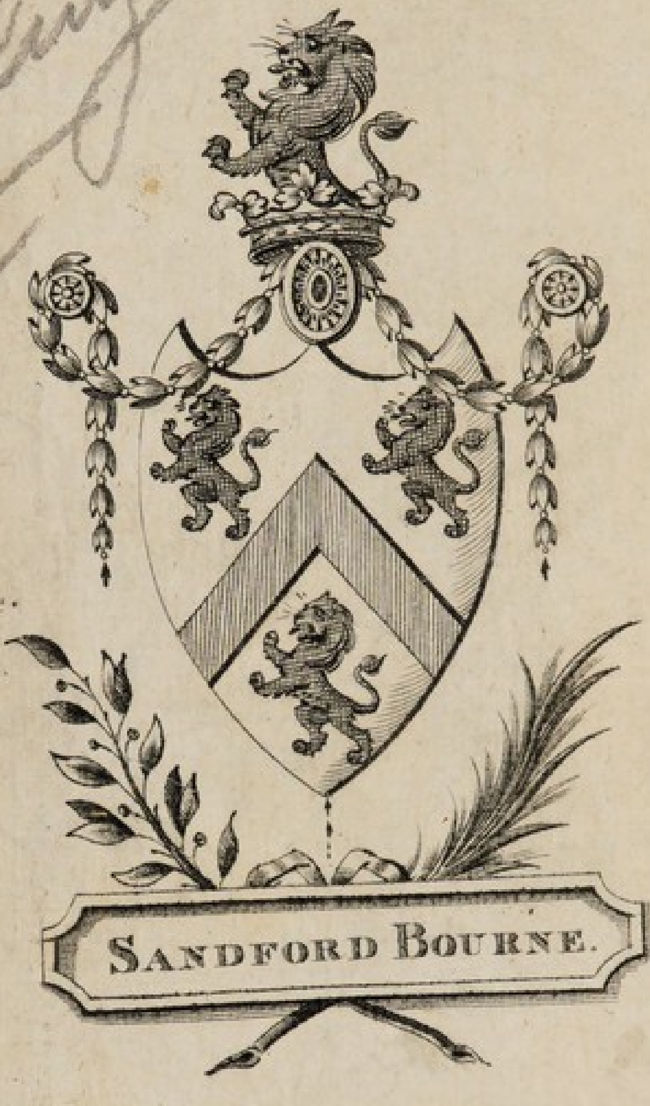
HIBERNIAN ACADEMY

PRÆMIA LAUDI


SANDFORD BOURNE.

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Richard Bourne deserved

This Premium, For

Dialling

At an Examination, held in the

HIBERNIAN ACADEMY.

Dublin, June 28 1765 } Andrew Buck

Head Master

THE

Young Gentleman's ASTRONOMY, CHRONOLOGY, AND DIALLING,

Containing ſuch

ELEMENTS of the ſaid Arts or Sciences, as are moſt uſeful and eaſy to be known.

By EDWARD WELLS, D. D. Rector of *Cotesbach* in *Leiceſterſhire*.

The THIRD EDITION *Reviſed, and Corrected, with* ADDITIONS.

LONDON:
Printed for JAMES and JOHN KNAPTON, at the *Crown* in St. *Paul*'s Church-Yard. 1725.

THE
Young Gentleman's
ASTRONOMY,

Containing ſuch

ELEMENTS of the *Aſtronomical* Science, as are moſt uſeful and eaſy to be known.

BY

EDWARD WELLS, D. D. Rector
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MDCCXXV.

The PREFACE.

T*HERE are two Ends of writing Books, which relate to the ſeveral Parts of Learning: one to* advance Learning *it ſelf; the other to* aſſiſt Learners.

In Purſuance of the former, the Capacioufneſs of the Subject *is chiefly to be conſidered; and nothing is to be omitted, which properly falls within the Compaſs of the Art or Science treated of. In purſuance of the latter, the* Capacities of the Learners *are principally to be regarded; and notice is to be taken, not of whatever* may be *known or done by the Art or Science treated of, but only of what is* moſt uſeful, *and withal* eaſy *to be known.*

Beſides, Regard is to be had, as to the Capacities *principally, ſo ſecondarily to the* Circumſtances *of the Young Students. As for thoſe who are to* make their Fortunes *by their Learning, more Particulars are requiſite to be known, and conſequently more Pains are requiſite to be taken by ſuch, than by others; who, being born to plentiful Eſtates, are by their Learning not to* make, *but to* adorn *their Fortunes already made.*

And there is the more Need of this distinct Consideration, because one of the first Things Young Gentlemen *become sensible of, is this; that they are not under a Necessity of* taking Pains *for their Livelihood. Which has such an Influence upon them, as that they are apt not to relish any Part of Learning, which requires more than ordinary Pains or Application of Mind. And indeed to expect they should act otherwise, is in effect no other, than to expect gray Hairs upon young Heads.*

Wherefore, the most proper Method to make Young Gentlemen Learned, *is this; to teach them at first only such Elements of the liberal Arts or Sciences, as are* most useful *in the common Affairs of Life, and withal* most easy *to be known. They have a competent Apprehension of the Usefulness of such Things as occur in the common Concerns of Life; and consequently hereby that Question frequently put by Young Students,* of what Use is this? *will be answered afore-hand, and so they will be rendered* willing *to understand what they apprehend the Use of. And when they find that the Understanding thereof carries in it no Difficulty, then they will be also* encouraged *to proceed. And when they have thus gone through, and become*

Masters

Masters of the moſt uſeful *and* eaſy *Elements of the liberal Arts and Sciences, they will thereby be enabled with much more Eaſe to conquer the more* difficult *Parts of Learning, if their own Inclinations ſhall lead them thereto hereafter, when they are come to Riper Years, and ſo can judge more rightly of the worth of Learning.*

On theſe Conſiderations, and with this View it was, that I drew up this Aſtronomical *Treatiſe, and gave it the Title of* the Young Gentleman's Aſtronomy ; *Such Aſtronomical Treatiſes as were afore extant among us; either treating only of the Doctrine of the Sphere or Globe, or elſe taking in ſeveral Particulars of the other Part of* Aſtronomy, *too difficult for, and not neceſſary to be known by Young Gentlemen.*

It only remains to be obſerved, that I ſuppoſe Young Gentlemen to proceed regularly in their Studies, and therefore to have learned Arithmetick *and* Geometry, *before they enter upon* Aſtronomy : *as alſo, that ſuch Particulars, as were not neceſſary to my preſent Deſign, and yet ſeemed too material to be quite omitted; I have added by way of* Annotations, *both in this Treatiſe, and the others of* Chronology *and* Dialling.

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THE

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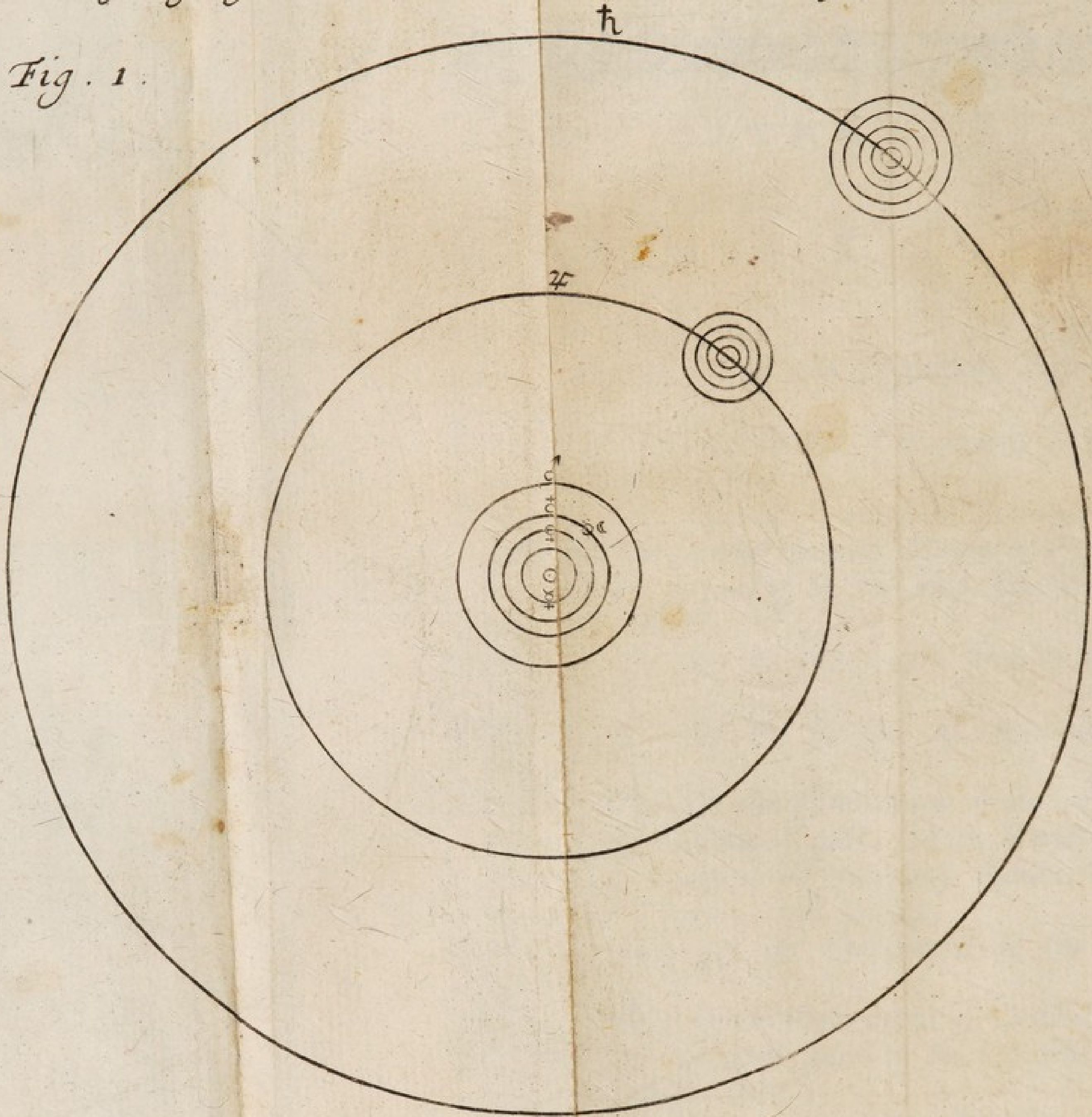
Fig. 1.



THE

Young Gentleman's

ASTRONOMY.

The INTRODUCTION.

W E are informed by *Moses* in his Sacred History of the Creation, that God *made Lights in the* (*) *wide Space of Heaven, to give Light upon the Earth, and to divide the Day from the Night, and to be for Signs and for Seasons, and for Days and Years*, Gen. i. 14---18. 1. *The Celestial Lights made* to what Ends.

(*) So the *Hebrew* Word *Rakiang* truly signifies. It is rendered in our *English* Bible the *Firmament*, in Conformiry to the *Septuagint* Version. See more of this in my Paraphrase on *Genesis*, just publish'd, *Chap.* i. 6. and in Note (*i*) belonging thereto, in reference to the Word *Firmament*.

B The

2. *The Celeſtial Lights are made ſubſervient to the Ends, for which they were created, principally by* Motion.

The principal Way, whereby the All-wiſe Creator of the World has rendered the Celeſtial Lights ſubſervient to the fore-mentioned Ends, is by certain eſtabliſhed Laws of *Motion*; according to which, they either *really* move themſelves, or at leaſt *ſeem* to us to move.

3. *We can only make probable Conjectures concerning the Laws of their Motion; which Conjectures are called* Hypotheſes, *and why.*

What theſe Laws of Motion are, the Divine Wiſdom has not thought fit to reveal unto us. Wherefore, all that we can do, is to make probable Conjectures concerning them. Such Conjectures are termed (*) *Hypotheſes*, i. e. Suppoſitions; becauſe it cannot be poſitively affirmed of the moſt probable Conjecture, that the Celeſtial Lights do ſo move; but only, that it is reaſonable to *ſuppoſe*, they move ſo, rather than any other Way; and that upon ſuch a Suppoſition, their (†) *Phænomena* (or Appearances) may be rationally ſolved or explained.

4. Aſtronomy, *what.*

The Explanation of theſe Hypotheſes, and the Solution of the Ce-

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(*) It is a *Greek* Word, derived from the Verb ὑποτίθημι, to *ſuppoſe*.

(†) It is a *Greek* Word alſo, derived from the Verb φαίνω, to *appear*.

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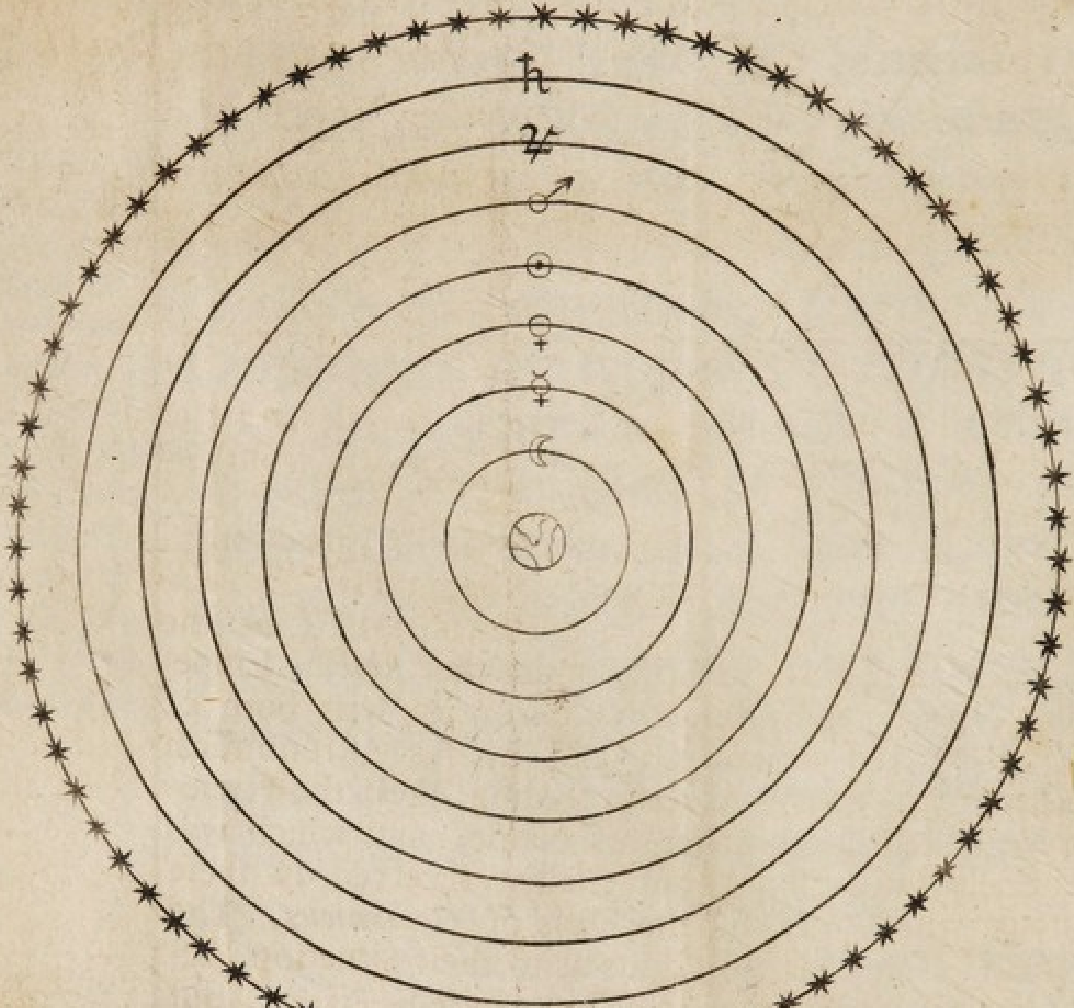
Fig. 2.



lestial *Phænomena* thereby, is what makes up the Science called (*) *Astronomy:* which is a *Greek* Word originally, and denotes in that Language the Doctrine or Knowledge of the *Laws*, or of the *Distribution* and *Situation* of the Stars, or Celestial Lights.

There are four more remarkable Hypotheses, the (†) *Ptolemaick*, the *Copernican*, the *Tychonick*, and the *Semi-tychonick*. Of these the *Copernican* 5.

The Copernican Hypothesis, why the most Probable.

(*) This Word may be derived, as to its latter Component, either from νόμος *a Law*, or from νομὸς *a Distribution, Seat*, or *Situation*.

(†) The *Ptolemaick* Hypothesis is so called from *Claudius Ptolemæus*, a famous Mathematician of *Pelusium* in *Egypt*, who lived in the former Part of the second Century after Christ, under the *Roman* Emperours *Adrian* and *Antoninus Pius*. He writ both of *Astronomy* and *Geography*; and by his Astronomical Writings was conveyed to succeeding Ages, the Hypothesis which goes under his Name, and which was generally, not to say universally, received in these Parts of the World till the Days of *Copernicus*. The Order of the Celestial Lights as to their Situation, according to this Hypothesis, is represented, *Fig.* 2. But since by the Help of *Telescopes*, the Phases of *Venus* and *Mercury* have been discovered, this Hypothesis is rejected, as not consistent therewith. I pass by the Epicycles, and several other Particulars justly blameable in this Hypothesis.

Copernicus, who was Born in 1473 at *Thorn*, a Town of Polish *Prussia*, perceiving the several Exceptions that *can* is now generally received by the more learned in *Aſtronomy*, as the moſt probable Hypotheſis: foraſmuch as it not only agrees with the Celeſtial *Phænomena*, but alſo explains the Motions

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that the *Ptolemaick* Hypotheſis was juſtly liable to, not only revived the old Hypotheſis of *Philolaus*, (which Cardinal *Cuſa* had moved and defended ſometime before him,) but alſo went ſo far as to illuſtrate how the Celeſtial *Phænomena* might be very well ſolved thereby; inſomuch that this Hypotheſis began preſently after to be embraced by many, if not by moſt, of the more Learned *Aſtronomers*, and from the principal Reviver of it, *Copernicus*, to be called the *Copernican* Hypotheſis. The Explication of this takes up great Part of this Treatiſe. To this belongs *Fig.* 1.

The *Tychonick* Hypotheſis is ſo called from *Tycho Brahe*, a noble *Dane*, who lived in the latter part of the ſixteenth Century, and is famous for his Aſtronomical Obſervations at *Uraniburg*, (a Caſtle built by him in the Iſland *Weer* or *Huena* in *Denmark*, and by him called by this Name, as importing the *Tower* or *Caſtle of Heaven*.) This great Perſon and Aſtronomer, though he approved of the *Copernican* Hypotheſis in rejecting the Epicycles, and other ſuperfluous and erroneous Particulars of the *Ptolemaick* Hypotheſis, yet could not reconcile himſelf to the Motion of the Earth, and the Sun's ſtanding ſtill, both aſſerted by *Copernicus*. Hereupon he ſet himſelf to contrive a new Way for ſolving the Celeſtial *Phænomena*, whereby he might avoid what was culpable in the *Ptolemaick* Hypotheſis, and yet ſtill retain the Motion of the Sun round the Earth, as round the Center of the World. To this his Hypotheſis appertains, *Fig.* 3.

The *Semi-tychonick* Hypotheſis is ſo ſtiled, as agreeing with the *Tychonick*, excepting only in this, that whereas

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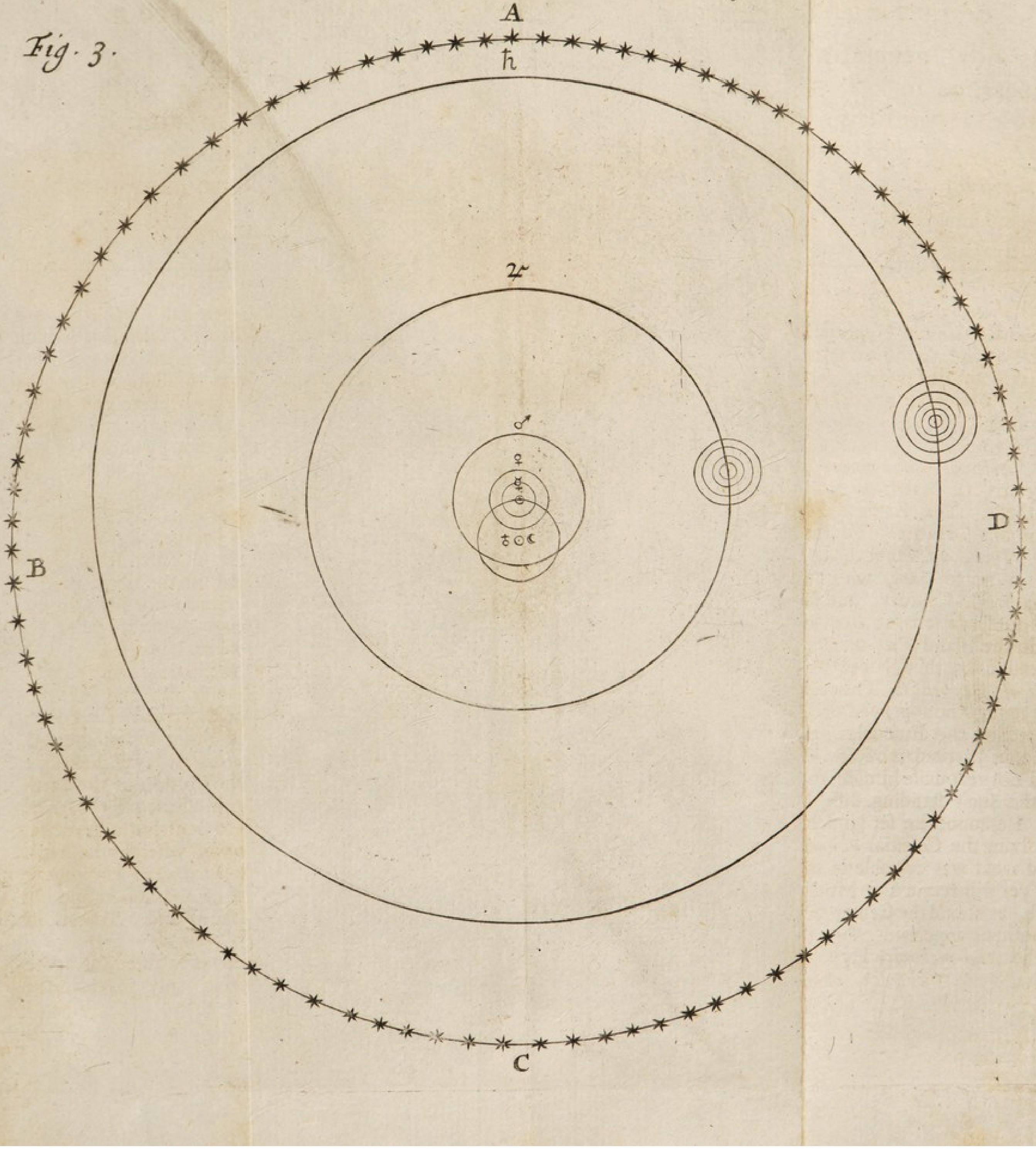
Fig. 3.



tions whence the ſaid *Phænomena* ariſe, after the moſt (*) ſimple and uniform Manner, and conſequently after ſuch a Manner as is moſt agreeable to the infinite Wiſdom of the Creator. I proceed therefore to ſhew, how the Celeſtial *Phænomena*, at leaſt the more remarkable of them, may be ſolved according to this Hypotheſis.

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whereas the *Tychonick* makes the Earth to have no Motion at all, the *Semi-tychonick* makes it to move round its own *Axis*, and ſo agrees therein with the *Copernican*. But though the *Tychonick* and *Semi-tychonick* Hypotheſis were both deſigned as Corrections of the *Copernican*, yet the Generality of the more Learned in *Aſtronomy* do ſtill prefer the *Copernican* as the moſt probable, and that for the Reaſon above-mentioned in ſhort, and to be more largely inſiſted on and explained in the Annotations next following.

(*) Theſe two Propoſitions, *viz. Fruſtrà fit per plura, quod fieri poteſt per pauciora:* and *Natura nihil agit fruſtrà*, being ſo evident to Reaſon, as by Logicians and Philoſophers to be eſteemed *Axioms*, i. e. unqueſtionable Truths; it hence follows, that That Hypotheſis is to be eſteemed moſt agreeable to the Wiſdom of God, the Author of Nature, which explains the Motions whence the Celeſtial *Phænomena* ariſe, after the *moſt ſimple* (or uncompounded) and *uniform* Manner; that is, which adjuſts the ſaid Motions to the feweſt Laws and Principles. But herein the *Copernican* Hypotheſis excells all the reſt, foraſmuch as according thereto, all the Bodies, on whoſe Motion depend the Celeſtial *Phænomena*, are retained in their proper *Orbits* by the ſingle Principle of Gravity, and move in their *Orbits* according to one general Rule, or Law of Motion. Of which ſee more in *Chap.* 1.

ſis. And in order hereunto it will be requiſite to begin with laying before the Reader the *Copernican* (*) *Syſtem*, i. e. in what Order the ſeveral Bodies, whereon depend the Celeſtial *Phænomena*, are placed with Reſpect one to the other, according to this Hypotheſis.

(*) The Word *Syſtem* is borrowed from the *Greek* Tongue, wherein it denotes that Frame or Model which ariſes from *placing* ſeveral Things *together*, it being a Derivative of the Verb συνίστημι, to *put* or *place together*.

CHAP.

CHAP. I.

Of the COPERNICAN SYSTEM *in general.*

Chap I.

THE *Copernican* Syſtem is repreſented, *Fig*. 1. where the Sun is placed in the Center, and ſuppoſed never to move out of it, but only to move therein round its own (*) *Axis*, from Weſt to Eaſt, in the Space of about 25 Days. This Motion of the Sun round its *Axis* is inferred from the Obſervations made of the Spots of the Sun. 1. *The Place of the* Sun.

