to *incline*, or *lean forward*; all which evidently denotes, a Denomination of the Zodiac from its INCLINATION to the *Plane* of the *Equator*.

So that the whole ZODIAC had the Name *Manzolo*, from a Reason quite different from that for which the *Arabians* gave the same Name to the 28 Parts or Divisions of it; because the same Word نزل *Naza'* in *Arabic* signifies *hospitatus fuit, habitatum venit*, he came to *sojourn*, to *inhabit*, or to *tarry with* for a short Time. Wherefore since the Moon runs through the Zodiac in $27\frac{1}{2}$ Days, they, by dividing it into 28 Parts, allow *one to the Moon for each Day*, which therefore might be very properly called منزل *Manzil*, i. e. *Hospitium*, *Mansio*, *Domus*, i. e. the *Mansion*, or *House* at which the *Moon inns every Day*.

The learned HYDE, in his Notes on ULUGH BEIGH's Tables renders منازل القمر *Manazil al Kamer* by *Mansiones Lunæ*, *Mansions of the Moon*; قمر *Kamar* being the Name of the Moon from the *third Day* of the Month to the End. This Name might be given it probably

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probably from the same Radix in Chaldee, קמר *fornicor*, to be made or bent in *Form of an Arch*, which is the Figure of the Moon at that Age.

These *Mansions* take their Names from some remarkable Stars in each; the *Ety-mons* of which will be given in their Place; we shall only here subjoin a Table of their Longitudes and Latitudes as they stand in the said Tables of *Ulugh Beigh*, from which it will be pretty easy to form an Idea in what Manner the Zodiac was divided into the *Mansions of the Moon* by the Ancients, and that is all we think necessary to be said upon so dry and insignificant a Subject.

Names.		Long.		Lat.		Names.		Long.		Lat.			
		S.	D.	M.	D.	M.			S.	D.	M.	D.	M.
1	Al Sheratein	0.	26.	40.	7.	13½.	15	Al Gaphr	6.	26.	44.	9.	30.
2	Al Botein	1.	9.	2.	2.	12.	16	Al Zubana	7.	9.	55.	2.	30.
3	Al Thuraiyâ	1.	22.	1.	3.	45.	17	Al Jclil	7.	25.	16.	5.	27.
4	Al Debarân	2.	2.	31.	5.	15.	18	Al Kalb	8.	2.	16.	4.	30.
5	Al Hek'a	2.	16.	31.	13.	20.	19	Al Shaula	8.	16.	13.	13.	43.
6	Al Hen'a	3.	1.	31.	7.	12.	20	Al Naâim	8.	28.	4.	10.	48.
7	Al Dirâ	3.	14.	19.	8.	12.	21	Al Belda	0.	0.	0.	0.	0.
8	Al Néthra	3.	29.	46.	1.	0.	22	Al Dâbih	9.	26.	20.	5.	46.
9	Al Terpha	4.	13.	16.	11.	3.	23	Al Bûla	10.	5.	14.	7.	37.
10	Al Gjeb'ha	4.	22.	13.	0.	9.	24	Al Suûd	10.	16.	11.	7.	46.
11	Al Zubra	5.	3.	4.	15.	27.	25	Al Achbiya	1.	0.	10.	8.	24.
12	Al Sérpha	5.	13.	49.	2.	0.	26	Al Mukdim	11.	18.	46.	24.	55.
13	Al Auwâ	5.	29.	28.	4.	27.	27	Al Muchir	0.	3.	55.	18.	52.
14	Al A'zal	6.	16.	10.	2.	9.	28	Al Rishâ	0.	23.	13.	25.	36.

It is somewhat strange that SCHICKHARD, who is the only Author I know of that treats professedly of *Arabic Etymologies*, should be totally silent (in his *Astroscopium*,)

about those of the most remarkable *Circles* and *POINTS* of the *SPHERE* or *GLOBE*. Neither does *Bainbridge*, *Gravius*, *Hyde*, *Scaliger* or *Costard* make any mention of them that I can find.

The Greeks, who transmitted to us the Astronomy of the Eastern Countries, have given New Names to almost every Part of the Sphere, leaving only *two Points*, and *two Circles* of *oriental* Complexion, which are as follow.

ZENITH is the *Pole* of the *Horizon* over our Heads, or the *Vertical Point* of the Sphere. But as most of the ancient Names have little of their original Purity and Form now remaining, so this Word is a remarkable Instance of such sort of Degeneracy; for the Arabic Word is *سمت*, *Semat*, *Zemat*, or *Zemt*, i. e. *Cæli Vertex*, or Point of the Heavens over the Head. See *CASTELLUS* in the *Radix سمت*, *Semat*.

NADIR is the *Pole* of the *Horizon* under our Feet, and therefore by the Greeks called *Antipodes*. We find nothing of the Original of this Word in *Schickhard*, *Minshew*, *Skinner*, *Spellman*, *Vossius*, or *Baily*; but in *Castell's* Lexicon, under the Word *נדר*, is the Arabic *نظر*, which has 59 Significations, and the 24th has this Form *نظير* *Nadsir*, which signifies *like*, *correspondent*, *equal to another*; and thus the *Nadir* is alike, and answers to the *Zenith*.

AZIMUTH is from the same Original as
Zenith

Zenith, viz. سمت, *Semt*, with the Particle ال, makes *Al Zemit*, corruptly called *Azimuth*; and denotes the Verticle Circle, which goes from the *Zenith* to the *Horizon*; as much as to say, the *Zenith-Circle*.

ALMICANTER is derived from مقنطرات, *Macanterat*, from قنط *Kanat*; so that with the Particle ال, Prefix م, and Suffix ر, there is made at length, *Almacantar*, as it should be wrote, which is any *Circle parallel to the Horizon*.

We now add a Word or two concerning the Constellations mentioned in the Old Testament; as they are undoubtedly the most ancient Specimens, or rather Foot-steps of Astronomy, that are now extant, so they are the least understood, or, perhaps it may be more truly said, Not understood at all. They are the following:

ASCH or *Aish*, in Heb. אש, Job. ix. 9. and xxxviii. 31. *Aben Ezra*, the most judicious Commentator among the *Jews*, tells us that by *Aish* is meant the *Greater Bear*; but Dr. *Hyde* takes it to be the bright Star in *Auriga*, called العيوق, *Aiyuk*. Some Jewish *Rabbies* tells us the *Seven Stars* are hereby intended; and others that it is *Aldebaran*, or the *Bull's Eye*; whence it is plain, no one knows what it is.

CHESIL, כסיל, Amos v. 8. Job ix. 9. and *Isaiah* xiii. 10. in which last Place it is in the Plural. *Aben Ezra* takes this to be the

the Scorpion's Heart. Rabbi *Tanchum* says, it is *Canopus* in the Ship *Argo*. *Vossius* thinks it is the Constellation *Orion*, as *St. Jerom* did of old. Dr. *HYDE* seems to think it must be *Canopus*, and the Stars about it; but Mr. *Costard* supposes it most likely to be the *Greater Bear*.

CHIMAH is another *Celestial Phænomenon* mentioned in Scripture, *Amos* v. 8. *Job* ix. 9. and xxxviii. 32. The Jewish Rabbies think that by *כימה* is meant the *Pleiades* or *Seven Stars*, the Translations vary greatly about it; the *Targum* of *Jonathan* upon *Amos* v. 8. retains both the Words *Chimah* and *Chefil*. And our Modern Commentators differ in Opinion no less than the Ancients; so that we are quite in the Dark about *Chimah* also.

MAZZAROTH (*מזרות*) is, says *Aben Ezra*, a Name for some Stars or other; as it is in the Plural, no doubt but it refers to some *Constellation*; unless with Mr. *Costard*, we suppose it to signify that Zone in the Heavens which included the 28 Divisions thereof, called the *Mansions of the Moon*, and in Modern Stile, the *Zodiac*.

MAZZALOTH (*מזלות*) is another Word equally unknown with the former. Mr. *Costard* supposes it means the same Thing, viz. the *Manazil Al Kamer*. And what he suggests for the Support of his Opinion is very rational, viz. that as *Manzil* comes from *نزل*, to *abide, inhabit, or dwell with one*;

one; so the Hebrew Root נול might formerly have the same Signification. The Learned *Castellus* mentions the 12 Signs of the Zodiac also; but he further observes, that it probably comes from the Root נול, to walk to and fro; and so denote the *Wandering Stars*, or PLANETS, and this Supposition will be corroborated by considering that these *Mazzaloth* were Objects of Heathen *Worship*, or *Idolatry* (see 2 Kings xxiii. 5.) and reckoned with the *Sun*, *Moon*, and *Host of Heaven*, or *Stars*: then the Passage will run thus—And he caused to cease those who burnt Incense to BAAL, to the SUN and to the MOON, and to the PLANETS, and to all the CONSTELLATIONS OF HEAVEN.

CHADREI TEMAN we have rendered *Chambers of the South*, from חדר, a *Chamber*, and תימן, *South*. These are therefore the Southern Constellations or some of the principal Stars in them, as *Canopus*, *Sirius*, &c. Job ix. 9.

SUCCOTH BENOth is another *Hebrew Phrase* for a Constellation. According to Rabbi *David Kinchi*, סבות, *Succoth* is the Feminine of סבו or שבו, a *Cock*, and *Benoth* is Feminine of בן *Ben*, a *Son*; So that *Succoth Benoth* is literally the *Hen and her Daughters*, that is, the *Hen and Chickens*, by which *Aldebaran* and the *Pleiades* have always been understood.

We now proceed to the ETYMOLOGY of the Names of the principal Fixed Stars which are as follows :

ALDEBARAN; the Orthography of which according to HYDE is *Al Debaran*; but according to *Schickhard*, it should be *Al Debaron*; it is composed of the Proposition ال, The, and دبران *Debaran*, from دبر, *præterit*, *he went before*, or *lead the Way*; for this Star is the *foremost*, and most *illustrious* of all the Stars in the Constellation *Taurus*, and is called the BULL'S EYE. And by *Avicenna*, the Stars of greatest Splendor, and the Planets, are called دباري *Debarei*, or CHIEFS of the *Hosts of Heaven*.

ALGENEB, from ال *the*, and جنب *Genib*, the *Side*; as being a conspicuous Star in the *Side of Perseus*.

ALIATH (sometimes called *Alioth*) the first Star in the Tail of the *Great Bear*. It is very strange, that *Schickhard* should not mention a Star of such great Notice and Use to Navigators; indeed its Etymon is not very obvious. I suppose it to be Mr. HYDE's الية, *Al'ya*, i. e. *Cauda*, a *Tail*; though I can find no such Word with such Signification [in *Castell's* Lexicon; ليت and from thence البيت, which signifies *strong, bold, strenuous*, &c. is the most probable Word I can meet with for the Original.

ALGOL, or *Ras Algol*, from راس, the Head.

Head, and الغول *Ghull*, a *Witch*; or Evil Spirit; and so it became applied to the snaky Head of *Medusa* the *Gorgon*; and by way of eminence, to the bright Star in that Constellation.

ALGJATHI, or *Ras Algethi*, from رأس, *Ras*, the Head, and جثا, *leaning* or *kneeling*; so *Hercules* was called from his *prone Posture* on the Globe; and so the bright Star in his *Head*, received the Appellation of *Hercules's Head*.

ALHAGUE, or *Ras Albangue*; but these are both very corrupt Pronunciations; for the Word is حوا, *Hauwâ*, *Serpentarius*, i. e. a Person who *breeds Serpents*, therefore the real *Orthoepy* is, *Ras Al Hauwâ*, the *Head of Serpentarius*; for so they called the bright Star in his Head.

ALAMAK, or *Alamach*; this is also very corruptly put for عناق, *Anak*, or *Alanak*, a very curious Animal in the Eastern Countries, a little bigger than a Dog, and is described to be somewhat like a Jackall or Lion's Provider. This bright Star *Al Anak*, is that above the left Foot of *Andromeda*, as described by *Ulugh Beigh*; but on Mr. Senex's Globes it is in the Foot.

ALDERAMIN, from ذراع, *Deraô*, an Arm, يمين, *jamin* right; as being a bright Star in the *Right Arm* of *Cepheus*. It is somewhat remarkable, that there is no Notice taken of this Star, in particular, by *Ulugh Beigh*;

but this is one of those he calls كواكب الفرق *Cawákib Al Phirk*, the Stars of Flock.

ALHATOD, this is derived from عتد, *Atud*, and this corruptly from عتود, *Atúd*, a He-goat of a Year old; but the true Word is عيوق, *Aiyúk*, *Capella*; so that *Al Aiyúk* is the Orthography of the Name of that Star of the first Magnitude we call the *Goat Star*.

ALRAMECH (that most splendid Star called ARCTURUS, in *Bootes*) from رامج, *Râmib*, or *Ramich*, a Lance; *Al Ramich* is therefore the *Star in the Lance* of *Bootes*, which Lance is not now in our Constellation; but in *Ulugh Beigh's Catalogue* it is described only as an extra-constellated Star, between the Thighs of *Bootes*.

ALGORAB, a bright Star in the Bill of الغراب, *Al Gorab*, the *Raven*.

ALGOMEISA, or more truly *Al Ghomús* from الغبيصا, *Bleer-eyed*; a Star in *Procyon*, or the little Dog, so called; of which you have a long Story in Dr. HYDE's Commentaries upon *Ulugh Beigh's Tables*.

ALPHARD, or (more truly) *Al Pherd*, from فرن, *solitary*; being that bright *solitary* Star in the *Hydra*, called the *Hydra's Heart*.

ALKES, by some called *Alkis*, and *Alches*; but they are all wrong, the Word being

ing الكاس, *Al Kâs*, the CUP; a Star of the Constellation *Crater*.

ATAIR, or rather *Attair*, from الطير, *flying*; being a Star in the *Flying Vulture*.

AZIMAN, sometimes called *Azineth* and *Hufimeth*, and by SCALIGER, *Huzmet*; and with him agrees SCHICKHARD, who derives it from حزم *Chazama*, a *Handful* or *Bundle of Wheat-Ears*, but Dr. HYDE says, the Genuine Name is from سبأك, *Simâk*, to lift up, hold out, or extend. By all which is meant, the bright Star called *Spica Virginis*, i. e. the *Virgin's Spike*, or *Ear of Corn*.

BETEN KETOS, i. e. the *Belly of the Whale*, from بطن *Baten*, the *Belly*; and قيطس, from the Greek κητος, *Cetus*, a *Whale*.

DANEB ELECID; the true Name is *Danab Al Asad*, from ذنب *Danab*, the *Tail*, and أسد, a *Lion*, the Name of a Star in the *Lion's Tail*.

DENEB ALGEDI, *Danab* as before; and حدي, *Gedi*, a *Goat*. A Star in the *Tail of the Goat*.

DENEB KAITOS, a bright Star in the *Tail of (Cetus) the Whale*, as before explained.

DUBHE, from دب, *Dub*, a *Bear*. The bright Star, marked *a*, in the *Back of the Bear*, so called by Preheminence.

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ENIF ALPHERAS, or (according to Dr. Hyde) *Empb Al Pháras*, from انف, the *Nose*, and فرس, *Pháras*, a *Horse*; a bright Star in the *Nose* or *Nostrils* of *Pegasus*, the *Winged Horse*.

FUMAHANT or *Fomohant*, but the real Etymon is *Pham Al Hât*; from فم, *Pham*, the *Mouth*, and حوت, *Hât*, a *Fish*; a Star of the first Magnitude in the *Mouth* of the *Southern Fish*.

JED ALPHERAS, from يد, the *Hand*, or *Fore Foot*, فرس, *Pharas*, a *Horse*; a Star in the *Fore-Foot* of *Pegasus*.

KALIB ELECID (it should be *Kalb Al Afad*) from قلب, *Kalb*, the *Heart*, and اسد, *Afad*, a *Lion*; that very bright Star call'd the *Lion's Heart*, of the first Magnitude.

KOCHAB, from كوكب, *Caucab*, a *Star*; or more consonantly from قطب, *Kutab*, a *Hinge* or *Axle* upon which any thing turns round; and therefore a very proper Name for the *North Pole Star* near the *Axis* of the *Earth*.

Kalb Alatrab; the true Etymon requires it to be pronounced *Kalb Al Akrab*, since the original Words are قلب, *Kalb*, the *Heart*, and عقرب, *Akrab*, a *Scorpion*; so that it denotes a Star of the first Magnitude, called the *Scorpion's Heart*; in Latin and Greek, Authors, *Antares*.

LESATH,

LESATH, *Scaliger* supposes it derived from لسعة, *Laf'a*, the *Puncture* made by the Sting of a Scorpion; but Dr. Hyde insists upon this Star in the *Scorpion's Tail*, being always called *Al-Shaula*, from the Word شولة, which signifies particularly, the *Tail of the Scorpion*, but of no other Animal whatever.

MARKAB, from مركب, *Morkab*, any sort of *Vehicle*, as a Cart, Chariot, Ship, &c. the same Star as before described by *Jed Al Pharas*, in the Wing of Pegasus.

MARPHAK; I presume this is the same Star which upon Mr. Senex's Globe is called *Marsic*, in the *Cubit of Hercules's right Arm*, as the Word مرفق signifies.

MAASYM is wrongly spelled for *Mi'sam*, because معصم signifies the *Back of the Hand*; and this Star is found in the *left Hand of Hercules*, in *Ulugh Beigh's Catalogue*.

MENKAR; I do not find this Word in *Ulugh Beigh*, nor in the Commentaries of Dr. *Hyde*; but *Shickhard* has it منقر, which he derives from the Hebrew Root נקר, *Nakar*, to corrode with the Bill; to dig Holes, as Birds do with their Bills; but what Relation this has to the *Bright Star in the Mouth of the Whale*, I do not see.

MIRACH, or *Mezar*; but *Mizar* is the same as the original ميزار, which is from ازار, *Izar*, a *Zone* or *Belt*. Hence *Mirath*, *Mirar*,

rar, *Miraz*, &c. by mistaking ز for ر. It is the Bright Star in the *Girdle* or *Zone* of *Andromeda*. There is also another of the same Name near the *Belt* of *Bootes*.