2. *The Place of* Mercury, Venus, *the* Earth, Mars, Jupiter, *and* Saturn; *and their Periodical Times.*

Round the Sun, as the Center of their *Orbits*, move ſix Spherical Bodies in this Order and Time, *viz.* *Mercury* next to the *Sun*, in about three Months; *Venus* next to *Mercury*, in about ſeven Months and an Half; after that the *Earth* in a Year; then *Mars* in about two Years; then *Jupiter* in twelve Years; and outermoſt

(*) See *Chap*. 3. *Sect*. 5. and the Note there.

Chap. I. of all *Saturn* in about thirty Years. Theſe are reſpectively denoted, *Fig.* 1. by their proper Characters.

3. *Of the* Moon, *and the* Satellites *of* Jupiter *and* Saturn.

As the forementioned ſix Bodies move round the *Sun*, ſo round three of them move other Bodies; *viz.* round the Earth moves the *Moon* in about 27 Days, 8 Hours; round *Jupiter* move four, and round *Saturn* move five Bodies, called reſpectively the (*) *Satellites* of *Jupiter* and *Saturn*. Of the *Satellites* of *Jupiter*, the innermoſt moves round *Jupiter* in 1 Day, 18 Hours; the ſecond in 3 Days, and a little more than Half a Day; the third in 7 Days, 4 Hours; the fourth and outmoſt in ſixteen Days, 18 Hours. Of the *Satellites* of *Saturn*, the inmoſt moves round *Saturn* in 1 Day, 21 Hours; the ſecond in 2 Days, 18 Hours; the third in 4 Days, and a little more than half a Day; the fourth in almoſt 16 Days; and the fifth in 79 Days, 8 Hours.

(*) They are ſo called, as attending *Jupiter* and *Saturn*, as a Prince is attended by his *Satellites* or Life-guard.

All the Bodies afore-mentioned, except the *Sun*, are called (*) *Planets*, (which Word in the *Greek* Language denotes *Wanderers*) forasmuch as never keeping for any Time the same Distance or Situation one to the other, they may be said to be always Straggling or *Wandring* from one another. And because the *Moon* and the *Satellites* of *Jupiter* and *Saturn* are Planets of Planets, hence they are distinguished by the Name of *secondary Planets*, and the other six Planets agreeably thereto are distinguished by the Name of *primary Planets*. Chap. I. 4. Planets, *why so called, and why distinguished into* Primary *and* Secondary.

The Distance of the primary Planets from the *Sun*, is much the same as is expressed, *Fig.* 1. For dividing the Distance of the Earth from the *Sun* into ten Parts, the Distance of *Mercury* from the *Sun* is almost four such Parts, of *Venus* seven, of *Mars* fifteen, of *Jupiter* fifty-two, and of *Saturn* ninety-five. 5. *The* Distance *of the* primary *Planets from the* Sun.

(*) Whereas the Planets are commonly reckoned *seven*, this is according to the *Ptolemaick* System, *Fig.* 2.

Chap. I.

6. *The* Distance *of the* secondary *Planets from their* Primary.

And as to the Diſtance of the ſecondary Planets from their primary reſpectively, it is eſteemed to be ſuch as this; *viz.* the Diſtance of the Moon from the Earth to be about 60 Semi-diameters of the Earth. The inmoſt *Satelles* of *Jupiter* is eſteemed to be diſtant $5\frac{2}{3}$ Semi-diameters of *Jupiter* from the Center of *Jupiter*; the ſecond *Satelles* it eſteemed to be diſtant 9 of the ſame Semi-diameters; the third $14\frac{1}{3}$ ſuch Semi-diameters; and the fourth $25\frac{1}{3}$ Semi-diameters. In like manner the Diſtance of the inmoſt *Satelles* of *Saturn* from the Center of *Saturn* is reckoned to be $4\frac{3}{8}$ Semi-diameters of *Saturn*; the diſtance of the ſecond to be $5\frac{3}{5}$ ſuch Semi-diameters of the third, 8 Semi-diameters; of the fourth, 18; of the fifth, 54 Semi-diameters of *Saturn*.

7. *The* Motion *of all the Planets is regulated after an* uniform *Manner.*

The Reaſon of taking ſuch particular Notice of the Diſtance of the primary Planets from the Sun, and of the ſecondary Planets from their reſpective Primary, is this, *viz.* becauſe theſe ſeveral Diſtances (as well as the ſeveral Times, wherein the Planets, whether Primary or Secondary, move round their reſpective *Orbits*, and which

which are therefore ſtiled their *Periodical Times*) are requiſite to be known, for the apprehending the Excellency of the *Copernican* Syſtem; according to which the Motion of all the Planets, both Primary and Secondary, are regulated by one general Law, which is this:

The Squares of the Periodical Times of the { *Primary* / *Secondary* } *Planets are one to another, as the Cubes of their Diſtances from the* { *Sun.* / *Center of the Primary.*

Thus for Inſtance as to the primary Planets, the Period of *Saturn* is (*rotunde*) 30 Years, of *Jupiter* 12; the Squares of which Numbers are 900 and 144. The Diſtance of *Saturn* from the Sun is found by Obſervation to be to the Diſtance of *Jupiter* from the Sun as about (*) 9 to 5, the Cubes of which are 729 and 125. But the Squares 900 and 144 are very nearly in the ſame *Ratio*, as the Cubes 729 and 125. And the *Ratio* in this and

8. *The ſame* exemplified *as to the* primary *Planets.*

(*) Namely the Diſtance of *Saturn* (as is above, *Sect.* 5. obſerved) from the Sun is 95, and of *Jupiter* 52, both Diſtances being meaſured by the ſame Meaſure.

the

Chap. I. the following Inſtances would be found more exact, were the Periods and Diſtances more exactly expreſſed by Numbers. In like manner the Period of the Earth is a little more than four Times greater than the Period of *Mercury*; and ſo the Squares of the Numbers expreſſing thoſe Periods will be almoſt as 17 and 1. And the Diſtance of the Earth from the Sun being divided into ten Parts, the Diſtance of *Mercury* from the Sun is found by Obſervations to be (little leſs than 4 ſuch Parts, *viz.*) 3 ſuch whole Parts, and 9 Tenths of another, the Cubes of which Numbers (*viz.* 10 and $3\frac{9}{10}$) are 1000 and 59. But it is obvious, that 17 is to 1, much as 1000 to 59. And ſo of the other primary Planets.

9. *And alſo as to the* ſecondary *Planets.*

As for the ſecondary Planets, the Periodical Times of the *Satellites* of *Jupiter* are (as is above, *Sect.* 3. obſerved) reſpectively as $1\frac{3}{4}$, $3\frac{3}{5}$, $7\frac{1}{6}$, and $16\frac{3}{4}$, and their Diſtances are as $5\frac{2}{3}$, 9, $14\frac{1}{3}$, and 25. But the Square of the Periodical Time of the innermoſt *Satelles*, namely 3, is to 13 the Square of the Periodical Time of the ſecond *Satelles*, as 170 the Cube of the Diſtance of the

the innermoſt from the Center of *Jupiter*, to 736 the Cube of the Diſtance of the ſecond from the ſame Center. Likewiſe 3 is to 51 the Square of the Periodical Time of the third *Satelles*, as 170 to 2890 the Cube of the Diſtance of the third from the Center of *Jupiter*. And again 3 is to 280 the Square of the Periodical Time of the fourth and outermoſt *Satelles*, as 170 to 15800 the Cube of the Diſtance of the ſaid outermoſt *Satelles* from the Center of *Jupiter*. And the ſame holds good as to the *Satellites* of *Saturn*. But as to the Moon, it is not applicable to her, foraſmuch as ſhe is the only ſecondary Planet, that moves about rhe Earth. Chap. I.

From what has been ſaid, evidently appears, that the Periodical Motions of the Planets are performed uniformly, or are regulated by one general Law. And from hence it is demonſtrated (*) by the Learned, that the Planets are likewiſe retained in their 10.

10. *All the Planets retained in their own* Orbits *by* Gravity.

(*) See Dr. *Gregory* (late *Savilian* Profeſſor at *Oxford*,) his *Aſtron. Phyſ. and Geom. Elem. lib.* 1. *prop.* 27, 28, 29, *and Sect.* 6. *and* 7. I ſhall only obſerve here, Chap. I. their proper *Orbits* after an uniform Manner, by one Sort of Force which makes them tend to the Center of their reſpective *Orbits*, aud is thence called *the Centripetal Force*, or in one Word, *Gravity*. And this is another Particular, wherein appears the Excellency of the *Copernican* Syſtem above any other; foraſmuch as this Syſtem may be preſerved by Gravity alone, uniformly propagated through the Univerſe, whereas (*) all the other Syſtems require ſome (one or more) other Force, beſides that of Gravity.

II. *All the Planets receive their* Light *from the Sun.*

All the Planets, Primary and Secondary, are Opacous Bodies, *i. e.* ſuch as have no Light of their own, but receive all their Light from the Sun; and ſo for this, as well as other Reaſons, are accounted as ſo many Dependants of the Sun. Whence the

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here, that any Body, when moved, will move uniformly in a ſtraight Line, if not hindred. And agreeably any Planet would fly out of its *Orbit* into a right Line, which is a Tangent to its *Orbit*, was it not hindered or pulled back and retained in its *Orbit* by ſome Centripetal Force, *i. e.* by Gravity.

(*) See *Greg. Aſtron. Phyſ. and Geom. Elem.* pag. 111, 112.

Sun

Sun with theſe its Dependants make up what is called the *Solar Syſtem*, deſcribed, *Fig.* 1. Chap. I.

As for the other Celeſtial Lights, called the *Fixed Stars*, they are independent of the Sun, as in other Reſpects, ſo in reſpect of Light; foraſmuch as they receive not their Light from the Sun, but ſhine with their own Native Light. Hence they are eſteemed to be, not only without this our Solar Syſtem, but as ſo many Suns themſelves, each being placed in the Center of ſome ſuch Syſtem, as this our Solar Syſtem, and there ſo *fixed*, as to have no Motion, but round their own *Axis*. They are ſuppoſed to be vaſtly diſtant from this our Solar Syſtem; which is the Reaſon that their Diſtance is taken no Notice of in the Deſcription of the *Copernican* Syſtem, *Fig.* 1. 12. *Of the* Fixed Stars.

Beſides the Celeſtial Lights already mentioned, there appear ſometimes *Comets*; which is originally a *Greek* Word, denoting in that Language as much as *Hairy*. Theſe Lights are called by the *Greeks*, *Hairy Stars*, becauſe they fancied the Streams of Light, which attend ſuch Stars, to reſemble Hair. It is found by Obſervations, that theſe Comets 13. *Of* Comets.

Chap. I. mets do (*) paſs through the Planetary Orbs of this our Solar Syſtem; but whether they depend only on the Sun, and ſo belong only to this our Solar Syſtem, or whether they move in Circular or ſuch like Lines, or whether they are ſo much as durable Bodies, is not yet diſcovered. For which Reaſons, there is no Notice taken of them, *Fig.* 1.

14. *The* Orbits *of the Planets are* Elliptical. Before we conclude this Chapter concerning the *Copernican* Syſtem in general, it ſeems proper to obſerve, that although the *Orbits* wherein the Planets move, are deſcribed, *Fig.* 1. as ſo many Circles, and may be well enough conceived as ſuch in many Reſpects; yet more ſtrictly ſpeaking, they are not exactly Circular, but Elliptical. And the like is to be underſtood as to the *Bodies* of the *Planets* themſelves, *viz.* tho' they are uſually call'd in ſhort Spherical Bodies, yet exactly ſpeaking they are Elliptical or Oval Bodies; ſuch as the *Moon* is deſcrib'd in the *Draught of the Eclipſe*, 1715, publiſh'd by that

(*) Hence the Line Comet deſcribes by its Motion, is called its *Trajectory*.

most

most eminent Astronomer Dr *Halley*: Chap. I.
From which it appears to what *Accurate* Skill in Astronomy our Great Professors thereof are now arrived.

Further it seems not improper to observe also here, that the fixed Stars being the most remote of all the Celestial Lights, and appearing to us as placed in one Concave Sphere; hence it is usual to denote the *Place* of any of the intermediate Celestial Lights, by assigning what Part of the Sphere of the fixed Stars they appear to us to be *in*, or more properly *under*. And accordingly it is usual to distinguish that Tract of the Sphere of the fixed Stars, under which all the Planets do move, by the Asterisms or Constellations that lie in that Tract; which being fancied to represent several Things, are therefore called *Signs*; and because the Things represented by them are most of them (*) *Zodia*, or Animals, hence all this Tract is stiled the *Zodiack*. Now the *Orbit*, wherein the Earth performs its Annual Period (and which the Sun seems 15. *Of the* Zodiack *and* Ecliptick.

(*) It is a *Greek* Word signifying *Animals* or *Living Creatures*.

Chap. I. to move round every Year) runs under the very Middle of the *Zodiack*; whence this middle Part of the *Zodiack* is of special Note in *Astronomy*, and is therefore distinguished by a peculiar Name, being called the (*) *Ecliptick*. It, as well as the whole *Zodiack*, is divided into twelve Parts, distinguished by the Name of the Constellation or Sign, to which each Part was formerly assigned. The (†) Names of the said Signs, together with the Characters whereby they are denoted in short, are as follows, *viz.*

♈	♉	♊	♋	♌	♍
Aries,	*Taurus,*	*Gemini,*	*Cancer,*	*Leo,*	*Virgo,*
♎	♏	♐	♑	♒	♓
Libra,	*Scorpio,*	*Sagittarius,*	*Capricornus,*	*Aquarius,*	*Pisces.*

16. *Of the* Nodes *of the Planets.*

Lastly, It seems proper here to observe, that the Planets do not move in *Orbits*, which exactly run one over the other, or are all contained in the same

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(*) The Reason of this Name, See *Chap.* 5. *Sect.* 21.

(†) The Names of the Signs are somewhat differently expressed in these two memorial Verses, *viz.*

Signa, Aries, Taurus, Gemini, Cancer, Leo, Virgo,
Libraq; Scorpius, Arcitenens, Caper, Amphora, Pisces.

Plane;

Plane; but their *Orbits* do all croſs one another according to ſeveral Degrees of Inclination, or which is the ſame, the Planes of their *Orbits* are variouſly inclined one to the other. Now the Earth being that Planetary Body we live on, hence the Plane of the *Orbit* of the Earth is taken by Aſtronomers for the Standard; and the Inclination of the Planes of the *Orbits* of the other Planets is reckoned greater or leſs, as the ſaid Planes incline more or leſs in reſpect to the Plane of the Earth's *Orbit*, or (*) (which comes to the ſame) to the Plane of the *Ecliptick*. The two Points, wherein the *Orbit* of any Planet croſſes the *Ecliptick*, are called the *Nodes* of that Planet. And thus much for the Syſtem of the World in general, and ſuch Particulars as relate to it in general.

Chap. I.

(*) For the *Ecliptick* is that Part of the Sphere of the fixed Stars, which the Plane of the Earth's *Orbit* produced thereto touches. So that the *Ecliptick* is no other than the Extremity of the Plane of the Earth's *Orbit*.

CHAP. II.

Chap. II. *Of the* DIURNAL PHÆNOMENA *common to the* CELESTIAL LIGHTS.

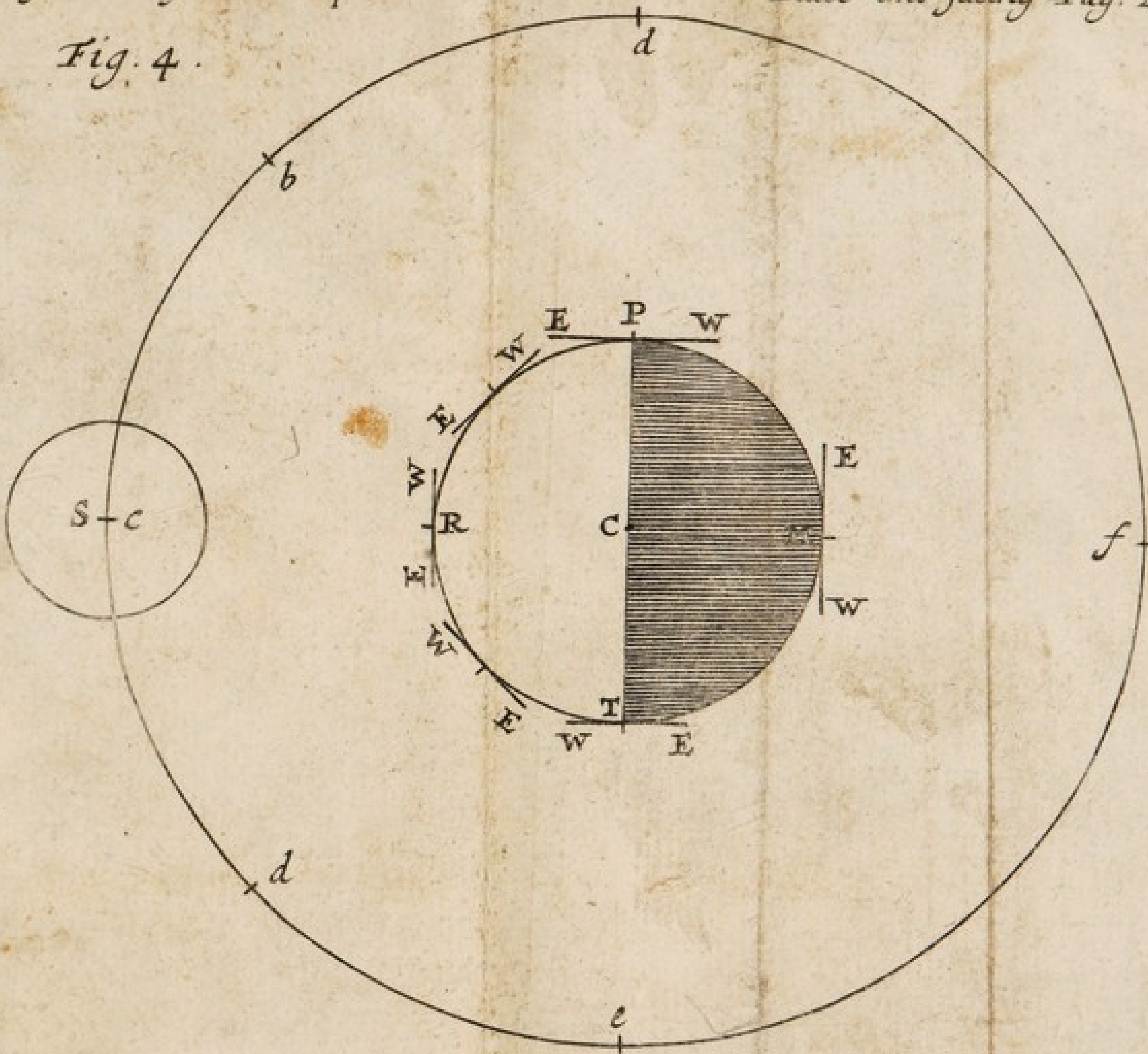
1. *The* Diurnal Phænomena *are common to the Celestial Lights in general.*

HAving in the foregoing Chapter explained, so far forth as is sufficient to the Design of this Treatise, the *Copernican* System in general, I now proceed to explain agreeably thereunto the *Phænomena* of the Celestial Lights. I shall begin with explaining the *Diurnal Phænomena* common to them in general, *viz.* their Rising, Setting, *&c.*

2. *They are to be solved by the* Diurnal Revolution *of the Earth.*

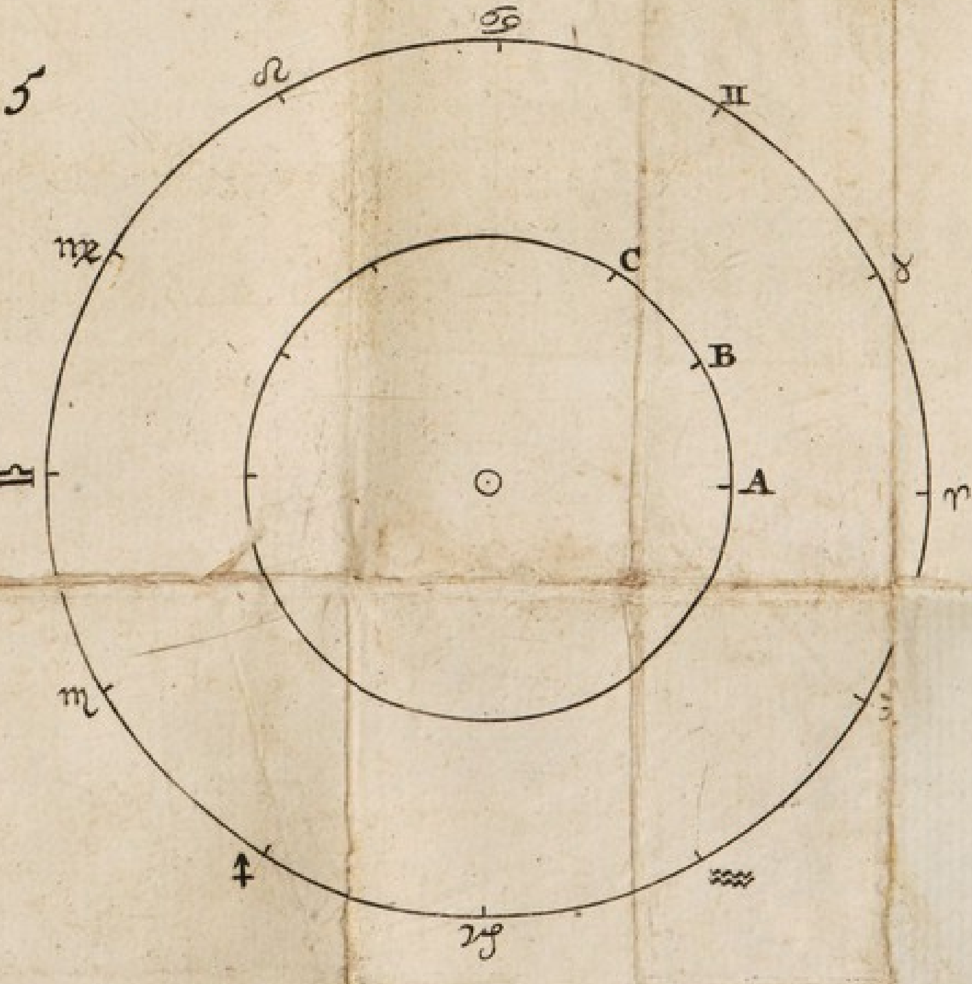
Now these *Diurnal Phænomena* of the Celestial Lights may be solved by the *Diurnal Revolution* of the Earth, *i. e.* by one single Revolution of the Earth round its own *Axis* in 24 Hours. This is illustrated *Fig.* 4, where the Circle PR TH denotes the Earth; C the Center of the Earth, thro' which is to be conceiv'd to pass perpendicularly its *Axis*, round which it makes its *Diurnal Revolution.* P denotes any Place on the Earth; the Line EW, that

Fig. 4.



Pag. 26.

Fig. 5



that Circle which bounds the Sight in the ſaid Place, and is by *Aſtronomers* called the (*) *Horizon*; E the Eaſt Point of the ſaid *Horizon*; W the Weſt: the Circle *a b c d e f* denotes the Circumference of the Heavens; the Circle S the Sun in the Heavens; the Semicircle P R T, the enlightened Hemiſphere of the Earth, or that Half of it which is oppoſite to the Sun; the Semicircle P H T, the darkened Hemiſphere of the Earth. Now the Earth being ſuppoſed in this Situation, and alſo to move round its *Axis* towards the Sun; it is evident, that the Place P of the Earth will juſt begin to be enlightened by the Sun, and ſo the Sun will appear there to be juſt Riſing, or aſcending the *Horizon* at E the Eaſt Point of it. The Earth being moved round its own *Axis*, ſo as that the Place P of the Earth, which afore was under the Point *a* in the Heavens, now is under the Point *b*; it is evident, that the *Horizon* of the ſaid Place P, will be now ſo ſituated, as that the Sun will appear to a Spe- Chap. II.

(*) It is a *Greek* Word, denoting in that Tongue ſomewhat that *bounds*.

Chap. II. ctator at P, as aſcended conſiderably above E the Eaſt End of the *Horizon*. And while, by the Revolution of the Earth round its *Axis*, the Place P paſſes from under the Point *b* in the Heavens to the Point *c*, the *Horizon* of the Place P will continually ſink lower and lower in Reſpect of the Sun, and ſo the Sun will appear to aſcend higher and higher, till P is come under *c*, where the Sun will appear in its greateſt Height above the *Horizon* for that Day; and ſo it will be Noon or Mid-Day at the Place P. For the Earth moving on, as the Place P paſſes from under *c* to *d*, the Weſt Point of its *Horizon* will aſcend higher and higher, and ſo the Sun will appear more and more to deſcend, as is repreſented by the *Horizon* at the Point of the Earth under *d*. The Place P being carried by the *Diurnal Revolution* of the Earth from under *d* to under *e*, the Sun will then appear juſt on W the Weſt Point of the *Horizon*, and ſo will appear to be juſt Setting. The Place P being come under *f*, it will be then Mid-night there. *Laſtly*, the Place P being come round again under *a*, it will be there

Sun-

Sun-rifing again. And thus it has been fhewn, that the fame *Diurnal Phænomena* of the Sun will come to pafs, if the Sun ftands ftill, and the Earth move round its own *Axis* from Weft to Eaft, or from under *a*, to under *b*, *c*, *d*, &c. in the Heavens; as are commonly efteemed to come to pafs by the Earth's ftanding ftill, and the Sun's moving round it from Eaft to Weft, or from *c* to *b*, *a*, *f*, &c. And that the fame holds good as to any other Celeftial Light, and the Earth, is obvious to fhew from *Fig.* 4, the Circle reprefenting the Sun being taken to denote any other Celeftial Light. Chap. II.