RIGEL, or *Regel*; from رجل, a *Foot*, in all *Eastern Languages*, from the Hebrew *Radix* רגל, the *Foot*. Many Stars in the *Feet* of *Animals* are so called, particularly that in *Orion's left Foot*.

SCHEAL, *Seat*, or *Scheder*, vicious Pronunciations of the original Word سعد, *Sa'd*, an *Arm*, or *Shoulder*; hence Stars so called in the *Shoulder* of *Cassiopeia*, *Pegasus*, &c.

ZUBEN, from زبانا, *Zubana*, the *Claws*, (viz. of the *Scorpion*, which in former Times made the two Scales of *Libra* or the *Ballance*.) Hence *Zubana Genubi*, (جنوبي, *Southern*) the *Southern Scale*; and *Zubana Shemâli* (شمالی, *Northern*) the *Northern Scale*. But it may well be supposed that many of the *Ancients* knew of no such Sign as *Libra* at all.

These are all the *Arabic Names* in the *Nomenclature* of the principal Stars, whose *Etymologies* are likely to be enquired after, as the rest are grown into *Disuse*; and therefore not worth *Recital*.



A P P E N D I X.

The PRINCIPLES of CHRONOLOGY, or
the DOCTRINE of TIME, *briefly ex-*
plained in all its useful DIVISIONS,
 CYCLES, PERIODS, *and* EPOCHS.

THE PRINCIPLES of CHRONOLOGY
 T very properly belong to a Treatise
 on the Use of the GLOBES; since
 many of the Problems require
 a Person to have distinct Ideas of *Years,*
Months, and *Days,* in the Computation of
 Time; and also that both the *Julian* and
Gregorian Kalendars, or the *Old and New*
Stile, are upon the Horizons of most Globes,
 and therefore ought to be described in all
 Books which treat of their Use.

CHRONOLOGY is the DOCTRINE of TIME;
 and is principally concerned in finding out
 the most proper and commodious Divi-
 sions and Measures of Time. Experi-
 ence has taught all Mankind, that the
 most

most convenient Division and Distribution of Time is into DAYS, MONTHS, and YEARS; but it has been found difficult to ascertain adequate Measures for these Divisions of Time; as Nature has afforded no *fixed Standard* for any One of them, that can be used in the Civil Occasions of Life, without more Trouble and Skill than can in common Affairs be applied.

DAYS are the least Divisions of Time that we have any natural Measure for; and that Measure is the *Rotation of the Earth* about its *Axis*; this is always equable and constantly the same; but as it depends upon a critical Observation of the Stars, it is not accommodated to *vulgar Use*. It was therefore found necessary to make the Measure of a Day equal to the Interval of Time which the Sun takes up *in passing* from the Meridian of any Place, and returning to it again; and this they call a *Solar Day*, and divided it into 24 equal Parts, called *Hours*, each of these they subdivide into 60 equal Parts or *Minutes*; each Minute in 60 other equal Parts or *Thirds*, and each Third into 60 *Fourths*, and so on.

But these Days and Hours are not at all Times equal; for sometimes the Sun returns to the Meridian of a Place, sooner than at others, on Account that the *Annual Motion* of the Earth is not in itself *equable*, nor is it made in a *Circle*. This *Solar* or *Apparent*

Apparent Time, is that which is shewn by *Sun-dials*.

This unequal Division of Time suits not the nicer Purposes of Astronomers; they have therefore invented an equable Division, and contrived to have a *Day of a Mean Length* between the longest and shortest *Solar Day*; and to divide Time into such equal Days, they have fixed upon *CLOCKS*, and *WATCHES*, whose Motions are the nearest to *equable*, of any they have been able to invent.

Of these 24 mean Hours, the Earth's Rotation upon its Axis employs $23^{\text{h}}. 56'. 3\frac{1}{2}''$. which is therefore called a *Sidereal Day*, as in that Time a Star after leaving the Meridian, returns to it again. Hence the Difference between this and a *Mean Day* is $3'. 56\frac{1}{2}''$. But the Difference between a *Mean* and *Solar Day* is to be found in an *Equation Table*, by which the Mean and Solar Time are mutually convertible into each other. Such a TABLE of the EQUATION of TIME I have lately published, adjusted to the Year 1767; with Directions for its Use.

DAYS, HOURS, &c. are Divisions of Time too small to answer the civil Occasions of Life, and the Purpose of Celestial Science. And the next larger Measure of Time to be found in Nature is the *Motion of the Moon*; this Motion is again two-fold, or rather is estimated by a Revolution from a *fixed Star* or

moveable Sun to the same again; and the Time spent in the former is, at a Mean, 27 Days 7 Hours, 43 Minutes, 4". 45'''. and is called a *Periodical* MONTH; but the Time employed in the latter is 29 D. 12^h. 44'. 2". 53''' and is called the *Synodical* MONTH, or LUNATION.

MONTHS of either Sort are a Measure of Time too defective for *General Use*; because of the many Irregularities of the Moon's Motion arising from the disturbing Forces of the Sun, Earth, and Planets. Astronomers, therefore, next contemplated the *Motion of the Sun*, and soon found it much more *equable* than that of the Moon, and as it was a Period of much greater Extent, they fixed upon it for a Measure of the largest Division of Time, and call it a YEAR.

YEARS, MONTHS, and DAYS, were all of them originally very imperfect, as resulting from very gross Observations, as Astronomy in its infant State, afforded no better Means. Nay, the Year at first instituted by ROMULUS, the Founder of Monarchy in Italy, consisted but of *Ten Months*, beginning with the Month *March*, but as this was short of the Sun's Period by two Months, these were added by his Successor *Numa Pompilius*, and were called *January* and *February*; thus the YEARS consisted of 12 Months.

But the Months of this Year being *Lunations*,

nations, or *Lunar Synodical Months*, of $29\frac{1}{2}$ Days each, this Civil *Lunar Year* consisted but of 354 Days. But the Sun in revolving once through the *Ecliptic* was found in Process of Time, to take up 365 Days, the Excess being 11 Days above the *Lunar Year*, they were added to it by the Emperor *Julius Cæsar*; which was therefore called the *Julian Year*.

The eleven Days added to *Equate* the Lunar with the Solar Year, the Greeks called *Epagomenæ*, whence they are by us called *Epacts*, whose Use will be shewn more fully by and by.

But the Year thus constituted by *Julius Cæsar*, of 365 Days, was observed by the Astronomers of that Age to be about six Hours shorter than the Time the Sun took up in running through the *Ecliptic*, the EMPEROR therefore ordered that every *Fourth Year* should consist of 366 Days, in order that the Seasons of the Year might be fixed to the the same Parts of the *Kalendar* continually, and the *Fasts* and *Feasts* be thereby rendered certain and permanent: This he did as *Pontifex Maximus*, or High Priest in the Roman *Hierarchy*.

This Day was in every fourth Year added to the 24th of *February*, or in this Year there were two 24ths of *February*. This in the Roman *Kalendar*, was the *Idus Sextus, ante*

Kalendas Martii, or 6th Day before the First of March in that Year; so that there being then *Bis Sextus Dies*, gave Occasion for that Year to be called *Annus Bissextiles*, or *Bissextile Year*, and vulgarly *Leap Year*.

But six Hours were afterwards found to be too much by 11.' 3." for by nicer Observations, succeeding Astronomers determined the True Length of the Solar Year to be 365^d. 5^h. 48' 57"; and therefore by the Addition of six whole Days, the Sun each Year began his Course, or entered the first Sign of the Ecliptic, 11' 3" before the preceding Year was ended: This *Precession of the Sun* (as it may be called) amounts to one whole Day in 131 Years. From Julius Cæsar to the Council of NICE, A. D. 325, was about 375 Years, at that time the *Vernal Equinox* fell upon the 21st of March, and consequently every 131 Years after, the Equinox must anticipate one whole Day; and therefore the *Seasons of the Year* and *Festivals of the Church*, must be rendered moveable, and in Time retrograde through the whole Kalendar.

This soon alarmed the Fathers of the Primitive Church, whose Knowledge in Astronomy never suffered them to suspect any such Thing: And as EASTER (the principal Feast) had been fixed to the *Sunday which was the first after the New Moon that happened next after the 21st of March*,

OR

or *Vernal Equinox*, they saw with Concern the unstable Condition of their Rubric; and in the Time of POPE GREGORY XIII. this Grievance was got to be so great, that the said *Equinox*, and *Easter* of Course, anticipated the Time to which the Fathers of the *Nicene Council* supposed they had fixed it, no less than 10 Days.

This Pope, therefore, convened a Council of the best Astronomers of that Age, and after a thorough Consideration of the Affair, it was ordered that 10 Days should be taken from the Month of October in 1582, by reckoning the 5th Day, the 15th. And to prevent the Regress of the Equinoxes in future, it was ordered that every Hundredth Year should consist of only 365 Days, whereas in the *Julian Account* it is a Leap-Year of 366 Days. This Reformation of the Kalendar is hence called the *Gregorian Account* or *New Stile*.

After the same Manner was the Kalendar rectified in *England* in the Year 1752, by throwing out 11 Days in the Month of *September* (as from the Council of *Nice* to that Year 1427 Years had elapsed) and besides, the Beginning of the *Civil Year* was fixed to the *First Day of January*.

But these *Emendations* of the Kalendar, which throw out *four Days* in 400 Years, are not yet so exact as they should be, because the 11' 3'', by which the *Julian Year* exceeds

exceeds the Truth in every Biffextile Year; will amount to but *three Days* in 391 Years. Therefore, if in every 391 Years three Days were expunged from the Kalendar, the Equinoxes would fall upon the same Days of *March* and *September* in every Year, and at the same Time of the Day, very nearly.

These are the Measures of Time for ordinary Use; but for the Purposes of *Computation* of Time, and *Ecclesiastic* CHRONOLOGY, larger Divisions have been found necessary, and have accordingly been invented at different Times; these are usually called CYCLES and PERIODS of Years.

A CYCLE (OR CIRCLE) of YEARS, is a certain Number of Years, Months, Days, &c. which, when they are passed, return again and again, in a constant *Round* or *Circulation*. Of these, there are three of principal Use. (1.) The CYCLE of the SUN. (2.) The CYCLE of the MOON. (3.) The CYCLE of INDICTION. With others of less Note.

The CYCLE of the SUN, is a *Circle* or REVOLUTION of 4 times 7, or 28 Years. It was customary in the first Ages of Christianity; to denote the seven first Days of the WEEK by the *seven* first Letters of the *Alphabet*, viz. A, B, C, D, E, F, G, in all their Almanacs; and as One of these must stand against SUNDAY, who was call'd *Dies Dominicus*, i. e. the *Lord's Day*; so that Letter

ter was called the *Dominical Letter*, as it shewed the *Sundays* throughout the Year, and was distinguished by *Red* in their *Rubrics*, as it is at present in our *common ALMANACS*.

Now because a *Julian Year* of 365 Days, contains 52 Weeks, and one Day; this *odd Day* will cause that the same Letter which pointed out the *Sundays* in One Year, could not do so in the next; for when any Year begins on *Sunday*, the Letter A is *Dominical* for that Year; and since the last Day is *Sunday* also, the *first Day* of the following Year will be on *Monday*, and of Course the 7th Day, which is *Sunday*, will have against it the seventh Letter G, which will be the *Dominical* for that Year; and for the same Reason, the Letter F will be *dominical* for the third Year; the Letter E for the fourth Year, and so on. Therefore in a *Cycle of seven Years*, the *Dominical Letters* will all return to their Office again in the Almanac, but in a retrograde Order, viz. G, F, E, D, C, B, A, G, F, &c.

But because in every *Leap-Year*, there are 52 Weeks, and two Days over, if such a Year succeeds the First, then the first Day will be *Tuesday*, and the *Dominical Letter* be F for the *Sunday*, which is now the 6th of *January*, and not the 7th as before. Hence by means of this *intercalary Day*,
the

the Order of Succession in the Dominical Letters will be interrupted every 4th Year; and consequently it will be four Times seven, or twenty-eight Years before the same Days of the Week return on the same Days of the Month, as at the Beginning; and then is the Cycle completed.

Further, it appears, that since in every Leap-Year, the Day is intercalated between the 24th and 25th of *February*, this 24th Day is to be considered as repeated twice with its proper Letter also; and therefore in every such Year, there will be two Dominical Letters, the first for *January* and *February*, and the second for the Year after. The Reason of which will appear by an Example; Thus in the Year 1772, the Dominical Letter was E to February 23, which was *Sunday*, but the next *Sunday*, (by a Repetition of the Letter F) was on the first of March, and indicated by the Dominical D, as is seen in the following *Hebdomade*, viz.

Feb. 23, 24, 25, 26, 27, 28, 29. 1.
E. F. F. G. A. B. C. D.

The Year 1772, was *Leap-Year*, and from thence to 1800 is just *one Cycle*, which we have represented in the following Table, that the Reader may have an easy Idea of all the Changes that happen, and in what Order
through

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 through the whole Cycle by *Intercalation* of
 a Day in each *Bissextile* Year.

Current Year.	Dominical Letter.	Current Year.	Dominical Letter.	Current Year.	Dominical Letter.	Current Year.	Dominical Letter.	Current Year.	Dominical Letter.	Current Year.	Dominical Letter.	Current Year.	Dominical Letter.
1772	E D	1776	G F	1780	B A	1784	D C	1788	F E	1792	A G	1796	CB
73	C	77	E	81	G	85	B	89	D	93	F	97	A
74	B	78	D	82	F	86	A	90	C	94	E	98	G
75	A	79	C	83	E	87	G	91	B	95	D	99	F

From hence it is evident, that the Year 1800 being Bissextile, the Dominical Letters will be ED, the same as the first of the Cycle above for 1772; and the same Letters return through the next Cycle from 1800 to 1828, and also in the next after to 1856, and so on for every future Cycle. From hence the following Rule for finding the Dominical Letter for any future Year is easily deduced, viz.

From the given Year subduct the Year 1772; divide the Remainder by 28; and to the Remainder of this Division, add 1772; the Sum will be the Year in the Table above, whose Dominical Letter is that which is sought.

For Example: What will be the Dominical Letter for the Year 1943? From 1943 take 1772, divide the Remainder 171 by 28; the Quotient is 6 Cycles, the Remainder 3 added to 1772, makes 1775 in the Table, whose Dominical Letter A is that required for the Year 1743.

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In like Manner you proceed for any Year past; thus suppose it required to find the Dominical Letter for the Year 1375; proceed thus; from 1800 to take 1375, and divide the Remainder 425 by 28; the Quotient is 15 Cycles past; and the Remainder 5 *taken* from 1800, leaves 1795, whose Dominical Letter D, is that for the Year required.

Thus 1800 divided by 28 quotes 63 Cycles past; and the Remainder 8 taken from 1800, leaves 1792, whose Dominical Letters are A, G, for the *first Year of Christ*, which thence appears was a *Leap-Year*.

By means of two small Tablets connected in the next Page, you find on what *Days of Month* the SUNDAYS fall in every Week throughout any given Year. To this End the upper Part contains the Days of the Month disposed in Rows of 7 to 31. Under these is a *Square of the Dominical Letters*, by the Side of which are placed the Names of such Months as have the Sundays upon the same Days, which are shewn in the *perpendicular Column* of Figures above, over any respective Dominical Letter in the horizontal Row of the Square below. Thus for Example: The Dominical Letter for the present Year 1773, being C, it appears that the Sundays in the Months of *January* and *October* are on the 3d, 10th, 17th, 24th, and 31st Days; that in
May

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May the 2d, 9th, 16th, 23d, and 30th, will be Sundays; in August the 1st, 8th, 15th, 22d, 29th are Sundays; and so for the rest. Hence the foregoing Table joined with these, constitute what may be called (with some Degree of Propriety) an *Universal ALMANAC*.

	S U N D A Y S.						
	1	2	3	4	5	6	7
Days of the Month.	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
	29	30	31				
Jan. Octob.	A	B	C	D	E	F	G
May	B	C	D	E	F	G	A
August.	C	D	E	F	G	A	B
Feb. Mar. Nov.	D	E	F	G	A	B	C
June.	E	F	G	A	B	C	D
Sept. Decemb.	F	G	A	B	C	D	E
April, July.	G	A	B	C	D	E	F

Besides the *Solar Cycle*, there is also a *Lunar One*, consisting of 19 Years, invented by *Meton*, an Astronomer at *Athens*, about the Year before *Christ*, 422. It was designed to shew when the *New and Full Moons* happen in every Year, and by that Means to ascertain the Time of *EASTER*, and all other *Moveable Feasts* depending thereon.

METON (and the Ancient Fathers) supposed that the Motions of the Sun and Moon coincided after 19 Years, in which

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Time there were 235 Lunations, but this was not strictly true, as thus appears;

	D.	H.	M.	S.
19 Julian Years contain - - -	6939.	18.	00.	00.
235 Lunations contain - - -	6939.	16.	31.	45.
Difference -	0.	1.	28.	15.

So that in every Cycle there will be an Error in Defect of the $1\frac{1}{2}$ Hour; and therefore in 304 Years, the New and Full Moons will happen sooner by the Cycle than they do in the HEAVENS, by *One whole Day*. But this the Primitive Christians were not sensible of, and so the *Lunar Cycle* of 19 Years, was established by the COUNCIL of NICE, A. D. 325, for finding and observing *Easter for ever*.

For this Purpose (in Imitation of the *Jewish Passover*) they appointed for the Celebration of EASTER *that Sunday which first happens after the Full Moon that immediately follows the Vernal Equinox*, which at that Time was on the 21st of March. This *Full Moon* was therefore called *The Pascal Term*; and as this might happen on the 21st of March, it is evident the *Earliest Easter* would be on the 22d of the same Month. On the other Hand, the 18th of April being the latest *Pascal Full Moon*, the 7th Day after, or 25th of April, is the *latest Easter* possible.