3. *The Probability of the* Copernican *Syftem further eftablifhed.*

But now it being juftly received by Philofophers as an unqueftionable Truth, that *Nature works after the moft fimple and compendious Manner*; it thence follows, that the Solution of the *Diurnal Phænomena* by the Revolution of the *Earth alone* round its own *Axis*, is much more agreeable to Nature, than the Solution of the faid *Phænomena* by the Revolution of *all the feveral Celeftial Lights* round the Earth.

Chap. II.

4.
The common *and* proper *Motion of the Celestial Lights, what.*

It remains only to obſerve, that whereas by the *Diurnal Revolution* of the Earth, all the ſeveral Celeſtial Lights ſeem to move in the Heavens from East to Weſt, hence this ſeeming *Diurnal* Motion of the Celeſtial Lights is called their (*) *common* Motion, as being common to all of them. Beſides which all the Celeſtial Lights, but the Sun, have a *proper* Motion; from which ariſe their proper *Phænomena*. As for the proper *Phænomena* of the Sun, they likewiſe ſeem to ariſe from the proper Motion of the Sun, but are really produced by another Motion which the Earth has, and whereby it moves round the Sun once every Year, whence its called the *Annual* Motion

(*) The *Diurnal* Motion is alſo called *Motus Primus*, either becauſe it is uſually *firſt* treated of, or elſe becauſe it is ſuppoſed according to the Vulgar or *Ptolemaick* Syſtem to be cauſed by the *Primum Mobile*, which according to the ſaid Syſtem is a Sphere above the fixed Stars, carrying all the Celeſtial Lights along with it from Eaſt to Weſt. Whence the ſaid *Diurnal* Motion is alſo called ſometimes *Motus Raptus*. In like manner the *proper* Motion is otherwiſe ſtiled *Motus Secundus*, in Contradiſtinction to the *Diurnal* Motion called *Motus Primus*.

of

of the Earth. Having therefore explained in this Chapter the *Diurnal* and common *Phænomena* of the Celestial Lights, I proceed to explain their proper *Phænomena*.

CHAP.

CHAP. III.

Chap. III.

Of the PHÆNOMENA (*commonly aſcribed to the ſeeming* Annual *Motion of the* SUN, *but rather*) *depending on the real* Annual *Motion of the* EARTH.

1. *The* proper Phænomena *of the* Sun, *why firſt explained.*

BEing to explain in the next Place the *Phænomena proper* to the ſeveral Celeſtial Lights, I begin with the proper *Phænomena* of the *Sun*; foraſmuch as the *Sun* is the principal Light of that Syſtem of the World, wherein we are placed.

2. *The ſeeming* Proper *or* Annual *Motion of the* Sun *is cauſed by the real Annual Motion of the Earth.*

Now theſe *Phænomena* of the *Sun*, which are vulgarly aſcribed to the ſeeming *Annual* Motion of the *Sun*, may be ſolved by the *Annual* Motion of the *Earth*. In order whereunto it is firſt to be ſhewn, that the *Annual* Motion of the Earth will cauſe the *Sun* to appear to us, as if it had ſuch an *Annual* Motion, though it really has no ſuch Motion. And this is illuſtrated *Fig.* 5, where the *Sun* is in the

the Center; the Circle next round it denotes the *Orbit* of the Earth, or that Circular Line which the Center of the Earth deſcribes by its Annual Motion; the outermoſt Circle denotes the *Ecliptick*, diſtinguiſhed into its 12 Parts or Signs. Now ſuppoſing the Earth to be at A, the *Sun* will appear to us to be at ♎; and ſuppoſing the Earth to move from A to B, and ſo to C, the *Sun* will thereby appear to us to move from ♎ to ♏, and thence to ♐. And in like manner, by the Earth's Motion along the Reſt of its own *Orbit* till it comes to A again, the *Sun* will ſeem to us to move along the reſt of the *Ecliptick* till it comes to ♎ again. 'Tis evident then, that, ſuppoſing the Earth to move as has been here deſcribed, the *Sun*, though it really ſtands ſtill, will ſeem to have the ſame *Annual* Motion along the *Ecliptick*, as it would have, if it really moved ſo, and the Earth ſtood ſtill.

Only 'tis remarkable, that whereas we commonly ſay, *the Sun is in* ♎ *or Libra*, when it is between us and *Libra*, (and ſo of any other Sign,) if we would ſpeak properly, and agreeably to the natural

3. *An Obſervation as to the common Way of ſaying, that* the

Chap. III.

Sun is in ſuch or ſuch a Sign.

natural Cauſe of this (and ſuch like) *Phænomenon,* we ſhould ſay, that *the Earth is then in* ♈ or *Aries*; foraſmuch as the Earth in its real Motion is always in the Point of the *Ecliptick* oppoſite to that, wherein the *Sun* appears to be.

4. *The* Variety of the Seaſons, *&c. how to be ſolved by the* Annual *Motion of the Earth.*

Having ſhewn that the *Annual* Motion of the *Earth* along the *Ecliptick* will make the *Sun* appear to us, as if it had ſuch an *Annual* Motion; I proceed now to ſhew, how the Variety of Days and Nights as to their Length, and the various Seaſons of the Year, (all commonly aſcribed to the ſeeming *Annual* Motion of the *Sun,*) may be ſolved by the *Annual* Motion of the *Earth.* And this is illuſtrated *Fig.* 6; for the clearer Underſtanding whereof there are to be premiſed the following Particulars.

5. *Of the* Equator, *its* Axis *and* Poles; *as alſo of the* Tropicks,

As the (*) *Axis* of the Earth (and ſo of the *Sun,* or any other Celeſtial Body) is the very Mid-line of it, which conſequently paſſes through its Center, and is repreſented, *Fig.* 6,

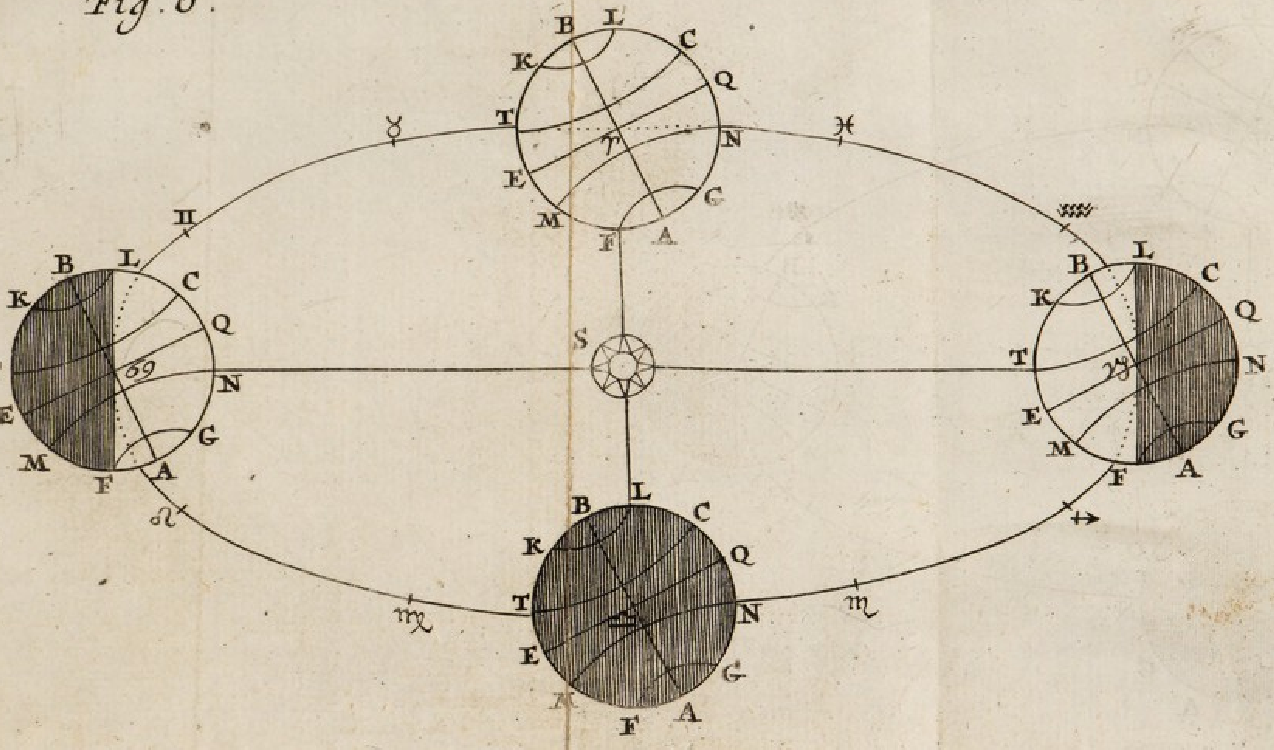
(*) The right Line, round which Bodies or Circles are conceived to move, are ſo called in Alluſion to the *Axis* or Axle-tree of a Chariot or Cart-wheel.

(where

Astronomy Plate 5.

Place this facing Pag. 28.

Fig. 6.



Chap. III.

Polar Circles, Equinoctial Points, Solstitial Points, *&c.*

(where the Circle A Q B E represents the Earth,) by the right Line A B; so the two Ends of any *Axis* are called its *Poles*, and consequently the two Ends of the *Axis* of the Earth are called the *Poles* of the Earth; which always pointing one Northwards, the other Southwards, hence the former is called the *North* Pole, and is denoted, *Fig.* 6, by B; the latter is called the *South* Pole, and is denoted by A. Between these Poles each Point of the Earth by its *Diurnal Revolution* does describe a Circle; of which that, which is in the very Middle between the Poles, and is the greatest, is called the *Equinoctial* or *Equator*, (denoted *Fig.* 6, by E Q,) because when the *Sun* is in the Plane of this *Equinoctial* Circle, it is equal Day and Night all over the World. And did this Circle exactly answer to, or run along under the *Ecliptick*, there would be equal Day and Night throughout the Year all over the World. But the Equator crossing the *Ecliptick*, hence it is equal Day and Night only twice in the Year, namely, when the *Sun* appears in one of those two Points of the *Ecliptick*, where the

Equator

Chap. III. *Equator* croſſes it, *viz.* in the firſt Degree of *Aries*, and the firſt of *Libra*; which are therefore called the two *Equinoctial Points*; and the Times of the Year anſwering thereto, the two *Equinox*'s, one the *Vernal*, the other the *Autumnal*. Among the other Circles, which the ſeveral Points of the Earth by its *Diurnal Revolution* deſcribe between the two Poles of the Earth, and which are all parallel to the *Equator*, there are four more remarkable, the two *Tropicks*, and the two *Polar* Circles. The two *Tropicks* are thoſe Circles on the Earth, which the *Sun* ſeems to go directly over, when it is at its greateſt *Declination* or Diſtance from the *Equator*, either Northward or Southward. Whence one is called the *Northern Tropick*, the other the *Southern*. And becauſe when the *Sun* appears to move vertically over the Northern *Tropick*, he appears alſo to be in the Beginning of *Cancer*, hence the ſaid *Tropick* is frequently ſtiled the *Tropick of Cancer*; and for the like Reaſon the Southern is otherwiſe ſtiled the *Tropick of Capricorn*. The Reaſon why both theſe Circles are called *Tro-*

picks

picks, is becauſe the *Sun* appearing then at his greateſt reſpective (Northern or Southern) Declination or Diſtance from the *Equator*, begins from thence preſently to (*) *turn back again* towards the *Equator*. And becauſe the *Sun* in the firſt Degree of *Cancer* and *Capricorn* does as it were make a Stand, going neither Northward nor Southward further from the *Equator*, hence theſe two Points of the *Ecliptick* are called the two *Solſtitial Points*; and theſe two Times of the Year are called the two *Solſtices*, one the *Summer*, the other the *Winter*. The *Tropick* of *Cancer* is repreſented, *Fig.* 6. by the circular Line T C, the *Tropick* of *Capricorn* by M N. The two *Polar* Circles are ſo called, either as being near to the two *Pôles* of the *Equator*, or becauſe they on the Earth (†) anſwer to thoſe Circles in the Heavens,

Chap. III.

(*) The *Greek* Verb τρέπω ſignifies to *turn*; whence is derived τροπικὸς denoting ſomewhat from whence a *Turn* is made.

(†) As every Point of the Earth by its real *Diurnal Revolution*, does *really* deſcribe a Circle between the two *Poles* of the Earth; ſo the *Sun*, by its ſeeming *Diurnal Revolution*, does ſeemingly deſcribe every Day

Chap. III. Heavens, which the (*) *Poles* of the *Ecliptick* ſeem to deſcribe by the apparent *Diurnal* Motion of the Heavens. Hence theſe *Polar* Circles are juſt as far diſtant from their reſpective *Poles* of the *Equinoctial*, as are the *Tropicks* from the *Equinoctial*, viz. $23\frac{1}{2}$ Degrees, this being the Meaſure of the Angle, which the Planes of the *Equator* and *Ecliptick* make by their mutual Inclination. Theſe *Polar* Circles do bound thoſe Tracts of the Earth, where it is Day or Night during more or fewer whole *Diurnal Revolutions* of the Earth, or for 24

Day a Circle, directly anſwering in the Heavens to that Circle on the Earth, to which the *Sun* is that Day Vertical. Hence there are uſually conceived in the Heavens, *Equinoctial* and *Tropical* Circles, which directly anſwer to the like *Terreſtial* Circles.

(*) As the Earth, Sun, and all the other Celeſtial Bodies are ſaid to have their reſpective *Axes*; ſo the Aſtronomical Circles (*viz. Ecliptick, Horizon,* &c.) are conceived by Aſtronomers to have their reſpective *Axes*; each of which is conceived to be a right Line paſſing through the Center of the ſaid Circles, ſo as to be perpendicular to their reſpective Planes: And the Extremities of any ſuch *Axis* is likewiſe called the *Pole* of the Circle, to which the ſaid *Axis* belongs. And conſequently (the *Axis* being always perpendicular to the Plane) the *Poles* of any Circle are always diſtant, each 90 Degrees from the ſaid Circle.

Hours

Chap. III.

Hours and upwards together. Of these *Polar* Circles, one is termed the (*) *Arctick* or northern Polar Circle, as being nigh the *Arctick* or north Pole of the *Equator*, and the other for the like Reason is termed the *Antarctick* or southern Polar Circle. The former is denoted *Fig.* 6, by the circular Line KL, the latter by FG. It only remains to observe, that the *Sun* (or any other Celestial Light) will appear to be vertical to that Point of the Earth, where a right Line drawn from the Center of the *Sun* (or other Celestial Light) to the Center of the Earth, crosses the Surface of the Earth. Thus *Fig.* 6, when the Earth is in the Beginning of *Capricorn* or at ♑, the *Sun* will appear to be vertical to the northern Terrestrial *Tropick* or TC, because a right Line drawn from S to ♑, will cross the Surface of the Earth at T. So when the Earth is at ♈, the *Sun* will appear vertical

(*) The north *Pole* of the *Equator* is called otherwise the *Arctick*, because it is near the Constellations called the great and little Bears; the *Greek* Word Ἄρκτος signifying *a Bear*; and hence the southern *Pole* is stiled the *Antarctick*, as being opposite to the *Arctick*.

Chap. III. to the Terreſtrial *Equator* or E Q, becauſe a right Line drawn from S to ♈ will croſs the Surface of the Earth in a Point of E Q; for in this Poſition of the Earth the Line S ♈ is to be conceived perpendicular to the *Axis* A B. Theſe Particulars being premiſed and apprehended, it will be eaſy to apprehend how the various Length of Day and Night, and the various Seaſons of the Year are produced by the *Annual* Motion of the Earth.

6. *The* Vernal Equinox *explained by the* Annual *Motion of the Earth.*

Suppoſe then the Earth to be at ♎, the *Sun* (as is afore obſerved, *Sect.* 3.) will appear at ♈, and ſo in one of the *Equinoctial* Points, and in the Middle between the Poles of the Earth A and B; and conſequently will enlighten from Pole to Pole, that Hemiſphere of the Earth which is oppoſite to it. Whence Half of the Terreſtrial *Equator* E Q, and of every Circle parallel thereunto, will at that Time be enlightened by the *Sun*, and Half will be in the Dark. And conſequently every Place on the Earth (foraſmuch as it lies either in the Terreſtrial *Equator*, or ſome Parallel to it) being carried round the *Axis*,

Axis, of the Earth in an uniform Manner by the *Diurnal* Motion of the Earth, will be as long in the Light, as in the Dark, *i. e.* the Day and Night will be then *equal* all over the Earth.

The Earth being moved by its *Annual* Motion from ♎ to ♑, the *Sun* appears then to us to be in ♋, where is its greateſt Declination northward. And the *Sun* being in this Situation, 'tis evident, that the Rays of the *Sun*, which enlighten one Half of the Globe of the Earth at a Time, reach beyond the north Pole B to L, and at the ſouth Pole reach no further than F. Whence it follows, that the Tract of the Earth within the north *Polar* Circle KL, at this Time of the Year enjoys Day-light throughout the whole *Diurnal Revolution* of the Earth; and on the contrary, that it is continual Night throughout the whole *Diurnal Revolution* of the Earth, in the Tract of the Earth lying within the ſouth *Polar* Circle FG. It follows alſo, that the greater Portions of the Parallels to the *Equator*, which lie between the *Equator* and northern *Polar* Circle, have the Light of the 7. *The Reaſon of the Days being* longeſt *at the Summer Solſtice.*

Chap. III. *Sun*; but the greater Portions of ſuch Parallels, as lie between the *Equator* and ſouthern *Polar* Circle, have not the Light of the *Sun*; and the Portion of the Parallel, which is or is not enlightened, is ſo much the greater or leſſer, as the Parallel is more or leſs diſtant from the *Equator*, there being exactly one Half of the *Equator* always enlightened, and the other not. And hence it is, that in this Poſition of the Earth in the firſt of *Capricorn*, when the *Sun* ſeems to be in the oppoſite, *viz.* firſt Degree of *Cancer*, the Days are longeſt in the northern Parts of the Earth, and the Nights ſhorteſt, and ſo it is Summer there. Whereas in the ſouthern Parts of the Earth, the Days are then ſhorteſt, and the Nights longeſt, and ſo it is there Winter. And the longeſt Day is ſo much the longer, as the Place is more remote from the *Equator*. But to ſuch as live on the Terreſtrial *Equator* it ſelf, Day and Night are now, and throughout the whole Year, equal one to the other, for the Reaſon above-mentioned.

The

Fig. 7.

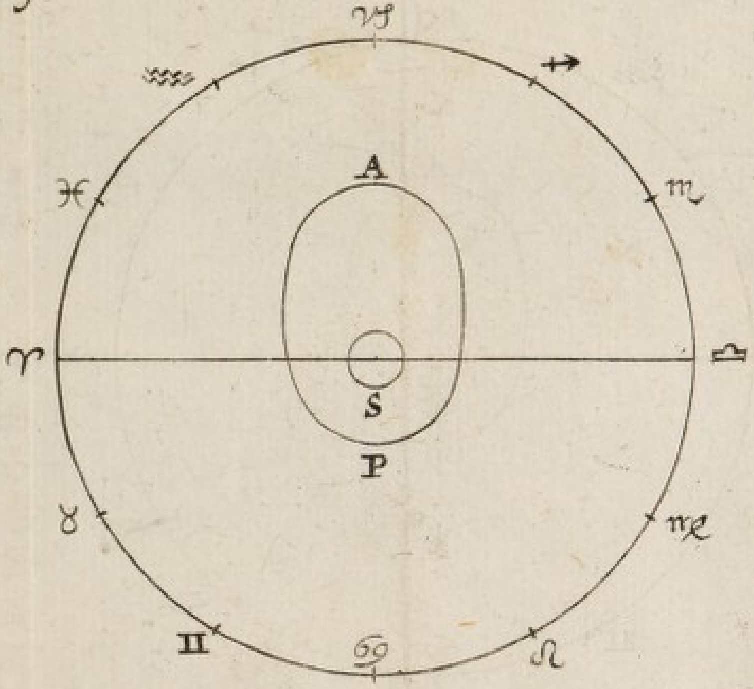
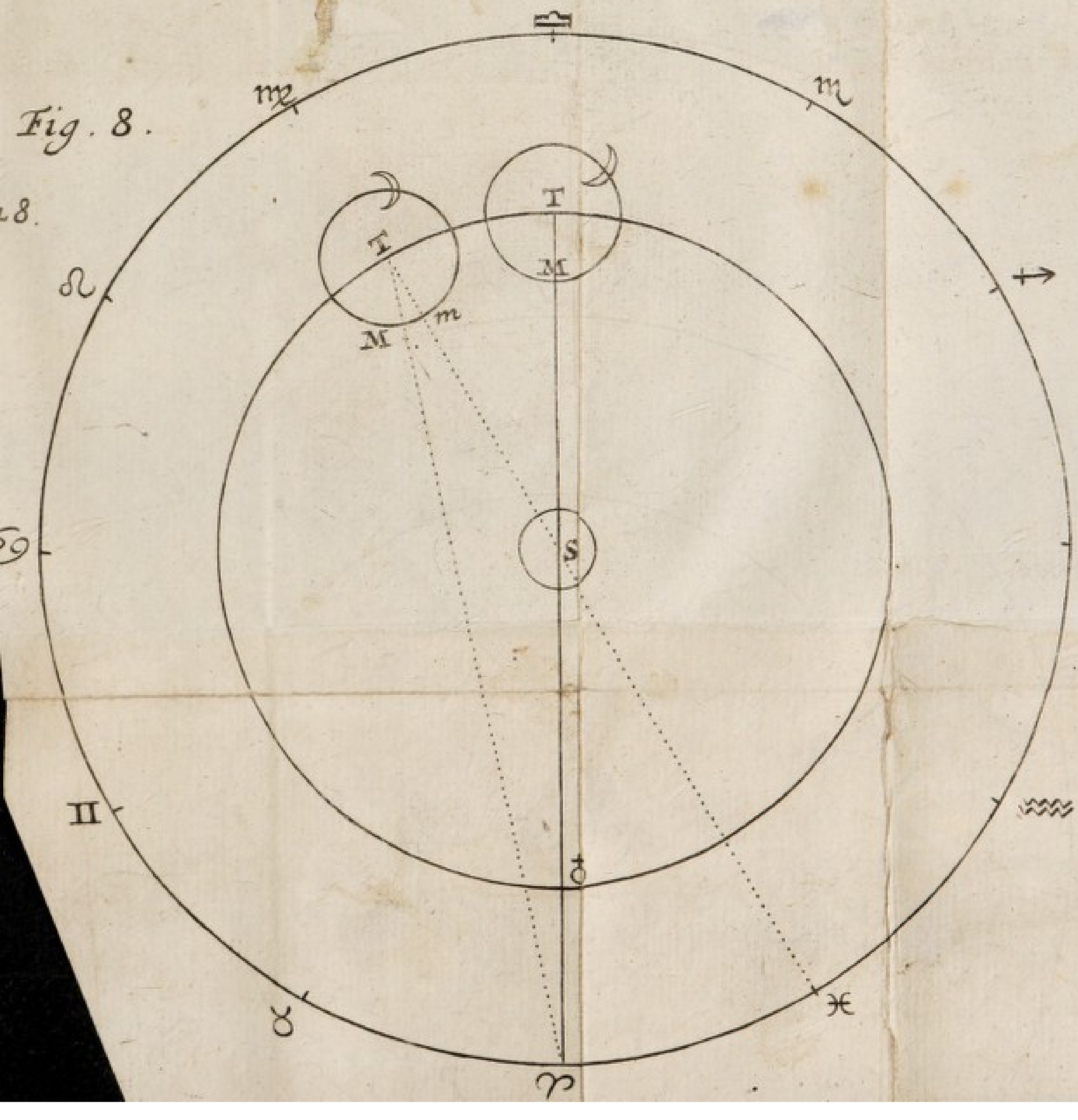


Fig. 8.



The Earth moving from ♑ to ♈, the *Sun* will ſeem to move from ♋ to ♎, and ſo will appear in the Celeſtial *Equator*, and make Day and Night equal, as when the Earth was at the oppoſite Point ♎, for the like Reaſons. In like manner the Earth moving from ♈ to ♋, the *Sun* will ſeem to move from ♎ to ♑, where it is in its greateſt ſouthern Declination. And conſequently at this Time of the Year, the like *Phænomena* will happen to the Inhabitants of the ſouthern Hemiſphere of the Earth, as happened to thoſe of the northern Hemiſphere, when the Earth was in ♑; and the like *Phænomena* will be in the northern Hemiſphere, as were afore in the Southern.

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8. *The* Autumnal Equinox, *and the Reaſon of the Days being* ſhorteſt *at the Winter Solſtice, explained.*

Having thus ſhewn, that the ſame *Phænomena*, as to the Length of Day and Night, and ſo as to the various Seaſons of the Year, will ariſe from the *Annual* Motion of the *Earth* round the *Ecliptick*, as from that of the *Sun*, at the *four Cardinal* Points of the *Ecliptick*, viz. the two *Equinoctial*, and the two Solſtitial Points; it is obvious, that the ſame *Phænomena* will likewiſe happen at *any the intermedi-*

9. *The Solution of the like reſpective* Phænomena *at the intermediate Points of the* Ecliptick, *is eaſily to be inferred from what has been ſaid.*

Chap. III. *ate* Points of the *Ecliptick*, from the Motion of the one as well as of the other, as to the Increaſe and Decreaſe of Day and Night, and conſequently as to the Difference of Seaſons.

10. *Of the* different Diſtance *of the* Sun *from the Earth, its ſeeming* different Magnitude, *and* different Rate of Motion.