Now from March 22d to April 25th are 35 Days, therefore some one Number be-
tance

tween 0, and 35, will point out the Distance of Easter Sunday from the 21st of March, in the several Years of this Cycle, and so they came to be called *Numbers of Direction*.

This Cycle was thought of such Consequence in former Times, that they expressed the Figures or Numbers of the several Years in *Characters of Gold*, and therefore the Years of this *Lunar Cycle* were called *Golden NUMBERS*, or *Primes*.

As the finding of EASTER depended on the *Full Moon* following the 21st of March, so it must equally depend on the *New Moon* preceeding that Day. Now, their Custom was to fix the *Golden Number* against the Days of the Month on which the *New Moon* happened in that respective Year, viz. In the first Year of the Cycle, the Number 1 was placed against all the Days on which the Moon changed. In the 2d Year of the Cycle the Number 2 indicated the *New Moons*. In the 3d Year the Number 3 did the same; and so on throughout the whole Cycle.

From what has been said it appears, that unless a Person were provided with a Kalendar for every Year of the Lunar Cycle, he could not tell on what Days of any given Year the *New Moons* fell; and therefore they had Recourse to another Expedient, and made Use of those Numbers they called *EPACTS*,
because

because being *added* to the *Lunar Year* of 354 Days, they equated it to the *Solar Year* of 365 Days; and the Difference being 11 Days, would be the *Age of the Moon* at the End of the Year, when there was a *New Moon* at the Beginning; and those subducted from $29\frac{1}{2}$ Days leave $18\frac{1}{2}$ for the Day of *January*, on which the first *New Moon* would happen in the following Year. And because *January* has 31 Days, if the remaining $12\frac{1}{2}$ be taken from $29\frac{1}{2}$ there will remain 17 for the Day of *February* on which the next *New Moon* happens; and in this Manner they are found through the second Year when the *Epact* is 11.

Again in the third Year the *Epact* will be 22, which taken from $29\frac{1}{2}$, leaves $7\frac{1}{2}$ for the Day of the first *New Moon* in *January*; these taken from 31, leave $23\frac{1}{2}$, which taken from $29\frac{1}{2}$, leave 6 for the Day of the *New Moon* in *February*, and so on through that Year.

On the Fourth Year the *Epact* is 33; but this being a Month of 30 Days, and 3 over. The foregoing Year had an additional or *Embolismic Month*; and the *Age of the Moon* on this *New Year's Day* was 3, which was therefore the *Epact* for finding the *New Moons* for this Year, as in the preceding Ones. Hence for the several Years of the Cycle, the *Epacts* will be as below.

Golden

Gold. Numb. 1. 2. 3.4. 5. 6. 7. 8. 9.10.
Epacts. — 0.11.22.3.14.25. 6.17.28. 9.

Gold. Numb. 11.12.13.14.15.16.17.18.19.
Epacts. — 20. 1.12.23. 4.15.26. 7.18.

But the *New Moons* found by these *Epacts* are very different from the *real New Moons* in the Heavens; for the Difference of the *Lunar* and *Solar* Years is not 11 Days, but only 10 Days, and 21 Hours; nor is the *Lunation* just $29\frac{1}{2}$ Days, but 29 Days, 12 Hours, and 44 Minutes. So that an Error *in Defect*, and another *unequal One* in *Excess*, will cause for ever a wider and wider Difference between the *Ecclesiastic New Moons* and the true *Astronomical Ones*, which can only be known by Calculations from proper Tables.*

The Cycle of the *Sun* 28, multiplied by the Cycle of the *Moon* 19, produces the Number 532; after which Period compleated, not only the *New and Full Moons* return on the *same Days of the Month*; but also the *Days of the Month* return to the *same Days of the Week*. And so the *Dominical Letters*

* For this Purpose I must recommend the Tables of Mr. CLAIRAUT as preferable to *Mayer's* on several Accounts, as I have shewn in my Preface to the Translation of them lately published, under the Title of INSTITUTIONS of *Astronomical CALCULATIONS*, &c.

and

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and *Moveable Feasts* return again in the same Order as before. This was called the *Victorian PERIOD* from its Inventor *Victorius*, A. D. 527, but was afterwards corrected by *Dionysius Exiguus*, A. D. 527, and from him was called the *Dionysian Period*; and also *the Great Paschal*, till the Time of Pope GREGORY XIII. who new-modelled the Year, as before related.

But none of all these Methods by *Cycles*, *Epacts*, &c. with all their Emendations, even by that celebrated *Pope*, and his *Astronomers*, could ever keep the New Moons of the Rubric to those of the Heavens, which has given Occasion for many ingenious and learned Men to find out Ways and Means for compleatly ascertaining the Time of the Celebration of *Easter*; among whom, no one has succeeded so well as the late EARL of MACCLESFIELD, in his REMARKS on the *Solar and Lunar YEARS*, &c. where he has given us a Table shewing by Means of the *Golden Numbers*, the several Days on which the *Pascal Limits* or Full Moons have, or will hereafter happen, from the *Gregorian Reformation of the Kalendar*, A. D. 1528, to the Year 4199 inclusive.

Because the Year 325 was the first of the *Lunar Cycle* (as settled by the *Council of Nice*) if the preceeding 324 Years be divided by 19, there will remain 1, which will shew that the first Year of Christ was the

2d of the Cycle ; and therefore if to any given Year you add 1, and divide the Sum by 19, the Remainder will be the *Golden Number* for that Year. Thus to the present Year 1773, add 1, and divide the Sum 1774 by 19, there will remain 7, the *Golden Number* for this Year.

Then in the following Table, the present Year 1773, falls between 1700 and 1899 in the *second Column*, and in which you observe the golden Number 7, against which in the Horizontal Line by the Side of the Table you see April 7th with the Letter F, which is the *Pascal Full Moon*; therefore the Dominical Letter for the present Year, being C, you find it by April 11th the next Sunday after the Full Moon; and consequently That is EASTER SUNDAY. Suppose for a 2d Example it were required to find Easter, A. D. 1943, the Dominical Letter is A as we have seen, and 1944 divided by 19; leaves 6 for the Golden Number that Year; then in the *third Column* you find 6 at the very bottom, against April 18th, the *latest Pascal Limit*: and the Letter A following, shews *Easter-Day* falls then on the 23d of the same Month.

Golden Numbers from the Year 1583 to 1699, and fo on to 4199, all inclusive.																Paschal Full Moons.	
583 to 1699	1700 to 1899	1900 to 2199	2200 to 2399	2400 to 2499	2500 to 2599	2600 to 2899	2900 to 3099	3100 to 3299	3400 to 3499	3500 to 3599	3600 to 3699	3700 to 3799	3800 to 4099	4100 to 4199	Days of the Month, and Sunday letters		
3	14	..	6	17	6	17	..	9	..	1	12	1	12	..	4	March 21. C	
..	3	14	..	6	..	6	17	..	9	..	1	..	1	12	..	22. D	
11	..	3	14	..	14	..	6	17	..	9	..	9	..	1	12	..	23. E
..	11	..	3	14	3	14	..	6	17	..	9	..	9	..	1	..	24. F
19	..	11	..	3	..	3	14	..	6	17	..	17	..	9	..	..	25. G
8	19	..	11	..	11	..	3	14	..	6	17	6	17	..	9	..	26. A
..	8	19	..	11	..	11	..	3	14	..	6	..	6	17	..	..	27. B
16	..	8	19	..	19	..	11	..	3	14	..	14	3	6	17	..	28. C
5	16	..	8	19	8	19	..	11	..	3	14	3	14	..	6	..	29. D
..	5	16	..	8	..	8	19	..	11	..	3	..	3	14	..	..	30. E
13	..	5	16	..	16	..	8	19	..	11	..	11	..	3	14	..	31. F
2	13	..	5	16	5	16	..	8	19	..	11	..	11	..	3	April 1. G	
..	2	13	..	5	..	5	16	..	8	19	..	19	..	11	..	..	2. A
10	..	2	13	..	13	..	5	16	..	8	19	8	19	..	11	..	3. B
..	10	..	2	13	2	13	..	5	16	..	8	..	8	19	..	..	4. C
18	..	10	..	2	..	2	13	..	5	16	..	16	..	8	19	..	5. D
7	18	..	10	..	10	..	2	13	..	5	16	5	16	..	8	..	6. E
..	7	18	..	10	..	10	..	2	13	..	5	..	5	16	..	..	7. F
15	..	7	18	..	18	..	10	..	2	13	..	13	..	5	16	..	8. G
4	15	..	7	18	7	18	..	10	..	2	13	2	13	..	5	..	9. A
..	4	15	..	7	..	7	18	..	10	..	2	..	2	13	..	..	10. B
12	..	4	15	..	15	..	7	18	..	10	..	10	..	2	13	..	11. C
1	12	..	4	15	4	15	..	7	18	..	10	..	10	..	2	..	12. D
..	1	12	..	4	..	4	15	..	7	18	..	18	..	10	..	..	13. E
9	..	1	12	..	12	..	4	15	..	7	18	7	18	..	10	..	14. F
..	9	..	1	12	1	12	..	4	15	..	7	..	7	18	..	..	15. G
17	..	9	..	1	..	1	12	..	4	15	..	15	..	7	18	..	16. A
6	17	17	9	..	9	..	1	12	12	4	15	4	15	15	7	..	17. B
14	6	6	17	9	17	9	9	1	1	12	4	12	4	4	15	..	18. C
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	19. D
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	20. E
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	21. F
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22. G
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	23. A
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	24. B
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	25. C

There was another Period called the CYCLE of INDICATION, which had no Relation to the *heavenly Motions*, but was only of *civil Use* among the *Romans*, viz. to indicate or make known the Times of certain Payments, &c. it consisted of three *Lustrums*, or 15 Years; and was established by the Emperor

Emperor *Constantine*, A. D. 312, in the room of the *Greek Olympiads*.

These OLYMPIADS were CYCLES of four Years; they were first instituted in Honour of *Jupiter Olympius*, in the 776th Year before Christ; so that the first Year of the *Christian Æra* was the first of the 195th *Olympiad*. In these Cycles, the *Festivals* and *public Games* were celebrated; and by their several Years were recorded the most remarkable Events of the *Grecian History*.

The most famous and useful *Period* of all in CHRONOLOGY, is that called the *Julian PERIOD*, from its supposed Inventor *Julius Scaliger*. This is the Result or Product of the *Cycles of the Sun, Moon and Indiction*, all multiplied together, viz. $28 \times 19 \times 15 = 7980$ Years. This Period hath its Beginning fixed to the 764th Year *before the Creation*, and is not yet compleated; it comprehends all other *Periods, Cycles, and Epochas*; and consequently the Times of memorable Actions, Events, and Histories. There is but one Year in the whole Period in which the Numbers for the Cycles, of which it is composed, are the same. And therefore if Historians had remarked in their Annals the Number of the Cycles in each Year respectively, there could have been no Dispute about the Time of any Action in past Ages.

The first Year of the *Christian Æra* was

the 4714th Year of the Julian Period, and therefore if to that you add the Current Year of Christ, 1773, you have 6487 for the present Year of the Period.

EPOCH or ÆRA, is a certain Term or fixed Point of Time, notified by some memorable Event, from which as from an *Exordium* or Origin, Historians make their Computations of Time, and all remarkable and remote Transactions are recorded and disposed according to the Series of Years of such or such an *Epoch*.

The most famous Epochs are those contained in the following Table; most of which have an uncertain Beginning, but the Times or Intervals of Events may be duly registered and stated by them. Thus if the *Council of Nice* was in A. D. 325, according to the vulgar Account of *Christ's Birth* being in the Year of the World 4009; we know as well that that Council was held 1448 Years ago as we could have done from the *True Christian Epoch*, which begun *Anno Mundi* 4005.

But if any Interval of Time happened *partly before*, and *partly after*, the Beginning of any Epoch, we can have but an imperfect Idea of it, thus the common Æra of Christ fixed to A. M. 4009 makes him but 33 Years of Age when crucified; but the True Year of his Birth being in 4005 of the World, gives his *true Age* at his Death, viz. in his 36th Year.

A TABLE

A TABLE of the most remarkable EPOCHS from the CREATION to the REFORMATION.

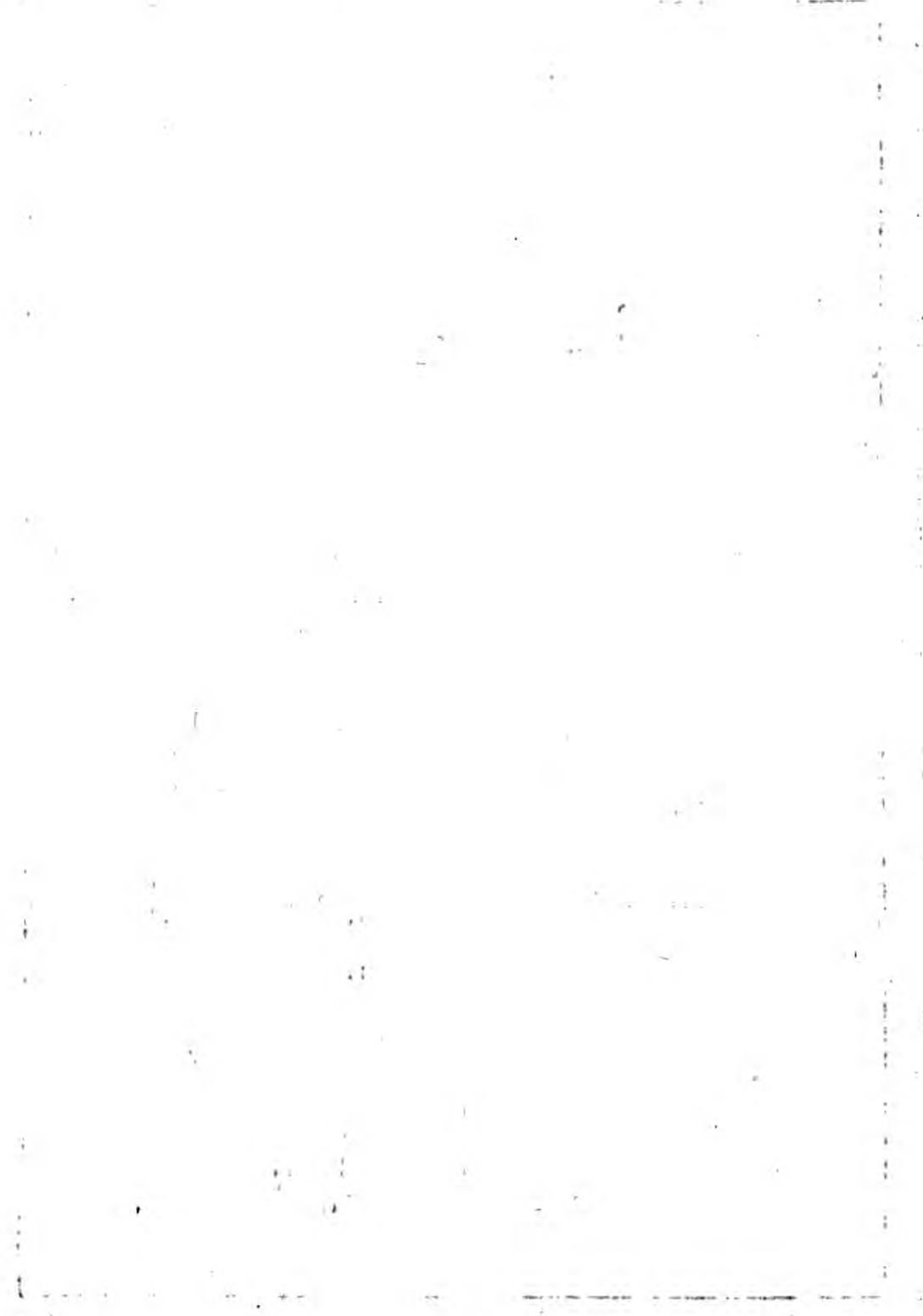
	Jul. Per.	A. M.	ante C.
1 The Creation of the World, after the Jews —	952	i	3760
2 The common Epocha of the Creation —	765	i	3950
3 The same by the Greek Emperors —	787	i	3926
4 The same in Mr. Bedford's Scriptural Chronology —	766	i	4007
5 The Deluge, or Noab's Flood —	2362	1657	2351
6 The Assyrian Monarchy by Nimrod —	2665	1960	2048
7 The Birth of Abraham —	2714	2009	1999
8 The Israelites 400 Years Servitude in Egypt —	2819	2114	1894
9 The Kingdom of Argos founded by Inachus —	2857	2152	1856
10 The Kingdom of Athens founded by Cecrops —	3157	2452	1556
11 The Israelites Departure out of Egypt —	3219	2514	1494
12 Their Entrance into Canaan, or the Jubilee —	3258	2553	1533
13 The Destruction of Troy —	3530	2825	1183
14 The first Sabbatical Year —	3260	2557	1431
15 The Jewish High-Priesthood —	3300	2603	1405
16 King David's Reign —	3646	2941	1067
17 The Foundation of Solomon's Temple —	3698	2993	1015
18 The Epocha of Nabonassar —	3966	3261	747
19 The Olympiads —	3938	3233	776
20 The Building of Rome —	3962	3257	751
21 The Destruction of the Kingdom of Israel —	3992	3287	721
22 The Babylonish Captivity —	4108	3302	606
23 The Destruction of Solomon's Temple —	4126	3421	587
24 Cyrus the Founder of the Persian Monarchy —	4178	3472	536
25 The Battle at Marathon —	4223	3517	491
26 Xerxes's Defeat at the Battle of Salamis —	4234	3528	480
27 Meto began his Cycle —	4282	3576	432
28 The Beginning of the Peloponnesian War —	4283	3577	431
29 Daniel's Seventy Weeks of Years began —	4269	3564	444
30 The Beginning of the Calippick Period —	4383	3677	331
31 The Death of Alexander —	4390	3684	324
32 The Grecian Epocha of the Seleucidæ —	4402	3695	312
33 The Æra of the Asmoneans or Maccabees —	4548	3841	166
34 The Antiochean Epocha —	4665	3958	49
35 The Correction of the Calendar by Julius Cæsar —	4669	3962	45
36 The Beginning of the Reign of Herod —	4677	3970	37
37 The Spanish Æra —	4676	3969	38
38 The Battle of Actium —	4683	3976	31