As the *different Length* of Day and Night, and the different Seaſons at different Times of the Year are *Phænomena*, which eſcape no one's Obſervation, and have been already accounted for; ſo there are other *Phænomena* of the *Sun*, which are not ſo eaſily to be obſerved, and therefore are taken Notice of only by the more curious in theſe Matters. Such is the *different Diſtance* of the *Sun* from the Earth at different Parts of the Year; as alſo its appearing of a *different Magnitude*, and its ſeeming to move at a *different Rate*. For as the *Sun's* Diameter appears leſſer about the Middle of *June*, and greater about the Middle of *December*, ſo the *Sun* is more diſtant from us in our Summer, than in our Winter; and alſo ſeems to move ſlower in the former, than in the latter; inſomuch that it takes up about eight Days more in its ſeeming to paſs from the Vernal to the *Autumnal Equinox*, than in its ſeeming to paſs from the *Autumnal* to the Vernal; although in both Intervals of Time it ſeems to paſs over but an equal Portion of the *Ecliptick*, namely, juſt Half. Theſe *Phænomena* of the *Sun*, as they depend one on the other, ſo may be all ſolved by the *Annual* Motion of the Earth, in an *Elliptical Orbit*, round the *Sun* placed in one of the (*) Focus's of the Ellipſis, as is illuſtrated, *Fig.* 7, where the Circle repreſents the *Ecliptick*, the Ellipſis repreſents the *Orbit* of the Earth, S the *Sun* placed in one of the Focus's of the ſaid Ellipſis. Now about the Middle of *June* the *Sun* appears to us in the Beginning of *Cancer*, and conſequently the Earth is in the Beginning of *Capricorn*, and ſo at the Point A of its *Elliptical Orbit*, that is, at its (†) *Aphelium* or greateſt Diſtance from the *Sun*; whence the *Sun*

Chap. III.

(*) In *Fig.* 6. the *Sun* is placed in the Center, not one of the Focus's, only for more Conveniency ſake in drawing the Figure. It may be eaſily conceived to be in the Focus next to the Sign of ♋, where it ought to be ſtrictly.

(†) What is here called the *Aphelium* and *Periheliam*, is by ſuch, as follow the Hypotheſis of the *Sun's* real

Chap. III. *Sun* appears then leſs to us. About the Middle of *December*, the *Sun* appears to us in the Beginning of *Capricorn*, and conſequently the Earth is then in the Beginning of *Cancer*, that is, at the point P of its *Elliptical Orbit*, and ſo at its *Perihelium*, or leaſt Diſtance from the *Sun*; which therefore appears to us then greater. Further, as the Line drawn from ♈ to ♎ through the Center of the *Sun* S, divides the *Ecliptick* into two Halves, ſo it unequally divides the *Orbit* of the Earth; the greater Segment whereof anſwers to the ſix Signs of the *Ecliptick*, which the Earth paſſes under between the Vernal and Autumnal *Equinox*; and the leſſer Segment anſwers to the other ſix Signs of the

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real *Annual* Motion, called the *Apogee* and *Perigee*; and theſe ſuppoſe the *Sun* to move *Annually* round the Earth in an *Eccentrical* Circle, which comes much to the ſame as an *Elliptical Orbit*. The *Aphelium* and *Perihelium* are not always in the ſame Points of the *Ecliptick*, but move a little and a little forwards according to the Series of the Signs. The former is at preſent reckoned about the 7th Degree of *Capricorn*, and the latter about the 7th Degree of *Cancer*. They are both Words derived from the *Greek* Language, and therein of the Importance above ſpecified.

Ecliptick,

Ecliptick, which the Earth paſſes under between the Autumnal and Vernal *Equinox*. Whence it comes to paſs, that the Earth taking up more Time to go along the greater Segment of its Orb, than the leſſer, the *Sun* ſeems to take up more Time, and conſequently to move more ſlowly, in paſſing along the ſix Signs of the *Ecliptick*, which it ſeems to paſs thro' between the Vernal and Autumnal *Equinox*, than it does in paſſing along the other ſix Signs of the *Ecliptick*, which it ſeems to paſs thro' between the Autumnal and Vernal *Equinox*. Chap. III.

As the Time of the Earth's *Annual* Motion from any Point of the *Ecliptick* to the ſame again, is computed 365 Days, 5 Hours, and 49 Minutes; ſo the Time of the Earth's Motion from the Vernal to the Autumnal *Equinox*, is computed 186 Days, beſides ſome odd Hours and Minutes; and from the Autumnal *Equinox* to the Vernal 178 Days, beſides ſome odd Hours and Minutes. So that the Difference between theſe two Intervals of Time is (as afore has been obſerved) about eight Days. 11. *The Time of the Earth's* Annual *Motion, or of the* Solar Year.

But

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12. *The* Sun, *why* hotter *to us in Summer, though* farther *from us.*

But there are two Difficulties, which are to be removed. One is in reference to what has been ſaid concerning the *Sun*'s being more diſtant from the Earth in Summer than in Winter. For ſince the *Sun* is the Fountain of Heat as well as Light to the Earth, it may be asked, how it comes to paſs, that the *Sun* is *hotter* to us in Summer than in Winter; if ſo be it be *further* from us in the former than in the latter. Now this Difficulty will be removed by conſidering, that the *Sun* (or any other Body of Fire) feels more or leſs hot to us, not only as it is nearer or further from us, but alſo as its Rays come more or leſs directly to us. Whence though the *Sun* be farther from us in Summer than in Winter, yet becauſe its Rays are much more nearly perpendicular to us in the former than in the latter, therefore it is hotter to us in the former than in the latter Seaſon. That the Rays of the *Sun* fall more nearly perpendicular, or more directly upon us in the Summer than in Winter, is obvious to infer from *Fig.* 6. For when in Summer the Earth is in the Beginning of ♑, and conſequently the *Sun*

Sun appears to be in the Beginning of ♋, the *Sun* is then in a perpendicular Line to T, or the Rays of the *Sun* then fall perpendicularly on the Terreſtrial *Tropick* T C; and therefore, although the Earth be about that Time in its *Aphelium* or greateſt Diſtance from the *Sun*, yet the *Sun* is then hotteſt to us in theſe Parts of the Earth north of the ſaid *Tropick*. But as the Earth moves from the Beginning of ♑ towards ♈ and ♋, ſo the Perpendicular from the *Sun* to the Earth moves from T towards M N the Southern Tropick, ſo that the *Sun* is exactly perpendicular to N M when the Earth is in the firſt of ♋, or at the Winter Solſtice. Wherefore, although the Earth be about that Time in its *Perihelium* or leaſt Diſtance from the *Sun*, yet the *Sun* is not then ſo hot to us, becauſe its Rays fall more obliquely; as is evident by ſuppoſing a right Line drawn from the *Sun* to the point T in that Poſition of the Earth at ♋.

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13. *The* Change of the Earth's place in its Annual

The other Difficulty is in reference to the *Annual* Motion of the Earth round its *Orbit*. For ſuch a Motion ſeems inconſiſtent with the Earth's retaining

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Orbit, *why it makes no ſenſible* Change as to the Earth's Situation in reſpect of the fixed Stars.

retaining always the ſame Situation in Reſpect to the fixed Stars. But it is to be known, that the Circle of the Earth's *Orbit* is ſo very little in Reſpect of the Sphere of the fixed Stars, that the Earth's changing its Place in the ſaid *Orbit* by its *Annual* Motion, makes no ſenſible Change of the Earth's Situation in Reſpect of the fixed Stars. In whatever Point of her *Annual Orbit* the Earth is, its *Axis* and *Equator* (being each every where Parallel to itſelf) will, if produced, fall on the ſame fixed Stars as to our Senſe, or ſo far forth as we can diſcern by our Sight; and conſequently all the Reſt of the fixed Stars (foraſmuch as they retain the ſame Situation among themſelves) will (†) retain the ſame Situation in Reſpect of the Celeſtial *Equator* and *Poles*; the Celeſtial *Equator* being always directly over the *Terreſtrial*, and the Celeſtial *Poles* being always directly in a right Line with the *Poles* of the Earth.

(†) Excepting the Change mentioned, *Chap.* 7. *Sect.* 5.

These

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14. *An* Eclipse of the Sun, *improperly so called.*

These Difficulties being removed, the only *Phænomenon* which remains here to be taken Notice of, is that commonly called *the Eclipse of the Sun*, but which ought to be called *the Eclipse of the Earth*. For the Word *Eclipse* does in the *Greek* Tongue signifie a *Deficiency*; and it is used in this Case to signify particularly that *Deficiency of Light*, which seems indeed to us to be in the *Sun*, but in reality is such only in Respect of the Earth. For the *Sun* is the Fountain of Light to this our Solar System; and consequently not receiving its Light by the Irradiation of any other Body upon it, but having its Light in it self, cannot suffer any such Defect of Light truly and really. Its Light may indeed be intercepted or hindred from coming to us by the Interposition of some opacous Body between Us and the *Sun*. But then it is the *Earth*, on which we are, not the *Sun*, that is deficient of Light, or *in an Eclipse*; and the opacous Body, whose Interposition between the Sun and Earth, causes the Earth to be thus in an Eclipse, is rhe Moon. Wherefore the Explanation of this *Phænomenon* depending

Chap. III. pending on the Motion of the Moon, it will be requisite to ſpeak firſt of that; after which I ſhall in a diſtinct Chapter explain the Eclipſes both of the Sun (as it is commonly called) and alſo of the Moon.

CHAP.

CHAP. IV.

Of the PHÆNOMENA *relating to the* MOON.

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THE Moon is a *ſecondary* Planet, foraſmuch as ſhe moves round the Earth primarily and immediately; and round the Sun only in a *ſecondary* Manner, *viz.* as ſhe moves round the Earth, which moves round the Sun. 1. *The Moon, a* ſecondary *Planet.*

A *Period* or ſingle Revolution of the Moon round the Earth from any Point of the *Zodiack* to the ſame, is called the Moon's (*) *Periodical* Month; and conſiſts of 27 Days, 7 Hours, and 3 Quarters. 2. *A* Periodical *Month, what.*

The Time from one *Synod* or Conjunction of the Sun and Moon to another, is called the Moon's (*) *Synodical* Month, and conſiſts of 29 Days, $12\frac{3}{4}$ Hours. 3. *A* Synodical *Month, what.*

(**) The Words *Period* and *Synod* are both of *Greek* Extraction, the former denoting *a going Round* a Thing, the latter a *Meeting* together of two or more Things.

The

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4. *The* Synodical *Month, why* longer *than the* Periodical.

The Reaſon of the *Synodical* Month being ſo much longer than the *Periodical*, is illuſtrated *Fig.* 8, where the Circle S denotes the Sun, the Circle T ♁ the *Orbit* of the Earth, T the Place of the Earth in the ſaid *Orbit*, the Circle M ☽ the *Orbit* of the Moon; M and *m* two ſeveral Places of the Moon in her *Orbit*, the outermoſt and greateſt Circle the *Zodiack*. Now let the Earth T be ſuppoſed in the firſt of *Libra*, and the Moon to be in her *Orbit* at M (in a right Line between the Earth and the Sun, and ſo) in Conjunction with the Sun in the firſt of *Aries*. The Moon moving thence Eaſtward, or according to the Series of the Signs, after 27 Days and 7 Hours and 45 Minutes, appears to us again in the firſt of *Aries*, i. e. at the point M of her own *Orbit*, in the ſecond Poſition of the Earth. For in the mean while the Earth has alſo moved almoſt a whole Sign Eaſtward, *viz.* almoſt to the End of *Libra*. And hence the Moon M, though come again to the firſt of *Aries*, is almoſt a whole Sign Weſtward of the Sun. This is repreſented by the two prick'd Lines, whereof that from M (in the ſecond

Poſition

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Poſition of the Earth to ♈ repreſents how the Moon appears then to us in the Firſt of *Aries,* while the other Line from *m* through S to the End almoſt of ♈ repreſents how the Sun appears at the ſame Time to be almoſt out of *Aries,* and ſo almoſt a whole Sign Eaſtward of the Moon. Wherefore the Moon muſt ſtill move ſo much further, *viz.* from M to *m* in her own *Orbit,* before ſhe will be in Conjunction again with the Sun. In going of which to overtake the Sun, is taken up the Time, whereby the *Synodical* Month exceeds the *Periodical, viz.* 2 Days, 5 Hours.

5. *The* Synodical *Month of* chief *Regard.*

It is the *Synodical* Month, which is principally made Uſe of in Computation of Time. Foraſmuch as the ſeveral Parts of this Month are ſenſibly to be diſtinguiſhed by the ſeveral *Phaſes* or Appearances of the Moon, reſpectively belonging thereunto.

6. *The ſeveral* Phaſes *of the Moon accounted for.*

The ſeveral Phaſes of the Moon are accounted for thus. The Moon is conceived to be an opacous Body, *i. e.* a Body which receives its Light from the Sun. It is alſo ſpherical, and conſequently has always one Half of it enlightened, namely, that Hemi-

Chap. IV. ſphere which is towards the Sun. Now from this Hemiſphere being ſeen by us, ſometimes more, ſometimes leſs of it, ariſe the ſeveral Phaſes of the Moon; for the better Underſtanding whereof it is to be further obſerved, that although the Moon be a ſpherical Body, yet the enlightened Portion of it, which is ſeen by us, appears by Reaſon of its Diſtance as if the Moon had a plain Surface. All which is illuſtrated, *Fig.* 9, where S denotes the Sun, T the Earth, OTR Part of the Earth's *Orbit*, ACKG the *Orbit* of the Moon, on the ſeveral more remarkable Points whereof, *viz.* A, B, C, D, K, F, G, H, is repreſented the Moon with its enlightened and darkened Hemiſphere; and at each Point ſo much of the enlightened Hemiſphere, as is within the Circle ACKG, is ſeen by us; but it appears to us, not as it is there repreſented, (*i. e.* not as a Portion of an Hemiſphere,) but as a Portion of ſome plain circular Surface, as is repreſented by the ſeveral little circular Draughts reſpectively adjoining. This being premiſed, 'tis evident from the ſaid Figure the 9th, that the Moon being

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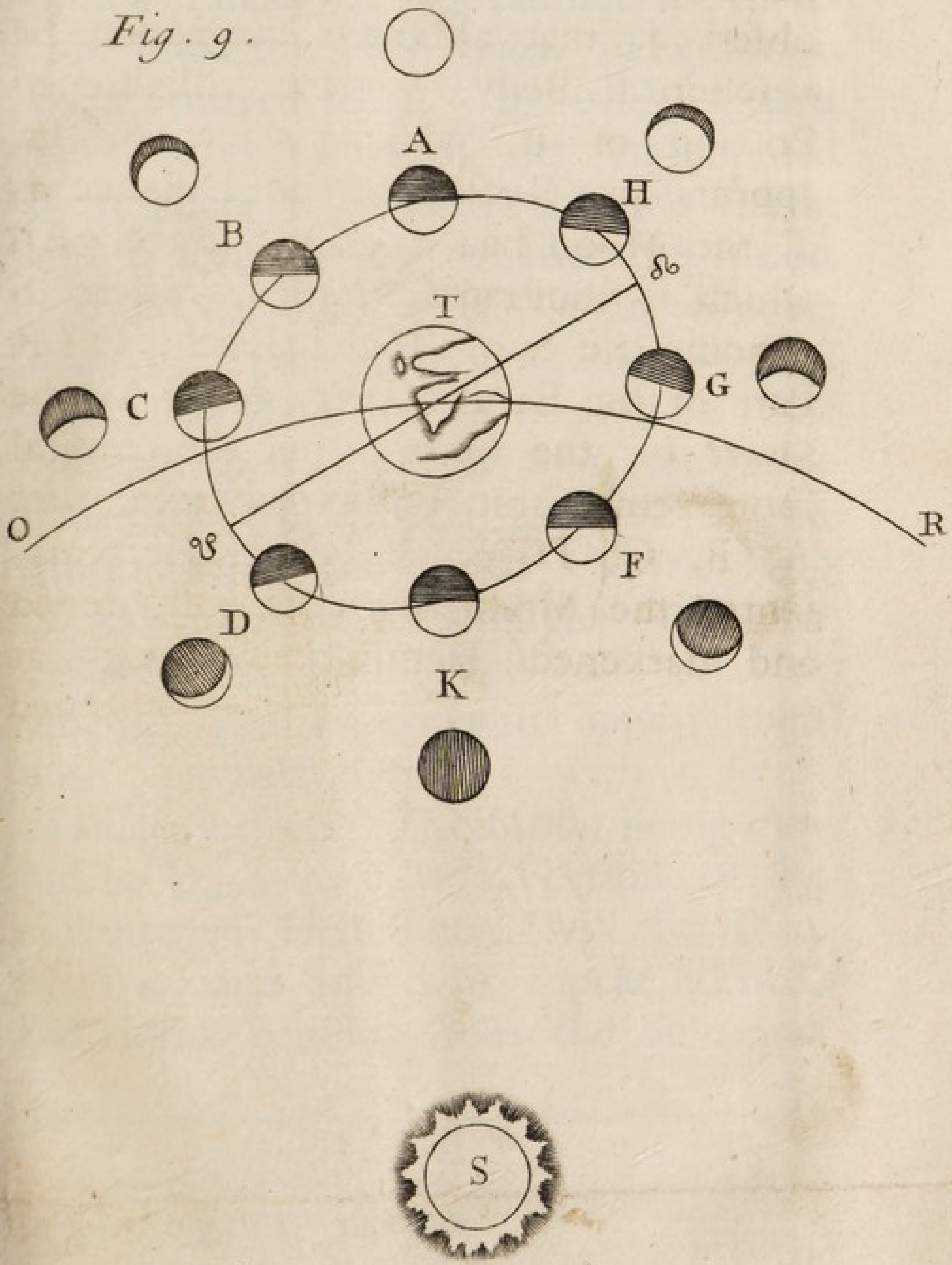
Fig. 9.



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being at A, all its enlightened Hemisphere is towards the Earth, and ſeen by Us, whence the Moon appears to us with a full Orb, (*i. e.* with a plain circular Surface all enlightened,) which Phaſis or Appearance is therefore ſtiled the *Full Moon*. The Moon being moved to B, 'tis evident, that only ſome Part of its enlightened Hemiſphere will be towards the Earth, and ſo ſeen by us; whence the Moon will appear like a (*) plain circular Surface, not fully enlightened, but ſomewhat defective of Light on that Side which is from the Sun, and conſequently will appear gibbous. The Moon being moved to C, juſt Half of its enlightened Hemiſphere will be towards the Earth, and ſeen by Us: whence the Moon will appear then with an half Orb, or with a ſemicircular Surface. The Moon being moved to D, a very little Portion of its enlightened Hemiſphere will be ſeen by Us, and this will appear horned, the Horns bending from the Sun, and

(*) Hence the Face of the Moon is called *Diſcus*, as reſembling a flat round Diſh.

Chap. IV. ſo (*) weſtward. The Moon being come to K, none of its enlightened Hemiſphere will be towards the Earth, and ſo the Moon will not be ſeen by us, and then it is ſaid to be *New Moon*; becauſe the Moon will a little appear *a-new* in F, and that again horned, the Horns now likewiſe bending from the Sun, and ſo (*) eaſtward. After which the Moon will appear at G with an half Orb again, (as at C;) and at H gibbous again, (as at B;) and ſo will proceed to A, where it will be again Full Moon. And ſo the Moon will have undergone her ſeveral Phaſes; which though they ſomewhat vary every Day, nay every Hour; yet are uſually taken Notice of, and diſtinguiſhed only in the fore-mentioned Points.

(**) Hence the memorial Verſe,

Dextra cavum Veteris complebit, Læva Recentis, i. e. when the *Horns* or *Hollow* of the Moon appear *Eaſtward*, or on the *left* hand as we look at it, then the Moon is *Increaſing*; and this Appearance of the Moon is to be ſeen only in the *Evening* or *former* part of the Night, a little *after* its change. But when the *Horns* or *Hollow* of the Moon appear *Weſtward*, or on the *right* hand as we look at it, then the Moon is *Decreaſing*, and this Appearance of the Moon is to be ſeen only in the *latter* part of the Night or *towards Morning*, a little *before* its Change.

Hence

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Hence the remarkable Phaſes of the Moon are five; whereof the two principal are the *New* and the *Full* Moon. The three other, *viz.* the *Gibbous*, *Half*, and *Horned* Moon, occur both between the New and Full Moon, and alſo between the Full and New Moon; only in a different Order. Between the New (which is alſo called the *Change*) and the Full, the Moon is firſt horned, then halved, and laſtly gibbous; whereas between the Full and Change, ſhe is firſt Gibbous, then Halved, and laſtly Horned. 7. *The remarkable Phaſes of the Moon,* five.

When the Moon is thus Horned, or a little before and after the New Moon, (*viz.* when the Moon is at the Points D and F,) beſides its bright Horns, the Moon has a faint Light, whereby all the Reſt of its Diſcus is rendred diſcernable. This faint Light has been thought by ſome to be the Moon's Native proper Light; but is now generally ſuppoſed by the learned in Aſtronomy to be no other than a Reflection of the Sun's Rays upon the Moon, the Earth's Poſition being ſuch at this Time, as very well ſuits to ſuch a Reflection, as may be ſeen, *Fig.* 9. And this Suppoſition is rendered ſtill 8. *The* faint Light *which is ſeen in the whole Diſcus of the Moon, a little before and after its Change; whence ſuppoſed to ariſe.*

Chap. IV. more probable, becauſe that as ſoon as the Moon is moved beyond the Limits of ſuch a Reflection from the Earth, the forementioned faint Light ceaſes.

9. *Of the Moon's Apogee and Perigee, &c.*

What has been afore obſerved of the Sun, is alſo obſerved by the Curious of the Moon; namely, that in one Part of her *Orbit* ſhe appears leſſer, and (*cæteris paribus*) ſlower; in the oppoſite Part bigger and ſwifter. Which *Phænomena* may be ſolved after the like manner, as are the like *Phænomena* of the Sun; *viz.* by the Moon's Motion in an elliptical *Orbit*, having one of its Focus's in the Center of the Earth. Accordingly this may be illuſtrated by *Fig.* 7, ſuppoſing the Ellipſis A P (which there repreſents the *Orbit* of the Earth) to repreſent the *Orbit* of the Moon and the Circle S (which there repreſents the Sun) to repreſent the Earth. For then A will repreſent the Moon's *Apogee* or greateſt Diſtance from the Earth, when ſhe will appear leſſer; and P her *Perigee* or leaſt Diſtance, when conſequently ſhe will appear greater. And becauſe ſhe is longer in paſſing the greater Segment of her *Orbit* between her *Apogee* and that Focus

cus of her *Orbit*, which is in the Center of the Earth, than the leſſer Segment between the ſaid Focus and her *Perigee*; therefore ſhe will appear to move ſlower, while ſhe paſſes along that Half of the *Zodiack*, which anſwers to the greater Segment of her *Orbit*; and ſwifter, while ſhe paſſes the other Half of the *Zodiack*, anſwering to the leſſer Segment of her *Orbit*. Chap. IV.

Among the *Phænomena* of the Moon more obvious to our Senſe, there remains only the Eclipſe of the Moon to be ſpoken of, which ſhall be explained in the following Chapter.

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Chap. V. *Of the* ECLIPSES *of the* SUN *and* MOON.

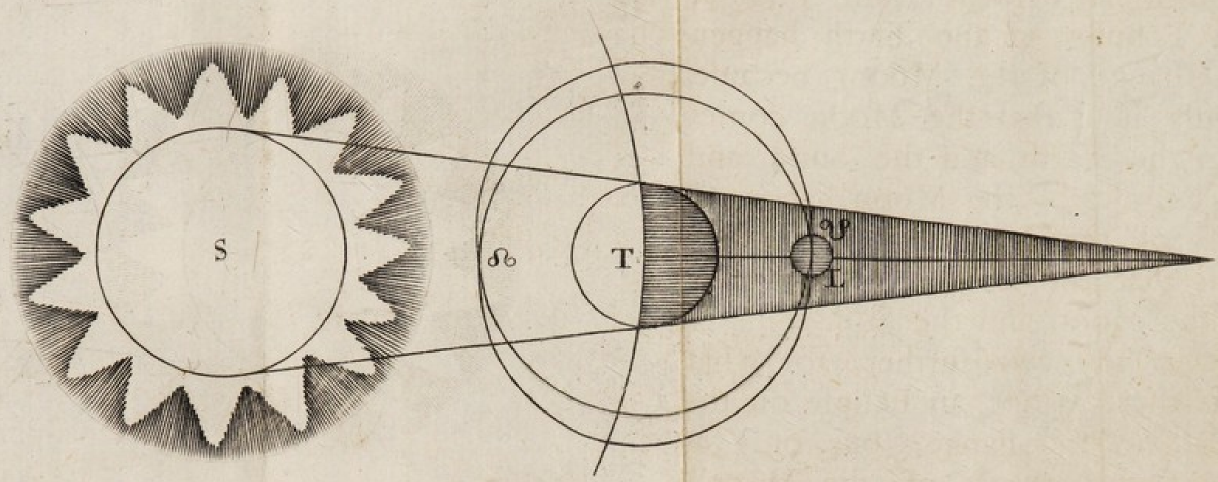
I. *An* Eclipse *of the Sun and Moon,* what.

THE Eclipses of the Sun and Moon are here ſpoken of together, becauſe as they ariſe from like Cauſes, ſo are they to be explained much after the ſame Manner. For it is to be remembred, that it has been afore (*) obſerved, that what is commonly called the Eclipſe of the *Sun*, is in reality the Eclipſe of the *Earth*. Wherefore, the Earth and Moon being both opacous Bodies, which receive Light from the Sun, an Eclipſe of the Earth (commonly called an Eclipſe of the Sun) is no other than a Deficiency of Light on the Earth, by the Moon's coming between the Earth and the Sun, ſo as to hinder the Rays of the Sun from falling on the Earth; juſt as an Eclipſe of the Moon is a

(*) *Chap.* iii. *Sect.* 14.