	Jul. Per.	A. M.	ante C.
39 The Epocha of the Title of <i>Augustus</i> —————	4687	3980	27
40 The true Birth of <i>CHRIST</i> —————	4710	4005	4
41 The Vulgar or <i>Dionysian</i> Year of Christ's Birth	4714	4909	<i>A. C.</i>
42 The Passion or Death of Christ —————	4746	4041	33
43 The Destruction of the City of <i>Jerusalem</i> ———	4783	4078	70
44 The <i>Dioclesian</i> or <i>Æra</i> , of Martyrs —————	4997	4292	284
45 The Epocha of <i>Constantine the Great</i> —————	5019	4314	306
46 The Council of <i>Nice</i> —————	5038	4333	325
47 The Encœnia of <i>Constantinople</i> —————	5043	4338	330
48 The Epocha of the <i>Hegira</i> —————	5335	4610	622
49 The Epocha of <i>Tesdejerd</i> —————	5345	4620	632
50 The <i>Jellalœan</i> or <i>Gelalœan</i> Epocha —————	5792	5067	1079
51 The Epocha of the REFORMATION —————	6230	5505	1517

F I N I S.

From the Press of BIRD and COX,
at Newton's Head in the Strand.

[Faint, illegible text]



Canicular ASTRONOMY.

Fig. 1.

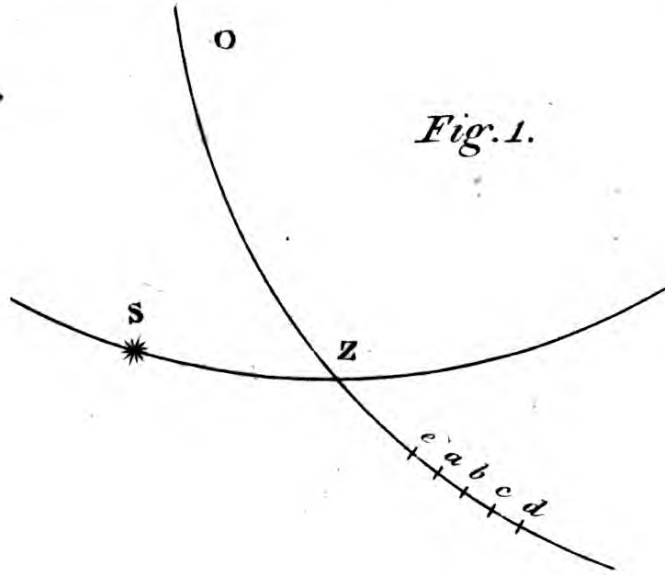
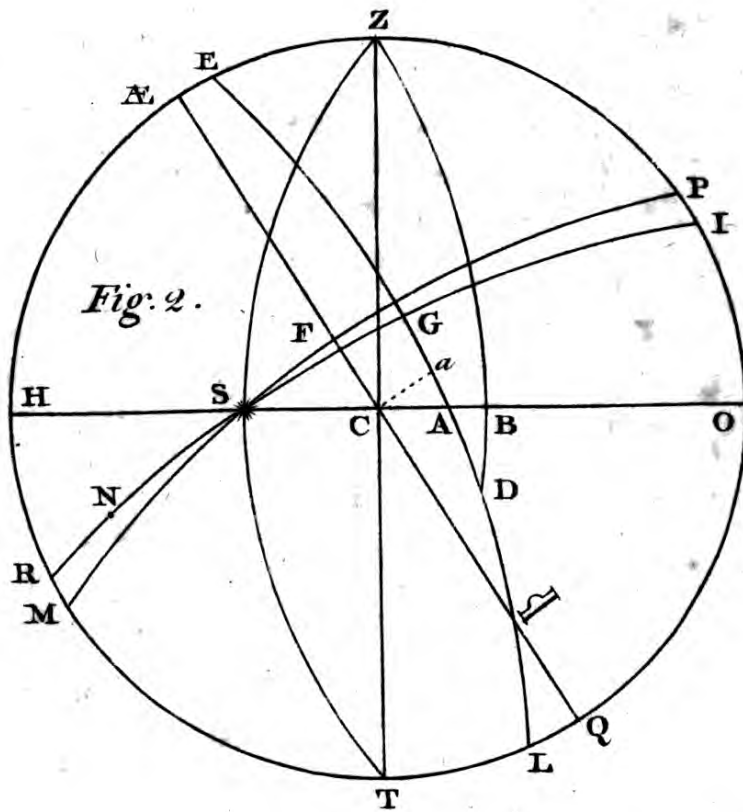


Fig. 2.



Jn. Lodge sculp.

65X58*65X58*35X42*57X42*35X55*35X42

The SOTHIAE PERIOD,

*And ancient Canicular ASTRONOMY
explained, and illustrated by CAL-
CULATION.*

***S the HELICAL RISING and SET-
* A * TING of the Heavenly Bodies were
*** omitted among the Problems of the
Stars, we shall here supply that Defect, es-
pecially as the Doctrine of the *Canicular*
ASTRONOMY (concerning which the learned
BAINBRIDGE wrote a Treatise,) depends en-
tirely upon it.

A Star or Planet is said to *rise Heliacally*, when it is at sufficient Distance from the Sun to be first seen distinctly in the Horizon at its *Rising* in the Morning; and it *sets Heliacally* when it ceases to be seen in the Horizon of an Evening after *Sun-set*. It has been found by *Ptolemy*, and other Astronomers, that the Distance of the Sun below the Horizon, is then about 12 Degrees, for a Star of the first Magnitude.

Therefore to find the *Helical* rising of a Star, bring it to the eastern Part of the Horizon, and lay the Quadrant of Altitude over the western Part of the Globe; and there

M m

move

move it so, that the 12th Degree may cut the Ecliptic; mark that Point in the Ecliptic, and The Point opposite to it, is that in which the Sun is 12° below the Horizon, when the Star rises, and the Time of the Year corresponding to that Place of the Sun, is found in the Calendar upon the Horizon, In the same Manner you find the Time when the Star *sets heliacally*.

It is supposed, the ancient *Egyptians* took this Method of observing the *Moon*, in order to get some Idea or general Measure for MONTHS; hence, they concluded, that the Time between *two heliacal Risings* of the Moon (or between *two New Moons*, as they are now called,) was 30 Days; and accordingly they divided their Year into 12 equal Months of 30 Days each; this was called the *Luni-Solar YEAR*; and consisted of 360 Days.

But having learned by continued Observations on the *Heliacal rising and setting of Stars*, that the true Length of the Year exceeded 360 Days, by about 5 Days, they added these 5 Days to the End of the Year, which then consisted of 365.

Because the *Egyptians* in these Observations made use of SIRIUS (the *Dog-Star**) this Year of 365 Days was called the *Canicular Year*. As Astronomy farther advanced, it

* The Latin Name for a *Dog* is *Canis*.

it was soon observed that this Year was deficient of the Length of the natural Year, by about 6 Hours (see Page 232) or a Quarter of a Day; for by that Space of Time they found the *heliacal Rising* of *Sirius* was later and later yearly. Therefore in 4 Years the Star rose one Day later, and in 4 times 365, or 1460 Years, it rose a *whole Year later*, that is, in the Compass of 1460 Years; *Sirius* would rise heliacally upon the *same Day of the Month*.

This Space of Time was by the *Egyptians* called the *Sothiacal PERIOD*, because the Name of *Sirius* with them was SOTH. And of Course, 1460 Solar Years were equal to 1461 of the *Egyptian Civil Years*; the first Month of which was called *Thoth*, and corresponded to *September* in the *Roman Calendar*. And it is to be supposed that the Beginning of the *Sothiacal Period* was at the *Heliacal Rising* of *Sirius* on the first Day of *Thoth*, or the Beginning of the *Egyptian Year*.

As PTOLEMY in his *Almagestum Magnum*, and many other ancient Astronomers, used the *Egyptian Year*, (first instituted by NABONASSAR, King of *Babylon* 747 Years before Christ, see Page 241) therefore to compare Observations made by the Ancients with those of modern Times, it will be very useful to have the *Julian* and *Egyptian Year* placed appositely by each other,* that their Correspondency

M m 2

spondency

* The Reader will find these two Calendars in my *Bibliotheca Technologica*, under the Title of *Chronology*.

spondency through the Whole may be seen at once; but it must be observed by the Reader who would be very correct, that the Beginning of the *Nabonassarean* Year, was really on the 29th of August.

Mr. BAINBRIDGE illustrates this Matter by the following Scheme (Fig. 1.) Let SZ be an Arch of the eastern Horizon, OZ a Part of the Ecliptic, and S the Place of the Star (*Sirius*) at its Rising. Let the Sun be rising at the same Time in Z, by his Light obscuring the Star at S. Now that the Star may be visible at Rising, it is required that the Sun be at some certain Distance from the Star, below the Horizon, and let that Distance be Za ; so that when the Sun is in a or lower, the Star rising at S will be visible, but if the Sun be any-where between Z and a , the Star will not appear at rising.