Deficiency

Fig. 10



Deficiency of Light in the Moon, by the Earth's coming between the Moon and Sun, so as to hinder the Rays of the Sun from falling on the Moon.

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2. *Eclipses of the Sun and Moon,* when *happen.*

Hence it is evident from *Fig.* 9, that all Eclipses of the Earth happen at the Change of the Moon, because then only it is that the Moon comes between the Earth and the Sun; and all the Eclipses of the Moon happen at the Full of the Moon, because then only 'tis that the Earth can come between the Moon and the Sun.

3. *Why not at* every *Change or Full of the Moon, but only at* some certain *Ones.*

It is to be shewn further, for what Reasons there is not an Eclipse of the Earth at *every* Change, but only at *some certain* Changes of the Moon; nor an Eclipse of the Moon at *every* Full, but only at *some certain* Full Moons. It is then to be known, that the *Orbit* of the Moon crosses the *Ecliptick*, so as to make an Angle of 5 Degrees Inclination. The Points where the Moon crosses the *Ecliptick*, are called the *Nodes of the Moon*, and are denoted, *Fig.* 10, by these Characters ☊ and ☋; the former of which is called *the Dragon's Head*, the latter *the Dragon's Tail.* The Moon crosses the *Ecliptick* at the Dragon's Head, when

Chap. V. when ſhe is entring on that Part of her *Orbit*, which inclines northward from the *Ecliptick*; and ſhe croſſes the Dragon's Tail, when ſhe is entring on that Part of her *Orbit*, which inclines Southward from the *Ecliptick*. Now the Nodes being the only two Points, where the Moon croſſes the *Ecliptick*, hence there can be no Eclipſe of the Earth, but when the Moon happens to Change in or near one of the Nodes; becauſe in this Caſe only, the Moon at her Change comes ſo between the Earth and the Sun, as to intercept the Rays of the Sun, and keep them from the Earth. And in like manner, there can be no Eclipſe of the Moon, but when the Moon happens to be at Full, in or near one of the Nodes; becauſe in this Caſe only, the Earth comes ſo between the Moon and the Sun, as to intercept and hinder the Rays of the Sun from falling on the Moon.

4. *The Shadow, in Eclipſes of the Sun and Moon, of* what Figure.

In an Eclipſe of the Earth, the Moon by intercepting the Rays of the Sun, caſts a Shadow on the Earth. And in an Eclipſe of the Moon, the Earth by intercepting the Rays of the Sun, caſts a Shadow on the Moon.

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These Shadows are of a (†) conical Figure, growing narrower and narrower, the further they go from the Earth and Moon, till at length they end in a Point, and so cease. Were these Shadows, either of a (*) cylindrical Figure, *i. e.* of an equal Thickness all along; or of a (*) conical Figure, but inverted the other Way, *i. e.* did they grow thicker and thicker, the further they are extended, then they would be extended *in infinitum*. But now 'tis certain, that the Shade of the Earth does not extend to the *Orbit* of the primary Planet *Mars*; forasmuch as when the Earth is directly between the Sun and *Mars*, the latter is not eclipsed, as it must necessarily be, did the Shade of the Earth reach to the *Orbit* of *Mars*.

5. *The Sun how demonstrated to be* bigger *than the Earth, and the Earth than the Moon.*

It being thus demonstrable, that the Shadow of the Earth ends in a Point, before it comes to the *Orbit* of *Mars*; hence it is also demonstrable that the Sun is bigger than the Earth; forasmuch as an opacous Body can't

(†) As in *Fig.* 13.
(**) This is evident from *Fig.* 11. and 12.

cast

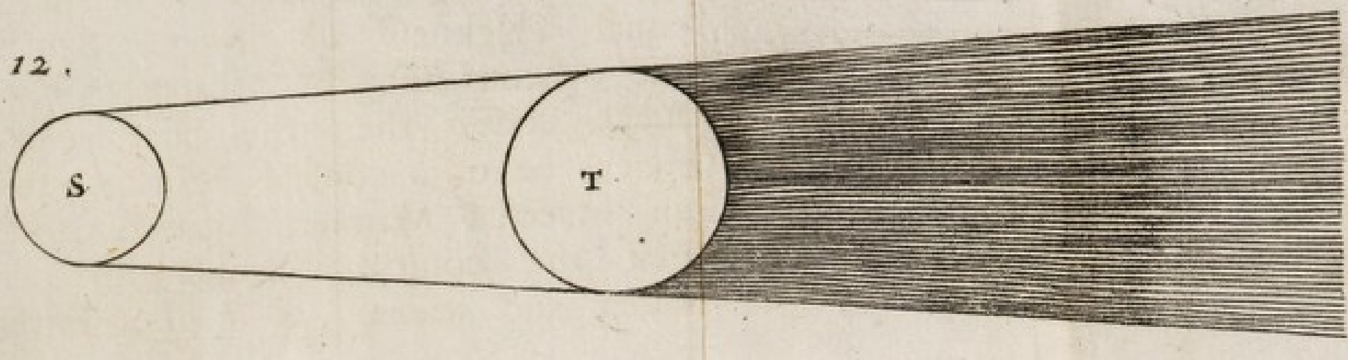
Chap. V. cast such a conical Shade, but when it is lesser than the lucid Body, whose Rays it intercepts. For if the opacous Body be equal to the lucid Body, then the Shadow will be of an equal Thickness all along. And if the opacous Body be greater than the lucid Body, then the Shadow will indeed be of a conical Figure, but in an inverted Manner, that is, so as that the conical Shade will grow wider and wider, as it goes further and further. And as the Sun may be thus demonstrated to be bigger than the Earth, so the Earth may be demonstrated to be bigger than the Moon; forasmuch as the Moon can be totally Eclipsed. For this could not be, was not the Cone of the Earth's Shadow, even in that Part of it which the Moon passes through in a total Eclipse, bigger than the Moon, though it be lesser than the Earth it self: what is here said is illustrated, *Fig.* 11, 12, 13.

6. *The Greatness of an Eclipse depends in one Respect on the*

The Shadows of the Earth and Moon being thus of a conical Figure, it is obvious that an Eclipse either of the Earth or of the Moon will be (*cæteris paribus*) greater or longer,

.11.

ig. 12.



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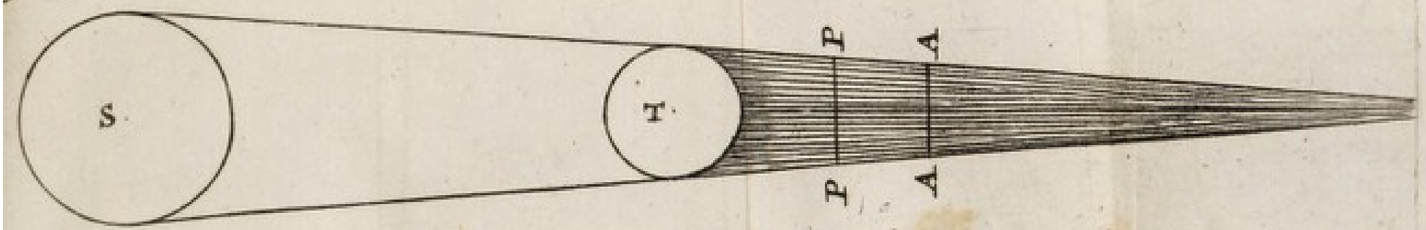


ag. 62.

Fig. 14.

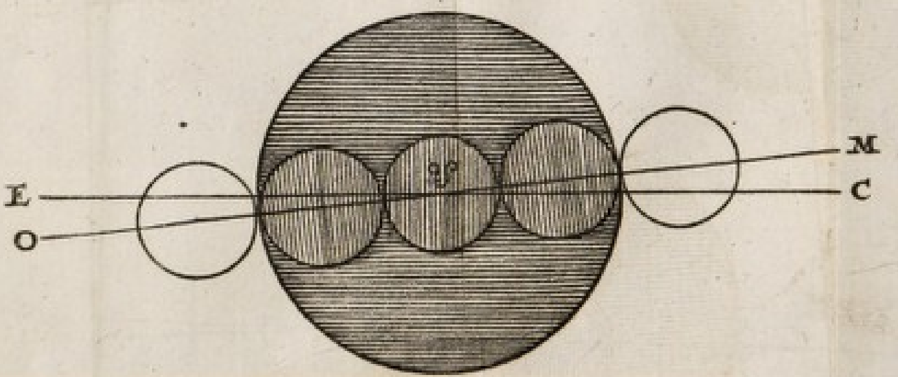


Fig. 15.

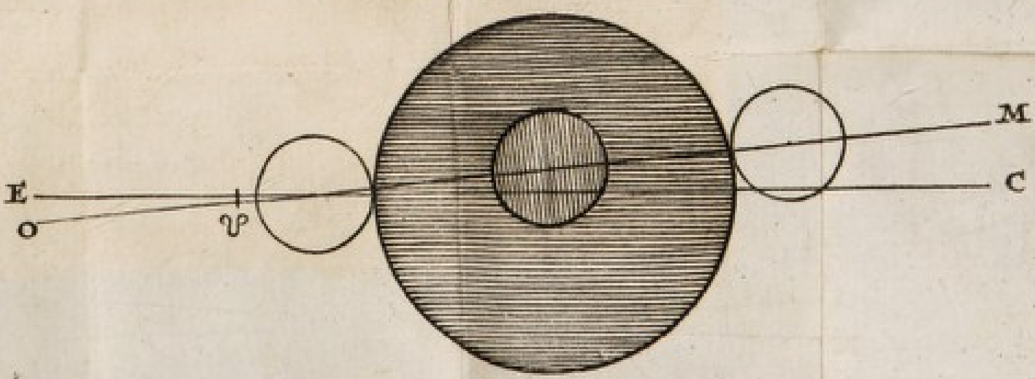
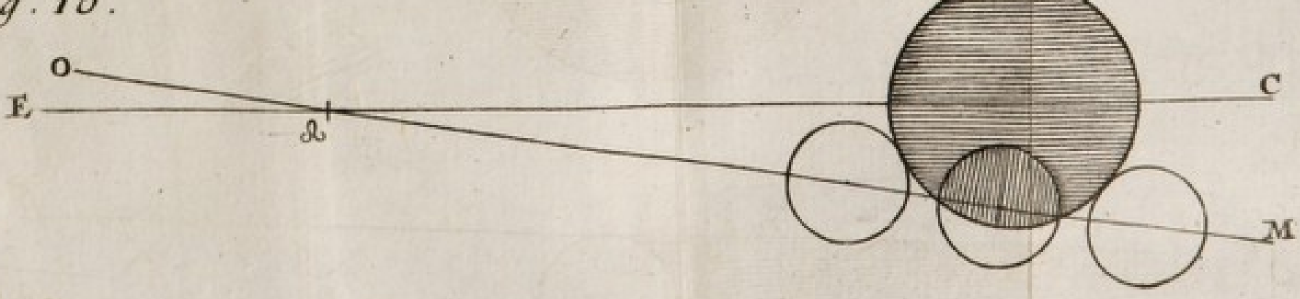


Fig. 16.



onger, when the Moon is in her *Pergiee*, than when ſhe is in her *Apo-gee*. For the Moon if ſhe be eclipſed n her *Perigee*, meets with a thicker Part of the Line of the Earth's Sha-dow, than if ſhe be Eclipſed in her *Apogee*; as is obvious from *Fig.* 13, where the Line P P denotes the Moon's Paſſage through the Shadow in her *Perigee*, and the Line A A in her *Apo-gee*. And in like manner, if the Earth be eclipſed when the Moon is in her *Perigee*, it meets with a thicker Part of the Cone of the Moon's Shade, than it does if it be eclipſed when the Moon is in her *Apogee*; as is ob-vious alſo from *Fig.* 13, taking the Circle T to denote the Body of the Moon; and the Line P P to denote the Paſſage of the Earth through the Shade of the Moon in her *Perigee*, and A A to denote the like in the *Apo-gee* of the Moon.

Chap. V. *Moon's be-ing in her* Apogee *or* Perigee.

But the Variety, that is obſerved in Reſpect to the Greatneſs and du-ration of Eclipſes, does principally ariſe from the Moon's being then more or leſs diſtant from a Node or the *Ecliptick*. Which ſhall be illuſ-trated, 7.

But princi-pallyon the Moon's Di-ſtance from her Nodes.

Chap. V. ſtrated, firſt in reference to the Moon, then in reference to the Earth.

8. *An Eclipſe of the Moon,* Total *or* Partial.

An Eclipſe of the Moon, conſidered as to its *Greatneſs*, is either *Total*, when the whole Moon is eclipſed; or *Partial*, when only a Part of it is eclipſed.

9. *A* Central *Eclipſe of the Moon, what.*

As to *Duration*, every total Eclipſe holds longer than any partial One. And, as ſome partial Eclipſes are of longer Duration than other Partial, ſo ſome total Eclipſes are of longer Duration than other Total. Such total Eclipſes, as are of the longeſt Duration, happen when the Moon is in a Node, and are called *central* Eclipſes, becauſe, as the Moon paſſes through that Section of the Cone of the Earth's Shadow, which meets with the *Orbit* of the Moon, the Center of the Moon paſſes exactly through the Center of the ſaid Section of Shadow.

10. *A* Central *Eclipſe illuſtrated.*

This is illuſtrated, *Fig.* 14, where the ſhaded Circle repreſents the Section afore-mentioned of the Earth's Shadow; O M the *Orbit* of the Moon, E C the *Ecliptick*. 'Tis evident, that the Moon in this Caſe croſſing a Diameter of the ſhaded Circle, makes the longeſt

ongeſt Stay ſhe can make in the Shadow of the Earth; and this Stay is omputed about four Hours long. Whereof the Moon takes up one Hour rom her Beginning to enter into the Shadow, till ſhe is quite immerged herein; two Hours more ſhe coninues quite immerged, paſſing on hrough the Shadow; and the fourth Hour is taken up from her firſt Beginning to come out of the Shadow, ill ſhe is got quite free of it. Whence by the Way it appears, that the Wideneſs of the Shade is equal to about hree Diameters of the Moon.

In *Fig.* 15, is repreſented a *total*, but *not-central* Eclipſe; which happens when the Moon meets with the Shadow of the Earth, though not at a Node, yet at a ſmall Diſtance from it. And as it is obvious from the ſame Figure, that every total, but not-central Eclipſe muſt be of a ſhorter Duration than a central, ſo it is alſo obvious that one total, but not-central Eclipſe will be longer than another, in Proportion to the Moon's greater or leſs Diſtance from a Node at that Time. 11. *A* Total, *but* Not-central *Eclipſe of the Moon.*

In

Chap. V.

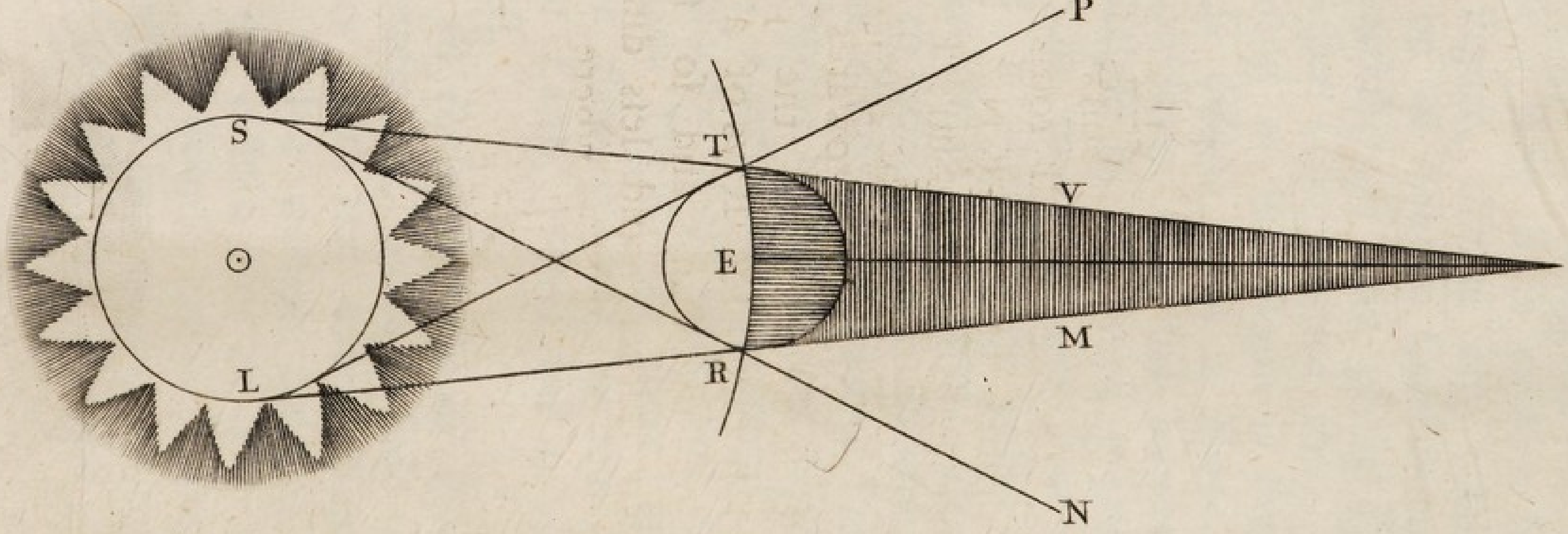
12. *A* partial *Eclipse of the Moon.* In *Fig.* 16. is represented a partial Eclipse. And it is evident from the same Figure, that as any total Eclipse must be of longer Continuance than any partial; so one partial Eclipse is of longer Continuance than another, according as the Moon is then more or less distant from a Node. It is also obvious, that the longer a partial Eclipse is, so much greater is it, *i. e.* so much greater Part of the Moon is darkned or passes through the Shadow of the Earth. Hence it is usual to conceive the Moon's Diameter, as divided into twelve Parts, called *Digits*; by which the Greatness of partial Eclipses are measured and distinguished; they being said to be of so many Digits, as there are such twelve Parts covered by the Shadow of the Earth, when the Eclipse is at greatest.

13. *Of the* Penumbra *in Eclipses of the* Moon. In all these Eclipses of the Moon, she enters the western Side of the Shadow with her eastern Side; and so it is her western Side which last quits the eastern Side of the Shadow, when the Eclipse ceases. But now as the eastern Limb or Side of the Moon draws towards the Shadow; before it

Astronomy Plate 10.

Place this facing Pag. 65.

Fig. 17.



it enters the thick Shadow it ſelf, and is quite darkened, it grows more and more dim, as it comes nearer and nearer to the Shadow. Which Dimneſs ariſes from a Penumbra or Duskiſhneſs, which always attends ſuch Shadows, and encompaſſes them all round. Thus *Fig.* 17, TUMR repreſents the Shadow, (where comes not any Part of the Sun's Light,) which is encompaſſed all round with the Penumbra UTPMRN, where only ſome Part of the Sun's Light is intercepted by the Earth. And this Penumbra is more dim towards TU and MR the edges of the perfect Shadow, becauſe the Rays of a leſſer Portion of the Sun, and ſo fewer Rays reach thither; and leſs dim towards TP and RN, where more Rays fall; and beyond which Limit, all the Rays of the Sun have a free Courſe.

In ſome Eclipſes the Moon quite diſappears in the perfect Shadow. At other Times ſhe appears even in the Midſt of the perfect Shadow, of a reddiſh Colour like a burnt Brick. Which reddiſh Colour is ſuppoſed to ariſe from the Rays of the Sun, either 14. *The Moon why appear of a* reddiſh *Colour in total Eclipſes.*

F ther

Chap. V. ther refracted in the Atmoſphere about the Earth, or reflected to the Moon by Particles flying without the Shadow of the Earth; or elſe to ariſe from the Illumination of the Stars, or all theſe Cauſes together.

15. How many *Eclipſes of the Moon uſually happen* in a Year.

There happen moſt Years two Eclipſes of the Moon at leaſt. For there being two Nodes, wherein the Moon croſſes the *Ecliptick*, and which move contrary to the Series of the Signs, and the Earth going round the *Ecliptick* every Year the other Way, or according to the Series of the Signs; hence it is obvious, that the Earth muſt meet the Moon's Nodes every Year. If therefore it happens then to be Full Moon, there muſt be a central Eclipſe. If it be not then Full Moon, but more than ten Days (and more than fifteen it cannot be) either before or after a Full Moon; yet ſo great is the Inclination of the Moon's *Orbit* to the *Ecliptick*, and ſo great is the Thickneſs of the Cone of the Earth's Shadow, that the Moon will ſcarce miſs going through ſome Part of the Shadow; and conſequently there will be at leaſt a partial Eclipſe. But if the Earth happens to

meet

meet a Node of the Moon on the very Day of a New Moon, or one or two Days before or after, (which happens but ſeldom) in this Caſe the Moon will be far enough to avoid the Shadow of the Earth, both in the foregoing and alſo following Full Moon; and ſo there will be no Eclipſe of the Moon that half Year. And this may ſuffice in Relation to the Eclipſes of the Moon. Chap. V.

Proceed we now to the Eclipſes of the Earth, which are commonly called Eclipſes of the Sun, foraſmuch as the Moon, which more or leſs covers the Sun, being not ſeen by us, the Deficiency of Light appears to our Sight as in the Sun it ſelf. Whence an Eclipſe of the Sun is diſtinguiſhed alſo into a *total* Eclipſe, wherein the Moon covers the whole Body of the Sun from us; and a *partial* Eclipſe, wherein the Moon covers only a Part of the Sun. 16. *An Eclipſe of the Sun* Total *or* Partial.

But it is to be well obſerved, that although an Eclipſe of the Sun be in reality an Eclipſe of the Earth; yet what is called a *total Eclipſe of the Sun,* is not to be conceived as in reality a *total Eclipſe of the Earth*; or 17. *Of a* Total *Eclipſe of the Sun.*

Chap. V. that the whole upper and opposite Hemisphere of the Earth is then deprived of the Sun's Light, as in a Total Eclipse of the Moon is the whole opposite Hemisphere of the Moon. The Reason of which Difference is this. The Earth being bigger than the Moon, the Cone of its Shadow is big enough to involve the whole opposite Hemisphere of the Moon in its Darkness. Whereas the Moon being less than the Earth, the Cone of her Shadow will involve at once only a small Tract (CD in *Fig.* 18,) of the opposite Hemisphere of the Earth, so as to hide the whole Sun from the Inhabitants thereof; and consequently there will appear only to these a Total Eclipse of the Sun, whilst to the Inhabitants of the adjoining Tracts BC, and DE, the Sun will appear to be but partially Eclipsed; and beyond these on each Side, there will be no Eclipse at all of the Sun, as is evident from the same *Fig.* 18.

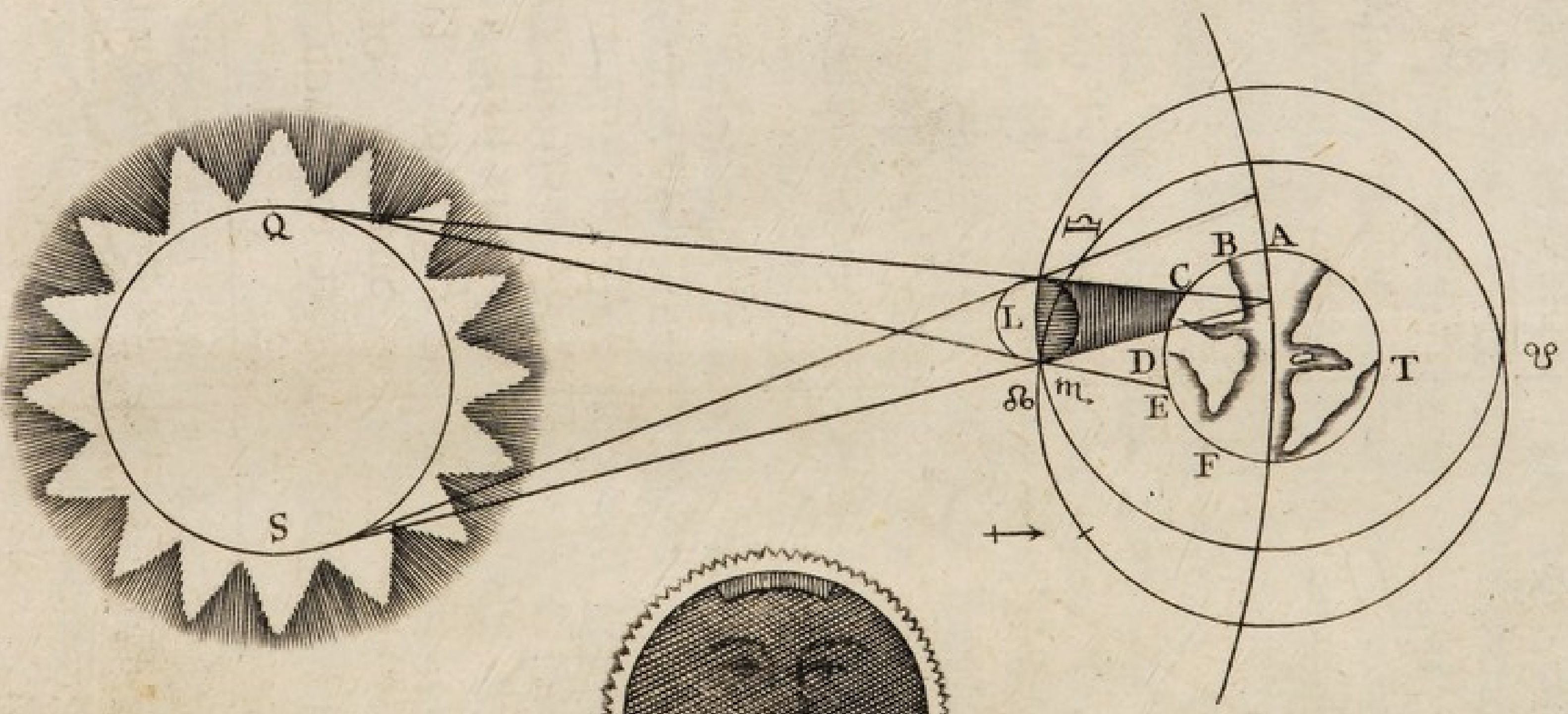
18. *The Sun continues totally Eclipsed, but a very short while.*

The Moon moving from West to East, that is, from ♎ through ♏ to ♐, hence her eastern Limb appears to us first to cover the western Limb of the Sun. And when there is a Total

Astronomy Plate 11.

Place this facing Pag. 68

Fig. 18.



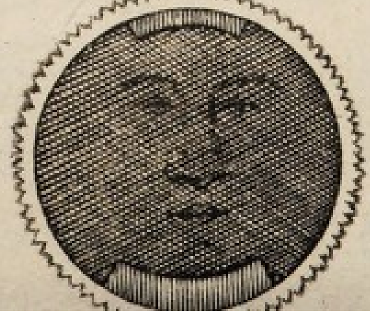


Fig. 19.

Total Eclipſe of the Sun, for the Time that the Moon covers all the Sun from us, it is ſo dark, as that ſometimes the Stars have appeared, and there has been need of Candle-light. But then this Darkneſs laſts but a very little While; for no ſooner is the (*) Diſcus or Face of the Sun quite covered by the Moon, but almoſt preſently ſome Part of the ſaid Diſcus begins to be uncovered again, and a very little Part of it being ſo uncovered gives a conſiderable Light. All which Particulars relating to a Total Eclipſe of the Sun were Actually exemplify'd here in *England* no longer than *April* 1715, and again, this preſent Year, *May* 11. 1724. Chap. V.

It happens ſometimes, that a Central Eclipſe of the Sun is not a Total Eclipſe; but about the Limb or Edge of the Moon, which looks like a black or dark Spot, may be ſeen the Limb of the Sun, which appears like a Circle of Light, as in *Fig.* 19. This is occaſioned by the Shadow of the Moon being too ſhort to reach quite 19. *A* central *Eclipſe of the Sun may be not a* Total.

(*) The Sun's Face is called its *Diſcus*, for the like Reaſon, as the Moon's Face is ſo called, taken Notice of *Chap.* 4. *Sect.* 6.

Chap. V. to the Earth; and this Shortneſs of the Moon's Shadow may be occaſioned, either by the Moon being in her *Apogee*, or elſe by the Rays of the Sun, which paſs by the Edge of the Moon, being bent by Inflection, and ſo ſhortening the Shade of the Moon.

20. *Of the Number of Eclipſes of the Sun in a Year.*

The greateſt Eclipſe of the Sun (wherein the Shadow of the Moon paſſes along the Middle of the Earth) is, when the Moon happens to be in a Node at the Moment of her Change. If ſhe be not far from a Node, the Shadow of the Moon, or at leaſt ſome Part of the Penumbra will fall on ſome Tract of the Earth, (as being large enough,) and will there make a Total, or at leaſt partial Eclipſe. And in this Reſpect there are more Eclipſes of the Sun, than of the Moon. But in Reſpect of any one given Place of the Earth, there are much fewer viſible Eclipſes of the Sun than of the Moon, for the Shade of the Moon is leſſer than the Shade of the Earth; and conſequently the former will not ſo often involve any given Place of the Earth, as the latter will ſome Part of the Moon.

It remains now only to obſerve, that the *Ecliptick* is ſo called, becauſe all the fore-mentioned Eclipſes happen, only when the Moon is in or near a Node, *i. e.* in or near the Plane of the *Ecliptick.* And as all Eclipſes of the Sun and Moon happen in the *Ecliptick,* ſo likewiſe do the Eclipſes of the other Planets, of which we come now to ſpeak. 21

21 *The* Ecliptick, *why ſo called.*

CHAP. VI.

Chap. VI. *Of the* PHÆNOMENA *of the* primary *Planets, of* SATURN, JUPITER, MARS, VENUS, *and* MERCURY; *as also of the* secondary *Planets, or the* SATELLITES *of* SATURN *and* JUPITER.

1. *The primary Planets distinguished into* Superiour *and* Inferiour, *with Respect to the Earth.*

AS there are five primary Planets besides the Earth, so they are distinguished, by Reason of their Situation with Respect to the Earth, into *Inferiour* and *Superiour*. The former are such as move between the Earth and Sun, and are two, *Venus* and *Mercury*; the latter are such, as have the *Orbit* of the Earth between the Sun and their own *Orbits*, and these are three, *Saturn*, *Jupiter*, and *Mars*. This with their respective Order may be seen, *Fig.* 1.

2. *Hence arises some* Difference,

Although both inferiour and superiour Planets agree in this, that the Planes of their *Orbits* cross the Plane of the *Ecliptick*; yet their different Situation

Fig. 20.

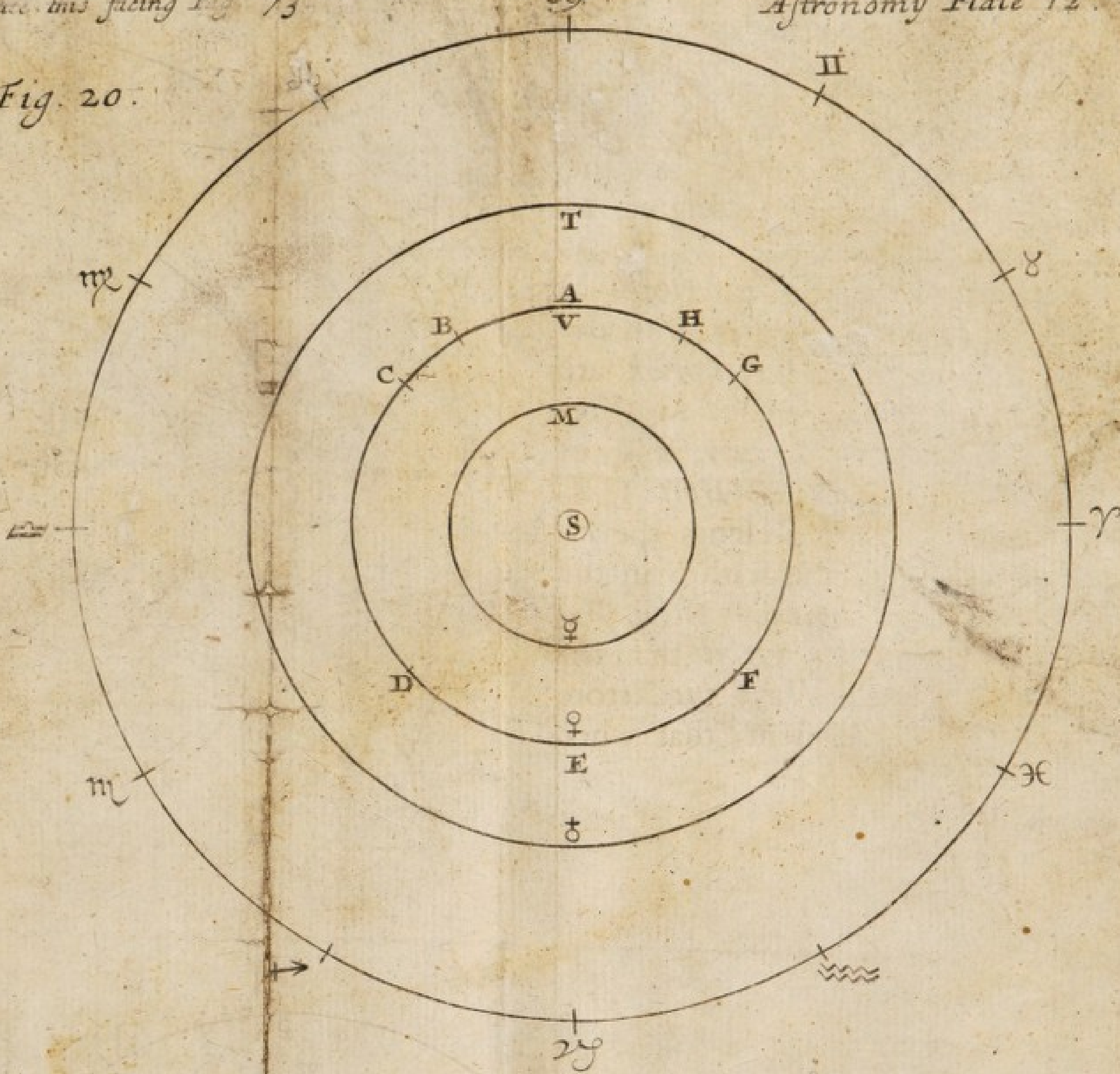


Fig. 21.

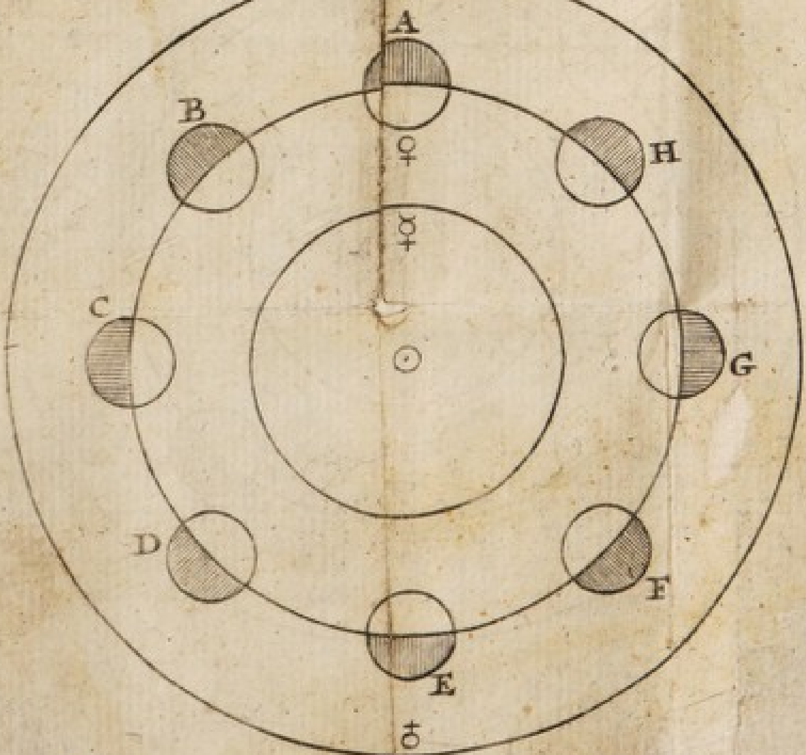
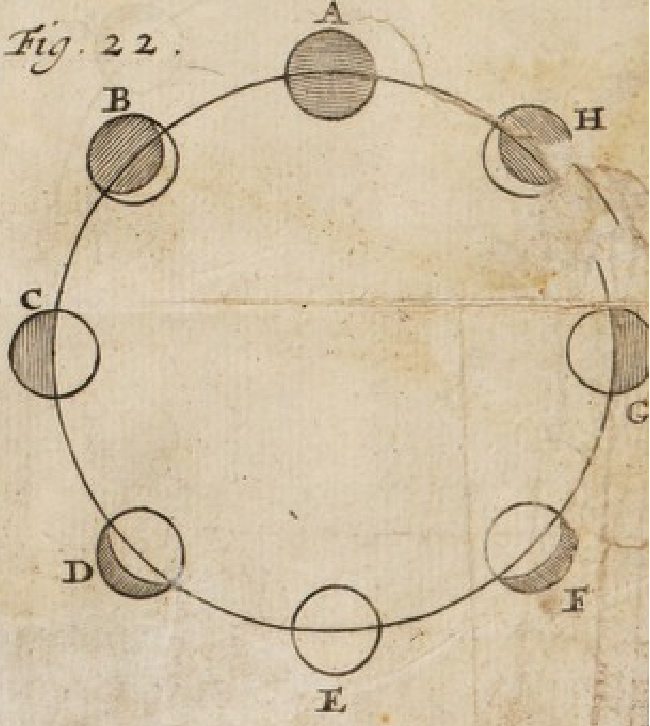


Fig. 22.



Situation with Reſpect to the Earth occaſions ſome Difference in the *Phænomena* reſpectively belonging to them.

Chap. VI.

as to their Phænomena.

I ſhall begin with the inferior Planets, whoſe *Orbits* together with the *Orbit* of the Earth and *Ecliptick* are repreſented, *Fig.* 20, namely, M ☿ repreſents the *Orbit* of *Mercury*, V ♀ of *Venus*, T the Earth in its *Orbit* T ♁, the outermoſt Circle repreſents the *Ecliptick*; the little Circle with S in the Center repreſents the Sun. Now *Venus* moving in a leſſer *Orbit* than the Earth, but the ſame Way, *viz.* from Weſt to Eaſt; it is evident, that when *Venus* is in DEF the more remote Part of her *Orbit* from the Earth T, ſhe will appear to us in T to move according to the Series of the Signs, (*viz.* from ♋ to ♑, &c.) and ſo to move *directly* forward. When *Venus* is come to G, from thence to H, ſhe will ſtill appear to move directly forward, but ſlower than before; foraſmuch as ſhe now moves as it were in a ſtraight Line towards T the Earth. As ſhe paſſes beyond H through A to B, moving quicker than the Earth, ſhe will paſs between the Earth and the Sun,

3. *The inferiour Planet* Venus, *why it appears ſometimes to move* Directly, *ſometimes* Backward, *and ſometimes to* ſtand ſtill.

Chap. VI. Sun, and will seem to us on the Earth to move contrary to the Series of the Signs, (*viz.* from ♑ to ♐,) and so to have a *retrograde* Motion, or to move backward. Between her direct and retrograde Motion, *viz.* about H, she will appear *stationary*, i. e. to stand still; forasmuch as the right Lines then joining the Earth, and *Venus* will for some Time continue parallel. And in like manner between her retrograde and direct Motion, *viz.* about B, she will appear a second Time to stand still. From what has been said 'tis obvious, that *Venus* when she is retrograde, as at A, is nearer the Earth, and therefore seems bigger; and on the other hand when she is direct, as at E, she is more remote from the Earth, and so (*cæteris paribus*) seems lesser.

4. *The several* Phases *of* Venus.

The several Phases of *Venus*, according to her different Position with Respect to the Earth, are represented as they are in themselves, *Fig.* 21. Whence it is evident, that when *Venus* is at A, that is, most retrograde and nearest to the Earth, she does not appear to us, her dark Face being ng towards us, and if ſhe then happens to be in or near enough to a Node, ſhe will paſs directly between the Earth and Sun, and ſo ſeem as a ſpot in the Sun. Otherwiſe, if ſhe be far enough from a Node, ſhe will go on one ſide of the Sun, either Northward or Southward. At B ſhe will appear horned, at C with an half Orb, at D gibbous, and at E (where ſhe moves moſt directly, and is moſt remote from the Earth) with a full Orb; unleſs ſhe be then in or near enough to a Node, in which Caſes ſhe will be hid from us by the Sun. After her Full, *Venus* undergoes the ſame Phaſes as afore, only in an inverted Order, till ſhe comes to her Change again. As *Fig.* 21, repreſents the ſeveral Phaſes of *Venus*, as they are in themſelves; ſo *Fig.* 22, repreſents them, as they appear to us on the Earth; the correſpondent Phaſes being denoted in both Figures by the ſame Letters, A, B, C, *&c.*

Laſtly, *Venus* moving round the Sun at a leſſer Diſtance than the Earth does, hence to us ſhe appears as always accompanying the Sun; her greateſt Elongation or Diſtance from the 6. *Why* Venus *appears always* accompanying *the Sun; and*

Chap. VI.

why called Phoſphorus, *and* Heſperus, *&c.*

the Sun being about 45 Degrees, or a Sign and Half. When ſhe appears before the Sun in the Morning, and ſo does as it were uſher in Day-light, ſhe is then called *Phoſphorus* or *Lucifer*, or the *Morning Star*; when after the Sun at Evening, then ſhe is called *Heſperus* or *Veſper*, or the *Evening Star*.

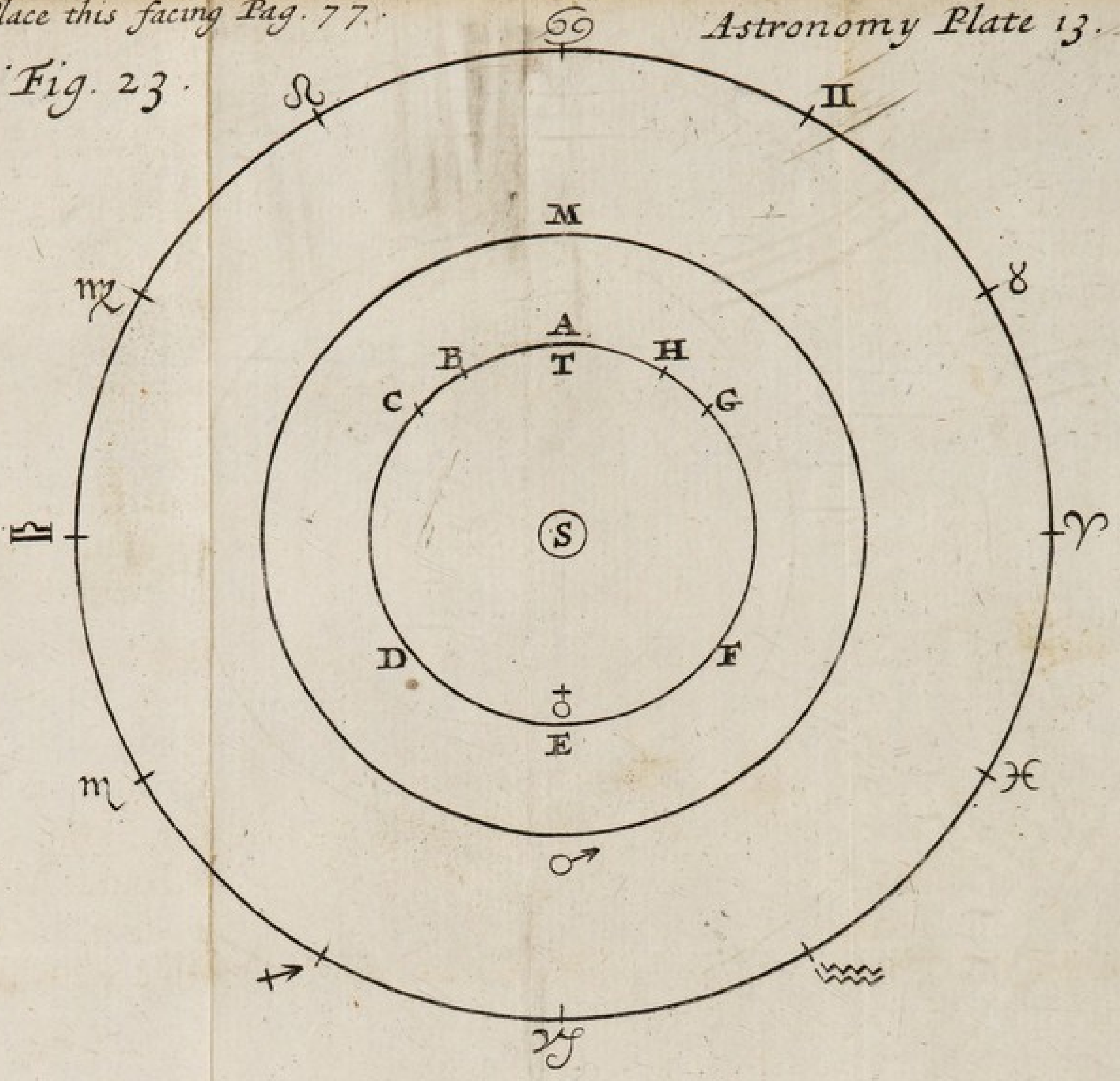
6. *Of the* Phænomena *of* Mercury.

What has been ſaid and illuſtrated concerning *Venus*, is alſo to be underſtood in reference to the like *Phænomena* of *Mercury*; only it muſt be conſidered, that the *Orbit* of *Mercury* being leſſer than that of *Venus*, hence *Mercury* never appears at ſuch a Diſtance from the Sun, being never a whole Sign diſtant from it, and ſo very ſeldom to be ſeen. In like manner, *Mercury* going round its *Orbit* in ſhorter Time than *Venus* does her *Orbit*; hence the direct Motions, Stations, and Retrogradations of *Mercury* will occur oftner, than thoſe of *Venus*. And ſo much may ſuffice for the two inferiour primary Planets.

7. *The A*greement *between*

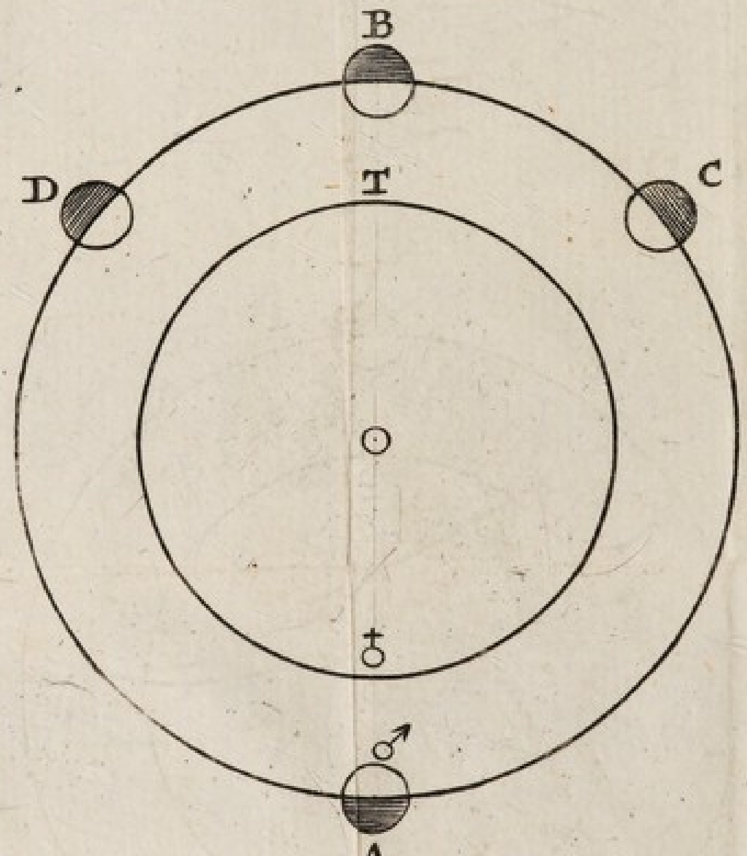
As the Agreement between the *Phænomena* of *Venus* and *Mercury* ariſes from their being both inferiour Planets

Fig. 23.



Pag. 80.

Fig. 24.



lanets to the Earth; ſo a like Agree-ment between the *Phænomena* of *Mars*, *Jupiter* and *Saturn*, ariſes from their being ſuperiour Planets to the Earth.

the Phænomena *of the* ſuperiour *Planets, ariſes from ſuch their Situation.*

8. Let then in *Fig.* 23, T ♁ repreſent the *Orbit* of the Earth, M ♂ the *Orbit* of (any ſuperiour Planet, particularly) *Mars*. 'Tis evident, that *Mars* will not appear to us always *accompanying the Sun,* (as do the inferious Planets, *Venus* and *Mercury*,) but will appear ſometimes as *diametrically oppoſite* to the Sun. For whereas the Earth goes round its *Orbit* ſooner, than *Mars* does his; 'tis obvious that the Earth will ſometimes be in the Middle between *Mars* and the Sun; for Inſtance, while *Mars* is at M, the Earth may be at .

The ſuperiour Planet Mars *appears ſometimes* Diametrically oppoſite *to the Sun.*

9. Further, ſuppoſing *Mars* to be in M, and the Earth to be in B, *Mars* will appear ſtationary, for the Reaſon aſſigned, *Sect.* 3, concerning the like *Phænomena* of *Venus*. As the Earth moves from B through C, D, E, F, G to H, *Mars* will appear to move forward among the fixed Stars; but with this Difference, that he will appear

The ſuperiour Planet Mars, *why appears ſometimes to* ſtand ſtill, *ſometimes to move* forward, *ſometimes* backward.

Chap. VI. appear to move quicker, when he is moſt remote from the Earth, and in Conjunction with the Sun, (*i. e.* when he and the Earth are ſo ſituated, as is repreſented *Fig.* 23, by ſuppoſing the Earth to be in D E F, and *Mars* in or about M,) and ſlower, when he is ſo ſituated with Reſpect to the Earth, as M is repreſented *Fig.* 23, to be ſituated with Reſpect to either of the two Segments of the Earth's *Orbit*, B C or G H. Whenever the Earth has ſuch a Situation to *Mars*, as H hath to M in *Fig.* 23, (which will at Length be, foraſmuch, as although *Mars* moves the mean Time round the Sun, the ſame Way as the Earth, or according to the Series of the Signs; yet the Earth moves faſter, and ſo will overtake *Mars*,) the Planet *Mars* will again appear to ſtand ſtill. And ſome ſhort Time after will appear to go backward, or contrary to the Series of the Signs. For the Earth, as it moves from H thro' A to B, having overtook and gone beyond *Mars*, will make *Mars* appear to us to move contrary to the Series of the Signs, or from ♋ towards ♊, *&c.* And in this Situation *Mars* appears

pears oppoſite to the Sun, and alſo greateſt, becauſe it is then neareſt to the Earth. Chap. VI.

10. *Jupiter and Saturn have the like fore-mentioned Phænomena with Mars.*

The like *Phænomena* happen to *Jupiter* and *Saturn*, ſave that the Retrogadations of *Saturn* are more frequent than thoſe of *Jupiter*, and of *Jupiter* than thoſe of *Mars*; foraſmuch as the Earth does oftner overtake *Saturn* than *Jupiter*, and *Jupiter* than *Mars*.