From a towards Z, take the Arch ac equal to a Quarter of a Degree; and on the other Side, take $ab=bc=cd=ae$; and the Motion of the Sun through a Quarter of a Degree is made in 6 Hours nearly, which is the Excess of the Tropical Year above the *Egyptian* Year of 365 Days.

These Things premised, it follows, that on the first Day of *Thoth*, in the *first* Year, SIRIUS at S is rising and visible when the Sun is at d ; the *second* Year, on the same Day of *Thoth*, the Sun will be at c ; in the *third* Year, on the first of *Thoth*, when he
is

is at *b*; and the *fourth Year* still on the first Day of *Thoth*, when he is at *a*; for at the End of every *Egyptian Year*, there was wanting to compleat the tropical Year, a Quarter of a Day; and to finish the Sun's Course, a Quarter of a Degree.

During these first 4 Years, then, when the Sun is in *d, c, b, a*, the Star rising at *S* will be visible on the first Day of *Thoth*. But in the 5th Year, on the first Day of *Thoth*, the Sun will be at *e*, and the Star rising at *S*, will not be seen; but on the second Day of *Thoth*, the Sun will be in *d*, and the Star rising at *S* will be visible. In the *sixth Year*, on the same second Day of *Thoth*, the Sun will be in *c*; the seventh Year in *b*; and the eighth Year in *a*. So that during these second four Years, the Star *S* will rise Heliacally visible on the second Day of *Thoth*. And after the same Manner it is shewn, that during the next four Years, the Star will rise and be visible on the *third Day*; and for the next four Years, on the *4th Day* of *Thoth*; and so on, till it has passed through all the Days of the Year.

Having thus explained the Nature of the *Canicular Year* and *Sothiacal Period*; Mr. BAINBRIDGE next proceeds to an *astronomical Solution* of the following Problem, *viz. For any given Time and Latitude of a Place, to find the Heliacal Rising of any given Star.*

In order to the Solution of this Problem, the *Longitude* and *Latitude* of the Star, as also its *Right Ascension* and *Declination*, are to be taken from Astronomical Tables; from thence we find the *Ascensional Difference*, and *Oblique Ascension*, and these being known, we find the Point of the Ecliptic rising with the Star, and the Angle contained between the Ecliptic and Horizon; and then, lastly, by these *Precognita*, we find the Sun's Place in the Ecliptic, in the *heliacal Rising* of the Star.

Having constructed a proper Scheme, (Fig. 2.) for *Heliopolis* in lower *Egypt*, we can thereby illustrate the Process of astronomical Calculation; for therein let HZOO be the Meridian; HCO the Horizon; P the North Pole; OP the Elevation thereof, or Latitude of *Heliopolis*; Z the Zenith. AECQ the Equator; EAL the Ecliptic; = the Autumnal Equinox; S the Place of *Sirius* in the Horizon rising heliacally; PSM a Circle of Declination; ISR a Circle of Latitude; N the South Pole of the Ecliptic. ZST the vertical Circle through *Sirius*. D the Place of the Sun at the heliacal Rising of the Star, to find which is the general Problem proposed.

Therefore let the Example be to find the *heliacal Rising* of *SIRIUS* at *Heliopolis* in the Year 1750. The Latitude of *Heliopolis* is $AZ = 30^{\circ} 22'$; and the Declination of *Sirius*,

is

is $SF = 16^{\circ} 23' \frac{1}{2}$; therefore in the Right angled Triangle SFC , say (by Case II. Anal. I. Page 203 of the Use of the GLOBES.)

As the Tang. of the Angle $SCF = 59^{\circ} 38'$	—	10.232165
Is to the Tangent of $SF = 16 23$	—	9.468580
So is the Radius	—	10.
To the Sine of the Arch $CF = 9 47$	—	9.236415

To the Right Ascension of *Sirius* for 1750, viz. $98^{\circ} 32'$, add the Ascension Difference now found, and the Sum will be $108^{\circ} : 19' =$ oblique Ascension of *Sirius*.

The next Thing to be determined is the Point of the Ecliptic A rising with *Sirius* S ; to find which there are given in the oblique Triangle $C \simeq A$, the Obliquity of the Ecliptic, or Angle at $\simeq = 23^{\circ} 28'$; the Angle $\simeq CA = 59^{\circ} 38'$, the Co-latitude; and $C \simeq$ the Supplement of Oblique Ascension (just now found) $71^{\circ} 41'$ to find the Side $A \simeq$.

In order to this, from the Point C let fall the Perpendicular Ca , then in the right angled Triangle $C \simeq a$ there are known the Hypotheneuse $\simeq C$, and the Angle \simeq , to find the Side Ca ; say (by Case III. Anal. 2.)

As Radius	—	10.
To the Sine of $\simeq C =$	—	9.977419
So is the Sine of $C \simeq a =$	—	9.600118
To the Side $Ca =$	—	9.577537

Then you find the Angle $\sphericalangle C a$ (by Case III. Anal. 3.)

As Co-sine of $\sphericalangle C =$	71° 41' —	9.497301
Is to Radius	_____	10.
So is the Co-tangent of \sphericalangle	23 28' —	10.362389
To the Tangent of $\sphericalangle C a =$	82 14' —	10.865088

Then from 82° 14' take 59° 38', there will remain the Angle $AC a = 22° 36'$.

In the right angled Triangle $\sphericalangle C a$ we find the Base $\sphericalangle a$, by saying,

As Radius	_____	10.
To the Sine of $\sphericalangle C =$	71° 41' —	9.977419
So is the Sine of $\sphericalangle C a =$	82 14 —	9.995998
To the Sine of $\sphericalangle a =$	7° 9 —	9.973417

In the right angled Triangle $AC a$, there are known the Side $C a$, and the Angle $AC a$; to find the Side $A a$ (by Case I. Anal. 1.) say,

As Radius	_____	10.
To the Sine of $C a =$	22° 12' —	9.577537
So is the Tangent of $AC a =$	22 36 —	9.619364
To the Tangent of $A a =$	8 56 —	9.196901

Then from 70° 9' ($= \sphericalangle a$) take 8° 56' there will remain 61° 13' $= \sphericalangle A$; which taken from 180°, will leave 118° 47', or \sphericalangle 58° 47', for the Point of the Ecliptic A rising with *Sirius* at S.

To

To find the Angle at A, say,

As the Sine of A a =	—	8° 56'	—	9.191130
To the Sine of AC a =		22 36	—	9.584665
So is the Sine of C a =		22 12	—	9.577537
				19.162202
To the Sine of CA a =		69 19	—	9.971072

Lastly; in the right angled Triangle ABD, there are known the Angle BAD, last found, and the Side BD, the Depresson of the Sun below the Horizon, which to render the very large and bright Star *Sirius* visible at S, in the clear and serene Air of *Egypt*, Mr. *Bainbridge* estimates at 11 Degrees.

Therefore say,

As the Sine of BAD =		69° 19'	—	9.971072
To the Sine of BD =		11 00	—	9.280599
So is the Radius	—	—	—	10.
				9.309527
To the Sine of AD =		11 46	—	9.309527

To the Co-orient Point of the Ecliptic A = \ominus 58° 47' add 11° 46', the Sum will be Ω 10° 33' for the Place of the Sun required, when *Sirius* rose heliacally in the Year 1750, which was on *July* 24th, *Old Style*.

Now from *July* 24. to *Aug.* 29. (or *Iboth*) when the *Sothiacal Period* begins, is 36 Days; therefore $36 \times 4 = 144$ Years yet to come of the Current Period; hence $1460 - 144 = 1316,$

= 1316, the Year of the Period for *An. Dom.* 1750. Also $1750 - 1316 = 434$ the Year of CHRIST, when the present Period began. Again $1460 - 434 = 1026$ the Year before CHRIST when the former Period began. And lastly, $1750 + 112 = 1862$, when the *Sothiac Period* begins again.

The Substance of his Book we have now nearly exhausted, and shall only further observe that when *Sirius rises heliacally*, those called the *Dog-Days* end, and they begin when this Star sets *heliacally*, i. e. when he is less than 12 Degrees from the Sun at his Setting; for during that Interval, this Star is above the Earth with the Sun, and because when the *heliacal Rising and Setting* were in the Beginning of the Month *Thoth*, these *Dog-Days* were very hot, it gave Rise to the superstitious Notions the Ancients had of the pernicious Influence of this Star on the Air, the Bodies of Animals, &c. But as they had no Intercalary Day, their *Dog-Days*, in one *Sothiac Period*, run through all the Months of the Year: whereas, with us, by Means of the Day added in *Leap Year*, they are always in the *Autumnal Season*.

These *Dog-Days* are a most ancient and remarkable Instance how easily the most absurd Superstition and palpable Imposture take Place in the Minds of the ignorant, credulous, and deluded Vulgar; and is therefore a convincing Proof of the invaluable Blessing
of

of **LEARNING**, which alone can preserve our Minds uncontaminated by the baneful Influences of those **FALSE LIGHTS**, which but too sensibly and frequently affect us.