11. *None of the ſuperiour Planets can hide the Sun, but any of them may be hid by the Sun.*

'Tis obvious, that the *Orbit* of the Earth being nearer the Sun than the *Orbits* of the Superiour Planets, none of theſe can hide the Sun from the Earth. But on the contrary, any of them may be hid by the Sun, while the ſaid Planet is direct, if it be but near enough to a Node.

12. *Saturn and Jupiter, why appear always with a full Orb.*

Laſtly. *Saturn* and *Jupiter* appear not to us with ſeveral Phaſes, but always with a full Orb; foraſmuch as that Hemiſphere of each, which is toward the Sun, and ſo enlightened, is alſo always toward the Earth, the Earth being (comparatively) never far diſtant from the Sun, which is the Center of the *Orbits* of *Jupiter* and *Saturn*. For the Diſtance of *Jupiter* from the Sun is above five Times and

Chap. VI. and that of *Saturn* almoſt ten Times greater than that of the Earth from the Sun.

13. *Mars, why not appears ſo likewiſe.*

But it is not ſo as to *Mars*. For the Diſtance of *Mars* from the Sun being but (*) half as much again as the Diſtance of the Earth from the Sun, it follows that the Hemiſphere of *Mars*, which is towards the Sun, will not always (ſo much as ſenſibly appear to) be toward the Earth. In *Fig*. 24. let T be the Place of the Earth in its *Orbit* T ♉, and the Circle A B C D denote the *Orbit* of *Mars*, 'Tis evident, that *Mars* being in A or B, (that is, either in Conjunction with, or in Oppoſition to the Sun,) turns the ſame Face towards the Earth, as it does towards the Sun, and ſo ſhines with a Full Orb. But in C or D the enlightened Face or Hemiſphere of *Mars* is not at all ſeen; but *Mars* appears a little defective of Light, in that Part of it which is from the Sun, and ſo appears gibbous. And thus we have ſolved at leaſt the more remarkable *Phænomena*,

(*) That is, as 15. to 10.

both

Astronomy Plate 14.

Fig. 25.

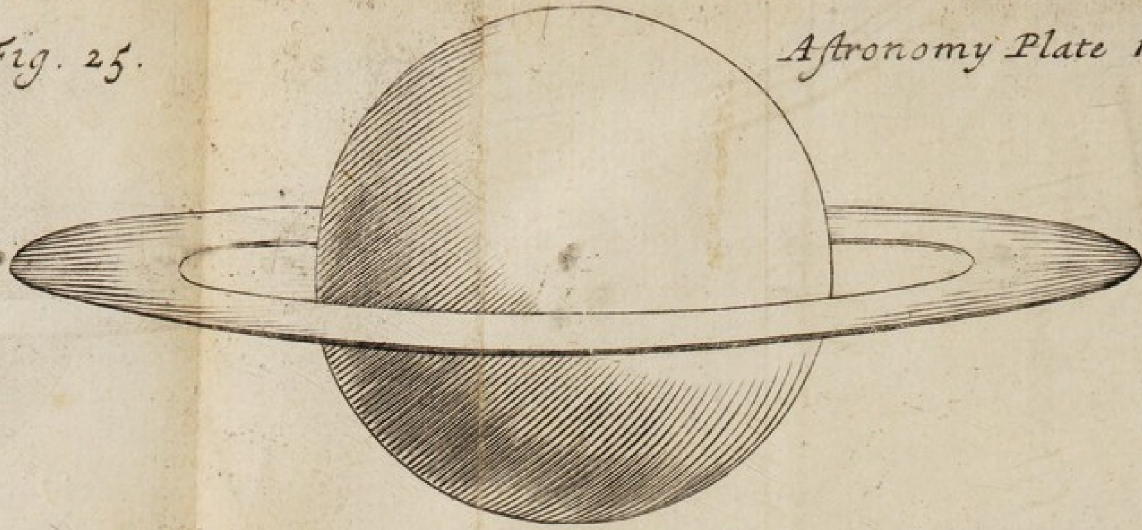


Fig. 26.

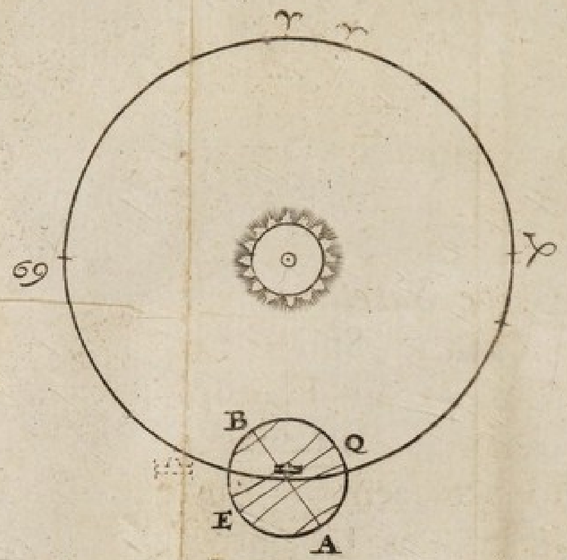
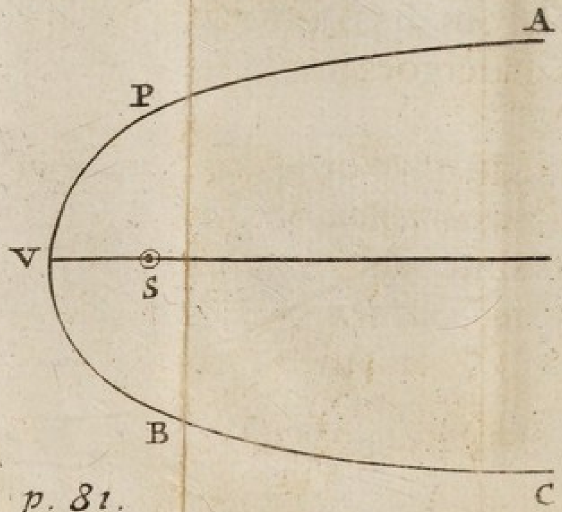


Fig. 27.



Place this facing p. 81.

both of the inferiour and ſuperiour *primary* Planets. Chap. VI.

It remains only to add ſomewhat concerning the *ſecondary* Planets, beſides what has been ſaid of them, *Chap.* 1. And the firſt Particular that deſerves Obſervation, is this, that the like *Phænomena* to thoſe which happen between the Earth and the Moon, happen between *Jupiter* and *Saturn*, and their reſpective *Satellites*; foraſmuch as the ſaid *Satellites* are no other than ſo many Moons in reſpect to their reſpective primary Planet. Hence, whenever either primary Planet ſo comes between the Sun, and any one of its reſpective *Satellites*, as to hinder the Rays of the Sun from falling upon it, it ſuffers an Eclipſe. And on the other hand, whenever any *Satelles* comes ſo between the Sun and its primary Planet, as to intercept the Sun's Rays from its Primary, the ſaid Primary undergoes an Eclipſe. 14. *The* Satellites *of* Jupiter *and* Saturn *undergo* Eclipſes, *&c.*

The ſecond Particular worthy of Obſervation is the *Phænomenon* of *Saturn*, which appears like an *Annulus* or Ring, encompaſſing *Saturn*, as is repreſented *Fig.* 25. From the vari- 15. *Of the* Annulus *or* Anſæ *of* Saturn.

G ous

Chap. VI. ous Poſition of this *Annulus* in reſpect of the Sun and the Obſerver, (it being opacous, like *Saturn* it ſelf,) ariſes the ſeveral Phaſes of (what they call) the *Anſæ* of *Saturn*, becauſe they appear like the two Handles of a Cup, or the like. And this is ſufficient to our preſent Deſign, concerning the inferiour and ſuperiour Planets, as alſo concerning the *Satellites* of *Jupiter* and *Saturn*.

CHAP.

CHAP. VII.

Of the PHÆNOMENA *of the fixed* STARS.

Chap. VII.

HAving ſhewn how the *Phænomena* of the Sun, and Moon, and planetary Stars may be ſolved, we are to proceed next to the Solution of the *Phænomena* of the *fixed Stars.* And theſe, not borrowing their Light from the Sun, but ſhining with their own native Light, are therefore not ſubject to any ſuch Deficiency of Light, as is called an Eclipſe.

1. *The* fixed Stars *not ſubject to* Eclipſes.

It is indeed obſerved of (*) ſome of the fixed Stars, that they do for a certain Period appear, and then diſappear. Which *Phænomena* is ſuppoſed to ariſe from the ſaid Stars having ſome *Maculæ* or Spots, which move round them in certain *Periodical* Times: as the Spots of our Sun are obſerved to move round it. Nay,

2. *Why ſome of them for a Time* appear, *and then* diſappear.

(*) Concerning ſuch fixed Stars, ſee Dr. *Gregory's Aſtron. Phyſ. and Geom. Elem. Lib.* 2. *Prop.* 30.

Chap. VII. it is thought, that theſe Spots do ſometimes grow ſo great, as to quite cover the Star to which they belong, and ſo to make it diſappear altogether; and that this is the Reaſon, that ſeveral fixed Stars obſerved by the Ancients, are now not to be ſeen. And this Opinion is countenanced by the Obſervations that have been made, that ſometimes a whole Year together our Sun has ſhone with a more faint Light than at other Times; this being ſuppoſed to be cauſed by the Spots of our Sun being for that Time grown greater than Ordinary.

3 *Of the different* Magnitude *of the fixed Stars.* As to the fixed Stars appearing of different *Magnitudes* or Bigneſs to us, this is aſcribed vulgarly to their being really ſome bigger than others. But the more learned in *Aſtronomy* refer this apparent Difference of Magnitude only to their different Diſtances from us. As this Difference of Diſtance is ſufficient ro make ſome appear bigger, ſome leſſer; ſo the Diſtance of the neareſt to us being vaſtly great, hence our Senſe of Viſion cannot diſcern the different Diſtances, and conſequently they appear to us as all placed in one and the

ſame

ſame concave Sphere. By Reaſon of their apparent different Magnitudes, they are uſually diſtinguiſhed into ſix Claſſes, being reſpectively called Stars of the *Firſt*, *Second*, &c. *Magnitude*. Chap. VII.

As to the Riſing, Setting, and Revolution of the fixed Stars round the Earth once in 24 Hours, it has been above obſerved, that theſe *Phænomena* may be ſolved by the diurnal Revolution of the Earth round its own *Axis*. But beſides this apparent diurnal Motion, from Eaſt to Weſt, the fixed Stars ſeem to have another Motion, whereby they ſeem to move very ſlowly from Weſt to Eaſt, or according to the Series of the Signs. This Motion is ſo very ſlow, that it is computed to require about 25 or 26 thouſand Years for the fixed Stars to ſeem carried thereby round the Heavens; whence it is ſtiled (†) *Annus Magnus*, or the *great Year*. 4. *The ſeeming* proper *Motion of the fixed Stars very ſlow*.

(†) It is alſo ſtiled *Annus Platonicus*, becauſe the Platoniſts teach, that every ſuch Period Things are reſtored to the ſame State and Condition, as they were ſo many Years afore.

Chap. VII.

5.
The proper Motion of the fixed Stars, not Real, but only Apparent; *and whence it arises.*

This Motion is commonly esteemed as the real proper Motion of the fixed Stars. But the more learned in *Astronomy* conceive the fixed Stars to have no such real Motion, as for other Reasons, so particularly for this, *viz.* because the said Motion of all the fixed Stars may be more simply, and compendiously solved, by the bare changing of the Places of the *Equinoctial* Points. For it comes to the same, whether we suppose the *Equinoctial* Points to be unmoveable, and the fixed Stars to move forward according to the Series of the Signs; or the fixed Stars to be unmoveable, and the *Equinoctial* Points to be moved backward, or contrary to the Series of the Signs. What has been said, is illustrated, *Fig.* 26, where ♈ ♋ ♎ ♑ represent the *Orbit* of the Earth about the Sun, A E B Q the Earth it self, ♈ and ♎ the two *Equinoctial* Points for any one Year. The Earth moving forward again from ♎ through ♑ towards ♈, the Plane of the Terrestrial *Equator* being produced, will pass through the Sun * at [♈,]

* *Note,* That these [♈] [♎] stand for the prick'd ♈ and ♎ in the Figure, the Types of which could not be had in Time.

before

before that the Center of the Earth Chap. VII. comes to ♈. And in like manner, the Earth moving forward from ♈ through ♋ to ♎, the Plane of her *Equator* being produced, will paſs through the Sun at [♎], before that the Center of the Earth comes to ♎. But the *Equinox* will be then, when the Sun is found in the Plane of the Terreſtrial *Equator*; and thoſe Points of the *Ecliptick* are rightly eſteemed the *Equinoctial* Points, wherein the Sun is ſeen at the two *Equinoxes*. Whereas, therefore, ♈ and ♎ were the *Equinoctial* Points the laſt Year, the next Year [♈] and [♎] will be the *Equinoctial* Points; and ſo the *Equinoctial* Points will go backwards, conſidered as to ſeveral Years. And by this Change of the *Equinoctial* Points, a fixed Star that keeps its Place at that Point of the *Ecliptick*, which is denoted by ♈, and where afore was the vernal *Equinoctial* Point, will now ſeem to be moved forward from the vernal *Equinoctial* Point to [♈] as much as the interval ♈ [♈.] Wherefore, this being the moſt Simple, and conſequently moſt natural Way of ſolving the *Phænomenon* we are ſpeaking of, it is generally embraced

Chap. VII. now a-days. And not only ſo, but it is alſo (*) mathematically demonſtrated, for what Reaſons the *Equinoctial* Points do thus move backward, or the *Equator* every Year croſſes the *Ecliptick* a little ſooner or forwarder than it did the laſt Year. Whence that which is commonly called the *proper Motion of the fixed Stars*, is now a-days ſtiled by the learned in *Aſtronomy*, the *Præceſſion* or *Anticipation of the Equinoctial Points*.

6. *The ſeveral* Conſtellations, *to which the more remarkaable fixed Stars are reduced.*

It remains only to ſet down the Conſtellations, whereto the more remarkable of the fixed Stars are reduced. It has been ſhewn already, what are the twelve Conſtellations or Signs, whereby are comprehended the fixed Stars that lie in the *Zodiack*. In reſpect of which, the other Conſtellations are diſtinguiſhed into northern or ſouthern. The northern Conſtellations firſt diſtinguiſhed by the Antients, are *the little Bear*, the *great Bear*, (or *Charles-wain*,) the *Dragon*, *Cepheus*, *Bootes*, the *northern Crown*, *Hercules*, the *Harp*, (or as it it is ſtiled

(*) See Dr. *Gregory*'s *Aſtron. Lib.* 1. *Prop.* 64.

by

by ſome, the *Vultur cadens*,) the *Swan*, *Caſſiopeia*, *Perſeus*, *Andromeda*, the *northern Triangle*, the *Charioteer*, the *great Horſe* or *Pegaſus*, the *little Horſe*, the *Dolphin*, the *Arrow*, the *Eagle*, *Serpentarius*, the *Serpent*. To theſe 21 northern Conſtellations were afterwards added the Conſtellations of *Antinous*, *Berenice*'s *Hair*, and (by us *Engliſh*) *Charles*'s *Heart*. The ſouthern Conſtellations known to the Antients are the *Whale*, *Eridanus*, the *Hare*, *Orion*, the *greater Dog*, the *leſſer Dog*, the *Ship*, the *Hydra*, the *Crater* or two-handed-Pot, the *Raven* or *Crow*, the *Centaur*, the *Wolf*, the *Altar*, the *ſouthern Crown*, the *ſouthern Fiſh*. To theſe 15 are not long ſince added 12 Conſtellations, made up of the fixed Stars about the ſouth Pole, and not viſible to us. *viz.* the *Phænix*, the *Crane*, the *Indian*, the *Peacock*, the *Apus*, the *ſouthern Triangle*, the *Fly*, the *Chamæleon*, the *flying Fiſh*, the *Toucan* or *American Gooſe*, the *Hydrus*, the *Dorado*, and the *Royal Oak*.

Chap. VII.

7. *Of the* milky Way.

Beſides theſe Conſtellations there appears in the Heavens a certain Tract, which goes quite round the Heavens, Chap. VII. Heavens, and from its appearing to be of a milky Whitenefs, is called *Via* (*) *Lactea*, or the *milky Way*. It is now, by the Help of Telefcopes, difcovered to be no other than an innumerable Multitude of little fixed Stars.

8. *Of the fixed Stars, called* Informes. Such fixed Stars as belong not to this Milky Way, nor to any of the Conftellations, are called *Informes*, as not being yet reduced to any *Form* or Image, as the Conftellations are. And fo much for the fixed Stars.

(*) It is for the like Reafon called *Galaxia* by the *Greeks*.

CHAP.

CHAP. VIII.

Of the PHÆNOMENA *of* COMETS.

Ch. VIII.

THere remains now only the *Phæ-nomena* of *Comets* to be ſolved, which are ſpoken of laſt, becauſe there are not yet ſuch Diſcoveries made, as afford the like Degree of Certainty in the Solution of the *Phænomena* of *Comets*, as there is in ſolving the *Phæ-nomena* of the other Celeſtial Lights; as alſo becauſe it is not known yet, whether Comets belong only to this our Solar Syſtem, or whether they may not alſo paſs into other of the Mundane Syſtems, which have the fixed Stars for their ſeveral reſpective Suns.

1. Comets, *why treated of in the laſt Place.*

It is ſuppoſed moſt probable by the Learned in *Aſtronomy*, that they move in ſome conick Section, which has the Sun in one of its Focus's. For this Sort of *Orbit* is found beſt to agree to the Obſervations that have been made concerning the Motion of Comets. Some indeed have formerly thought,

2. *Comets ſuppoſed to move in ſome co-*nick Section.

Ch. VIII. thought, that they move in right Lines; and ſome Calculations that have been made concerning their Motion, have agreed well enough to this Hypotheſis. But then it is to be noted, that this will hold the ſame, although Comets move in a conick Section, if ſo be the Obſervations be made in that Part of their *Orbits*, which comes very near to a right Line. Let A P V B C in *Fig.* 27, be a conick Section very eccentrical, and let one of its Focus's be S the Center of the Sun. It may be, that the Comet may be obſerved, whilſt it is moving along the Part A P of its *Orbit*; and the reſt of the Time, whilſt it moves from P through V B to C, it may be hid from us by the Rays of the Sun. Or the Comet may be ſo hid from us, whilſt it moves along A P V B, and may be then obſerved, when 'tis come to B, as it is about to deſcribe the Line B C. And in both theſe Caſes, the Line deſcribed by the Comet will not be ſenſibly different from a Right. Moreover, the Comet being obſerved in A P his Deſcent towards the Sun, and then drawing daily nearer to the Sun,

and

and after that lying hid for some Time under the Sun's Rays, and at Length getting again out of the Sun's Rays on the other Side of the Sun; hence it comes to pass, that one and the same Comet is looked upon to be two different Ones, which both move only in right Lines, *viz.* one in A P, the other in B C. Whereas in reality it may be all the while one and the same Comet, whose Trajectory (or Line, which it describes by its Motion) if considered together, both as to its Descent toward the Sun, and also as to its Ascent from the Sun, will hence be found to be no other than a conick Section, as was afore laid down. Ch. VIII.

3. *Comets supposed to move in that conick Section, which is called an* Ellipsis.

Of the three conick Sections, the *Ellipsis* is found most agreeable to the Motions (as of the Planets, so also) of Comets. And it can be no other, if Comets be Bodies of a lasting Substance as are the Planets, and like these have a Periodical Motion round the Sun. If Comets have not such a Periodical Motion, then their Trajectory is Parabolical, or Hyperbolical.

Some

Ch. VIII.

4. *The various Motions, &c. of Comets.* Some Comets move like the Planets, from Weſt to Eaſt; ſome from Eaſt to Weſt; others from North to South, and others laſtly from South to North. And their *Orbits* as to Greatneſs, Situation, and Inclination, as well in Reſpect to one another, as to the *Orbits* of the Planets, are various and different.

5. *Comets conſiſt of two Parts, an* Head *and* Tail. *Laſtly*, A Comet does viſibly conſiſt of two Parts, one called the *Head*, the other called the *Tail*. The Head is the Solid Body of the Comet, and is opacous, as appears from the Shadow it caſts. The Tail is conceived by the Learned to be no other than a thin Vapour ariſing from the Head by Heat. Namely, whilſt the Comet is deſcending to its *Perihelium*, thoſe Vapours which had afore ſettled on it, when it was in the Regions remoteſt from the Sun, being now rarefied by the Heat of the Sun do aſcend, *i. e.* fly off that Way which is from the Sun. Hence it comes to paſs, that the Tail of a Comet grows greater and greater, as the Comet approaches nearer and nearer to its *Perihelium*; and on the other hand, the Tail grows leſs and leſs, as the

Comet

Comet goes further and further from the Sun; and consequently the Tail is greatest and most shining, presently after the Comet has been most heated in its *Perihelium*. And thus it has been shewn, how the more remarkable *Phænomena* of the Celestial Bodies may be solved or explained according to the *Copernican* Hypothesis.

CHAP. IX.

Chap. IX. *A Description of the Celestial* (*and also Terrestrial* GLOBE.)

1. *The Celestial* Phænomena *are represented by* artificial Machines, *the chief whereof is the* Globe *or* Sphere.

IN the foregoing Chapters, the Celestial *Phænomena* have been treated of, as considered *in themselves*. I proceed now to treat of them, as they are represented by *artificial Instruments* and *Machines*, among which the chief is the *Sphere* or *Globe*.

2. *The import of the Words,* Sphere *and* Globe.

The Word *Sphere* we borrow from the *Greek* Language, as we do the Word *Globe* from the *Latin*; each Word, in its respective Language, answering one to the other, and denoting a round Body, that is, according to the Mathematical Definition thereof, a Body from whose inmost Point, called its Center, all right Lines drawn to its Surface are equal one to the other. But the Word *Sphere* is now a-days commonly used to denote a Machine somewhat different from a Globe, and more peculiarly

culiarly stiled an *Armillary Sphere*; forasmuch as it does not consist of a round continued Surface, but only of some Circles duly placed together, and fancied to resemble *Armillæ*, i. e. Bracelets. Chap. IX.

3. Spherical *and* Theorical *Astronomy, what, and why so called.*

The Sphere and Globe are made to represent principally such *Phænomena*, as arise from the Diurnal Motion. Whence that Part of *Astronomy*, which treats of the diurnal Motion, is frequently stiled (*) *Spherical Astronomy*, or the *Doctrine of the Sphere.* In like manner, the other Part of *Astronomy*, which treats of the annual and proper Motion, is stiled *Theorical Astronomy*, from the Schemes or (as it is said) little Paper Machines, formerly made to illustrate the (†) Theory of the said proper Motion, and thence called *Theoriæ*.

4. *The common* Celestial Globe, *how far useful in Astronomy.*

There are Spheres made agreeable to the *Copernican* Hypothesis, and others made agreeable to the vulgar

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(*) This makes the first Part in common Astronomical Treatises, and Theorical Astronomy the second Part.

(†) It is originally a *Greek* Word, denoting *Speculation* or *Contemplation.*

Chap. IX. or *Ptolemaick* Hypothesis. But the former Sort being very costly, and the latter Sort being not of so general Use (even in their own Way, or according to the *Ptolemaick* Hypothesis) as the Artificial Celestial Globe, hence this is most commonly made use of to illustrate to young Students the Celestial *Phænomena.* And when they have been once set right as to the true System of the World, and the true Causes of the said *Phænomena,* by having had the *Copernican* Hypothesis explained to them; then it is allowable for them to make Use of the common Celestial Globe, though it represents the Celestial *Phænomena,* not according to their *real Nature,* but only according to their *Appearances:* Forasmuch as it is convenient, not to say necessary, in common Discourse to talk of the celestial *Phænomena* according to the common Notions of them, *i. e.* according to their Appearance to our Senses, from which the Vulgar derive their Notions.

5\. *On Account of such its Usefulness, the Cele-*

On these Considerations, having in the eight foregoing Chapters of this Treatise explained the real Nature and Causes of the Celestial *Phænomena,* *na,* I ſhall in the remaining Part of this Treatiſe ſhew, how the ſaid *Phænomena* are repreſented by the Celeſtial Globe, as to their Appearance to our Senſe. And therefore I ſhall firſt (in this Chapter) deſcribe the artificial Celeſtial Globe, and then (in the following Chapter) ſhew the Uſe thereof. Chap. IX. *ſtial Globe is here treated of, and deſcribed.*

6. *Of the* Horizon *of the Celeſtial Globe;* Among the ſeveral Circles belonging to the celeſtial Globe, I ſhall begin with the *Horizon*; foraſmuch as the artificial *Horizon* is the outermoſt Circle of the artificial Globe, and that which encloſes and upholds all the reſt of the ſaid Globe.

7. *The* Horizon *two-fold,* Senſible *and* Rational. It has been (*) afore obſerved in ſhort that the *Horizon* is ſo called, as being that Circle which bounds the Sight. To which it is further to be added here, that the *Horizon* is diſtinguiſhed by *Aſtronomers* into the *ſenſible* and the *rational Horizon.*

8. *The* ſenſible Horizon, *what, and why ſo called.* For a right and clear Apprehenſion of the ſenſible *Horizon,* it muſt be called to Mind, that the Sight, if not hindered, extends it ſelf equally every Way.

(*) *Chap.* 2. *Sect.* 2.

Chap. IX. Hence (†) it comes to paſs, that, when we ſtand upon the Surface of the Earth, and the Eye has a free View all round, ſo much of the Heavens as is ſeen, appears to us under the Figure of a concave Spherical Surface, reaching to the Surface of the Earth. The ſeeming Interſection or Meeting of the Surface of the Earth with the fore-mentioned concave ſpherical Surface of the Heavens, being continued every Way round the Eye, repreſents a Circle, which is called (by a *Greek* Word) the *Horizon*, becauſe it *bounds* the Sight, and divides the ſeen Part of the Heavens from the unſeen; and it is particularly ſtiled the *ſenſible Horizon*, becauſe it does thus actually fall under our *Senſe* of Viſion, when the Eye has a (*) free View.

9. *The* rational Horizon, *what, and why ſo called.*

The *rational Horizon* is ſo called, becauſe it falls not under our Senſe of Viſion, but is only to be conceived by our *Reaſon*. For hereby is denoted that *Horizon*, which would bound the Sight ſuppoſing the Earth biſect-

(†) See this illuſtrated *Fig.* 1. of my Opticks.

(*) Hence it is obſervable, that every *Horizon* that actually bounds the Sight, is not properly the ſenſible *Horizon*.

ed,

ed, and one Half of it removed, and the Spectator placed on the Center of the Earth. What has been said of each *Horizon*, is illustrated *Fig.* 28, where the greater Circle denotes the Heavens; the little Circle, the Earth; the Line drawn through P, the sensible *Horizon*; the other Line the Rational. Whence is also evident, that the sensible *Horizon*, and its respective rational *Horizon*, are always parallel one to the other, and that their mutual Distance is the Semi-diameter of the Earth. Chap. IX.

10. *The Earth but as a* Point *in respect of the Sphere of the fixed Stars.*

Now the whole Earth being but *as a Point* in respect of that vastly Distant Sphere, wherein the fixed Stars seem to be all placed; hence the Distance between the rational and sensible *Horizon*, being no more than the Semi-diameter of the Earth, makes no sensible or considerable Difference as to the *Phænomena* of the fixed Stars.

11. *Of the* Parallax *of the Celestial Lights.*

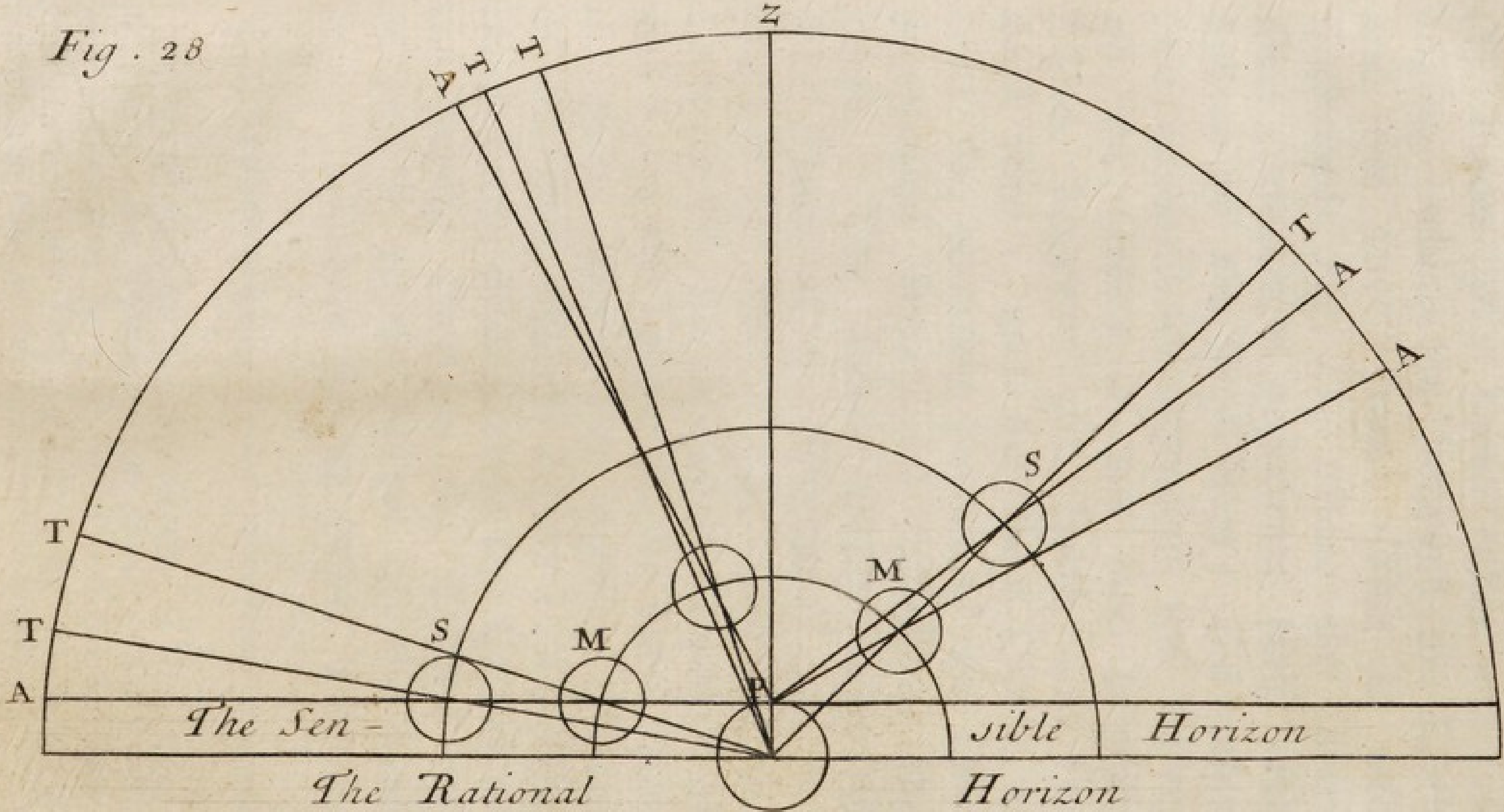
But the Distance between the rational and sensible *Horizon*, bears a considerable Proportion to the Distance of the other celestial Lights from the Earth, and consequently makes

Chap. IX. a considerable Difference as to the (*) Places of these other celestial Lights, which are between the Earth and the fixed Stars. This is also illustrated *Fig.* 28, where the outermost Semicircle represents Half the Sphere of the fixed Stars; the other two Semi-circles represent the Halves of the *Orbits* of any two celestial Lights between the Earth and the fixed Stars; and the little Circle about the common Center of the forementioned Semicircles represents the Earth. The Lines drawn from P (the Place of the Spectator) on the Surface of the Earth, through the Centers of the Celestial Lights M and S, to the Sphere of the fixed Stars, do there denote the *apparent* Places of the said celestial Lights; and the other Lines drawn from the Center of the Earth, through the Centers of M and S, to the Sphere of the fixed Stars, do there denote (what are cal-

(*) Here must be remembred what is said, *Chap.* 1. *Sect.* 15. viz. That that Point or Part of the Sphere of the fixed Stars, between which and the Spectator any other of the Celestial Lights appears to be, is counted the *Place* of the said Celestial Light.

led)

Fig. 28


Z
A
T
T
T
A
A
S
M
M
S
P
A
T
T
The Sen-
sible Horizon
The Rational
Horizon

led) the *true* Places of M and S. Chap. IX.
Whence may be learned, the Reaſon of thus taking Notice of the Rational *Horizon*, foraſmuch as *that* is eſteemed by *Aſtronomers*, the *true* Place of a *Phænomenon*, (where it would be ſeen to a Spectator placed on the Center of the Earth, *i. e.* where) it is with reſpect to the rational *Horizon*. Thus T is the true Place of M and S, A the apparent Place of each. The Difference between the true and apparent Place (which are always in the ſame vertical Circle) of any celeſtial Light or *Phænomenon*, is called its (*) *Parallax*.

Having

(*) It is a *Greek* Word ſignifying a *Variation* or *Difference*. It ſeeming too long a Digreſſion to inſert into the Body of this Chapter an Explication of the *Parallax*, and on the other hand the *Parallax* ſeeming a Particular too material to be only mentioned, I judged it beſt to adjoin here by way of Note, what ſeems requiſite to be ſaid of it. The *Parallax* then may be conſidered, either with Reſpect to different celeſtial Lights or the ſame. In the former Reſpect, the *Parallax* is greater or leſſer, as the Celeſtial Lights are leſs or more diſtant from the Earth. Thus *Fig.* 28, the *Parallax* T A of M, is greater than the *Parallax* T A of S. And hence the Moon has the greateſt *Parallax*, as being neareſt of all the Celeſtial

Chap. IX.

12. *The* Horizon *of the Globe represents principally the rational* Horizon.

Having shewn the Difference between the sensible and rational *Horizon*, and withal taken Notice, that it is the *rational Horizon*, which is principally regarded by *Astronomers*, it is next to be observed, that accordingly it is the *rational Horizon*, which is principally

---

Lights to the Earth. In respect of the same Celestial Light, its greatest *Parallax* is at the *Horizon*; and as the Celestial Light ascends higher and higher above the *Horizon*, so its *Parallax* continually decreases, till it quite ceases in the *Zenith* or Vertical Point. For there the two Lines which mark out the apparent and true Place, do fall in together, as is evident from *Fig.* 28. What more seems requisite to be here observed, is the Angle made by the meeting of the two Lines just mentioned in the Center of the Celestial Light, is called the *Parallactical Angle*, or the *Angle of the Parallax*, and by it the *Parallax* is measured; as also that the apparent Place is always *lower* or nearer to the *Horizon*, than the true Place. Whence the *Parallax* has a quite contrary Effect to *Refraction*; forasmuch as this causes a *Phænomenon* to appear *higher*, or more above the *Horizon* than really it is. Thus in *Fig.* 29, let T denote the Earth, surrounded with the Atmosphere AED; S some Star, and O the Spectator on the Surface of the Earth. Were there no Atmosphere, or were it of an equal Thickness with the *Æther*, the Rays of Light would come directly or in a right Line from S to O. But the Rays, when they have passed through the *Æther* SQ, entring at A into the Atmosphere, which is thicker than the *Æther*, hereby is refracted (*i. e.* as it were broken) and bent towards the right Line QP, which is perpendicular to the Surface of the Atmosphere

Astronomy Plate 16.

Fig. 29.

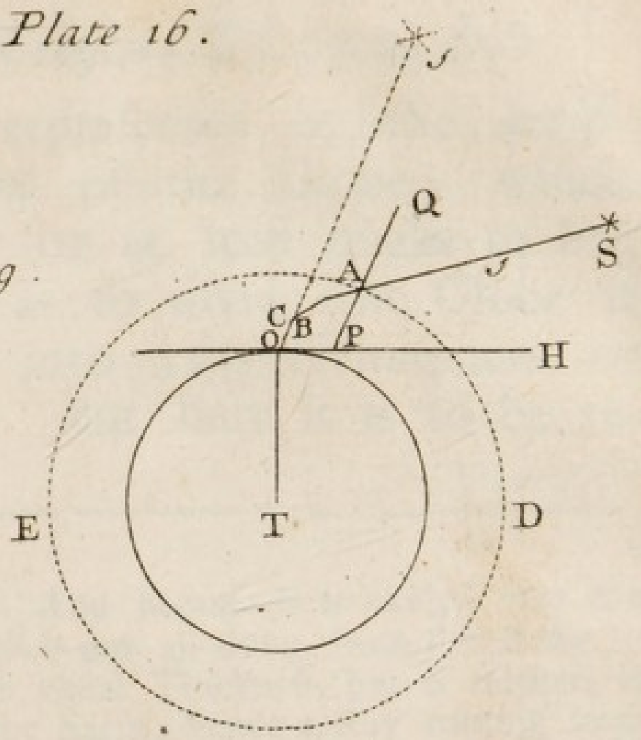
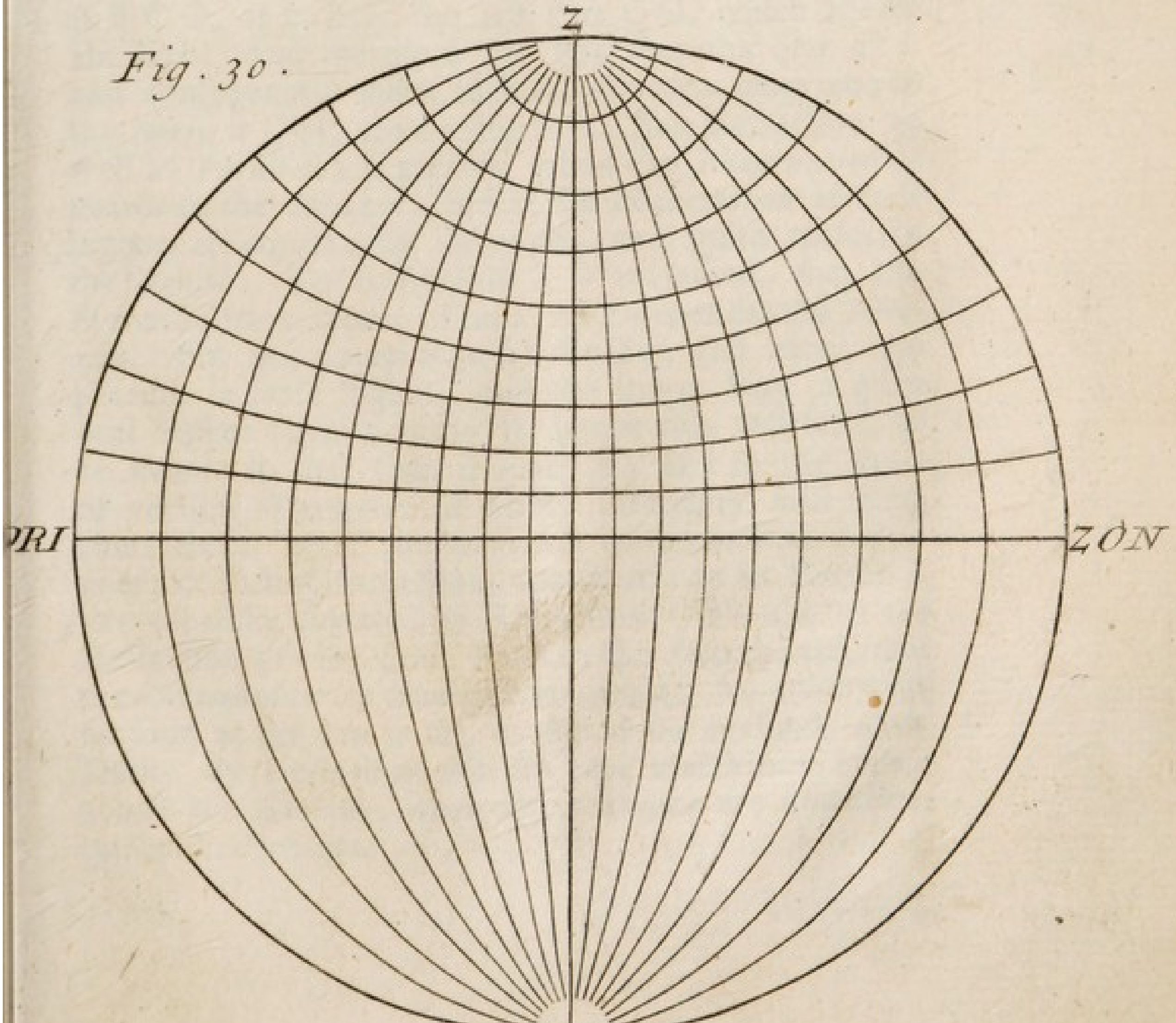


Fig. 30.



Place this facing p. 104

principally represented by the *artificial Horizon* of the Globe; which therefore is (or at least ought to be) so placed, as to divide the Globe it self exactly into two Hemisphers or equal Parts. But here it is to be re- Chap. IX.

---

mosphere at A. And because it is likely, that the Atmosphere it self is not all along, from the *Æther* to the Earth, of an equal Thickness, but is thicker, as it is nearer to the Earth; hence a Ray coming from the Star S will be refracted, not only at A, but also at other Points within the Atmosphere, (as at B, C, *&c.*) and at each of these Points will be refracted the same Way, *viz.* toward T. But of the Ray A B C O, it is only the last Part C O, which affects the Eye; and therefore the Eye sees the Star at *s.* and consequently much higher, or much more above the *Horizon* O H, than really it is. But Refraction (as well as *Parallax*) is greater, when the *Phænomenon* is nearer to the *Horizon*; and as the *Phænomenon* ascends higher, it continually decreases, and quite ceases in the *Zenith*. To Refraction it is attributed, that the Sun and Moon appear of an Oval Figure near the *Horizon*. For the upper Rim of the Sun and Moon appearing a little higher, and the lower Rim a great deal higher than it really is, hence this will seem to be nearer to that than it really is; and so the erect or vertical Diameter of either Luminary will seem contracted; while the tranverse or horizontal undergoes no such Contraction, forasmuch as its Extremities are alike elevated by Refraction. 'Tis also to the Refraction of the Sun's Rays to the Atmosphere, that the *Crepusculum* or *Twilight* is owing; for otherwise, as soon as the Sun is set, it would be presently quite Dark. By Refraction also the Sun and Moon appear above the *Horizon*, when their Bodies are somewhat under the *Horizon*.

marked,

Chap. IX. marked, that although the whole broad wooden Circle, which encompasses the rest of the Globe, may sometimes be called the *Horizon* of the Globe, yet properly and strictly it is only the inner Rim or Edge of the upper Surface of the said broad wooden Circle, that is the *Horizon* of the Globe, and (*) represents the true *Horizon*, whether Rational or Sensible.

13. *Of* Almicantars, *the* Zenith *and* Nadir.

For the Measuring of the Altitude or Depression of any *Phænomenon*, (i. e. its Distance above or below the *Horizon*,) Here are conceived Circles to run parallel to the *Horizon* through every Point of the Globe; which (as is illustrated *Fig.* 30,) grow less and less on each Side of the *Horizon*, as they are more remote from it, and at length End in two Points. One of these Points being always

(*) The *Horizon* (as is above observed) is that Circle, *i. e.* that circular Line, wherein the Surface of the Heavens and the Surface of the Earth intersect, or are conceived to intersect, one the other. But a circular Line has only a circular Length, no Breadth, nor Thickness. And therefore it is properly the inner Edge of the upper Surface of the broad wooden Circle, which is the artificial *Horizon* of the Globe.

over

over the Vertex, or Head of the Spectator, is therefore called the *vertical Point*, or by a single *Arabick* Word, the *Zenith*. The other Point, which is diametrically opposite to the former, is called by an *Arabick* Word, the *Nadir*. The *Zenith* is represented *Fig.* 30, by the Point Z, the *Nadir* by the Point N. The fore-mentioned parallel Circles between the *Horizon* and the *Zenith* or *Nadir*, are called from their Use, *Circles* or *Parallels of Altitude*, and by an *Arabick* Word, *Almicantars*.

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14. *Of* Azimuth's *or* Vertical *Circles*.

For denoting what Point of the *Horizon* any *Phænomenon* is in, or is at least to be referred to, there are conceived also Circles crossing every Point of the *Horizon* at right Angles, and all crossing one another in the *Zenith* and *Nadir*. And from their common Intersection being thus in the *Zenith* or vertical Point, they are stiled *vertical Circles*, or by an *Arabick* Word, *Azimuths*. These are also illustrated *Fig.* 30.

15. *Of the four* Cardinal *Points of the* Horizon.

Among the Points of the *Horizon* there are four, which are called the *Cardinal* (i. e. Principal) Points, and are distinguished by the Names of the *East*

Chap. IX. *East*, *West*, *North*, and *South* Points. The east and west Points of every *Horizon* are those, wherein the Sun rises and sets, when he is in the *Equinoctial.* The other two are each 90 Degrees distant from the former, one towards the north Pole, and thence called the north Point; the other toward the south Pole, and thence called the south Point.

16. *Of the* prime Vertical *and* Meridian.

Among the vertical Circles, those two are of special Note, which pass through the Cardinal Points of the *Horizon.* That which passes through the east and west Points is called the *prime* Vertical; the other which passes through the north and south Points is stiled the *Meridian,* because every Day, when the Sun comes to that Circle, it is then *Meridies* or Mid-day within that *Horizon.* When any celestial Light is risen, it ascends still higher and higher, till it comes to the *Meridian*; and as soon as it has crossed that, it begins to descend lower and lower. Hence, when it is at the *Meridian,* it is said to *culminate,* (i. e. to be at its *Culmen* or Top-height for that Day,) and such its

its greatest Height is therefore called its *meridian Altitude*. Chap. IX.

17. *The* upper *and* lower, eastern *and* western *Hemispheres, what.*

As the *Horizon* divides the World into an upper and lower (or visible and invisible) Hemisphere; so the *Meridian* divides the World into an eastern and western Hemisphere; the former being so called, because it is that wherein the celestial Lights do rise; the other, because it is that wherein they set.

18. *The* Meridian of the Globe, *what.*

Though the whole brass Circle, which is immediately upheld by the *Horizon* at its north and south Points, be frequently called in gross the *Meridian of the Globe*; yet properly and strictly speaking, the artificial *Meridian* is only the graduated Edge of the said brass Circle.

19. *Of the* Quadrant of Altitude.

The *Meridian* is the only vertical Circle which is distinctly represented on the Globe. As for all the rest, they are represented in Part by the *Quadrant of Altitude* respectively applied to the Body of the Globe, from the *Zenith* to the *Horizon*. It is a long narrow Strip of Brass, made thin, that it might be pliant to the Body of the Globe; and made to reach from the *Zenith* to the *Horizon*, so

Chap. IX. so much of it as is contained between the *Zenith* and *Horizon*, being divided into 90 Degrees, as being just equal to the fourth Part of the Circumference of the Globe; whence it takes the Name of the *Quadrant*, being peculiarly stiled the Quadrant of *Altitude*, from its Use in taking the Altitude of any Point of the Globe. And as the Strip of Brass so called does by its Length from the *Zenith* to the *Horizon*, represent the fourth Part of a vertical Circle; so being rightly fastned on Top at the *Zenith*, and then moved round the Body of the Globe, by such its Motion, the several Points thereof will represent the several Almicantars between the *Zenith* and *Horizon*.

20. *Of the* Axis, *and* Poles *of the World, in the artificial Globe.*

Within the brass Circle called the *Meridian* of the Globe, hangs the Body of the Globe, being upheld by two Iron (as it were) Pins fastened to the *Meridian*, the Body of the Globe being made to turn round upon these two Pins, which therefore represent the *two Poles of the Equator*, or (as they are otherwise called) *of the* (†)

(†) They are so called, because all the World, but the Earth, seems to turn round upon them.

World;

World; that by the little Bear on the Surface of the Globe, representing the Arctick or north Pole; and the other, the Antarctick or south Pole. The Piece of Iron passing through the Center of the Globe, and of which the two Irons Pins afore-mentioned are the Extremities, represents the *Axis of the World*.

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21

Of the Equator. Ecliptick, *two* Tropicks, *and polar Circles of the artificial Globe.*

From what has been above said, (*Chap. III. Sect.* 5.) it is obvious, that the *Equator* of the Celestial Globe is the great Circle, drawn on the Surface of the Globe in the very Middle between the two Poles already mentioned; as also, that the great Circle, which crosses obliquely the said *Equator*, is the *Ecliptick* of the Globe; and that the two lesser Circles, which the said *Ecliptick* touches at its greatest Declination (northward or southward) from the *Equator*, are the two *Tropicks* of the Globe; that on the north Side of the *Equator*, the *Tropick of Cancer*, that on the south Side, the *Tropick of Capricorn*; lastly, that the two lesser Circles drawn on the Surface of the Globe at the same Distance (*viz.* $23\frac{1}{2}$ Degrees) from each Pole of the *Equator*, as the *Tro-*

picks

Chap. XI. *picks* are from the *Equator* it ſelf, are the *polar Circles* of the Globe; that about the Arctick or north Pole, the *Arctick Circle*; that about the Antarctick or ſouth Pole, the *Antarctick Circle*.

22. *The* Equator *always* biſected *by the* Horizon. In reference to the *Equator*, it is here to be added, that whereas it has been afore in this Chapter, *Sect.* 15, obſerved, that the eaſt and weſt Points of any *Horizon* are thoſe, where the Sun riſes and ſets when he is in the *Equator*; and whereas alſo it is then equal Day and Night all over the World; it hence follows, that the artificial *Equator* in any due Poſition of the Globe, muſt cut the *Horizon* exactly in its eaſt and weſt Points; and there cut it ſo, as to be equally divided by the *Horizon* into two Parts, one Half being above the *Horizon*, the other below. And by theſe Particulars it may be further proved, whether a Globe is truly made.

23. *The Poſition of the* Equator *to the* Horizon *three-fold.* The Poſition of the *Equator* to the *Horizon*, is in general three-fold. For the *Equator* cuts the *Horizon*, either at *right* Angles, or at *oblique* Angles, or elſe it is *Parallel* to the *Horizon*.

Such

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Such as live under the celestial (or which is the same, upon the terrestrial) *Equator*, their *Horizon* is crossed by the *Equator*, and consequently by all its Parallels at right Angles; and hence these are said to live in a *right Sphere*. The Property of which Sphere is this, that it is therein equal Day and Night through the whole Year. For the *Equator* and all its Parallels being bisected by the *Horizon* in a right Sphere, (as may be shewn by putting the mechanical Globe into such a Position, *viz.* so as that the *Equator* of the Globe may move round under the *Zenith*,) and the Sun's diurnal Motion being always either in the *Equator*, or one of its Parallels; hence it follows, that the Sun (moving all the 24 Hours alike) must always make as long a Stay above, as below the *Horizon*, in a right Sphere; and consequently, that it must be there equal Day and Night through the whole Year. 24. *Of a right Sphere.*

Such as live on either Side the *Equator*, between it and its Poles, their *Horizons* do cross the *Equator*, and consequently its Parallels, at An- 25. *Of an oblique Sphere.*

Chap. IX. gles leſs or more oblique, according as they live leſs or more diſtant from the *Equator*. Hence theſe are ſaid to live in an *oblique* Sphere, and their *Horizons*, though they all biſect or *equally* divide the *Equator* it ſelf, yet do all leſs or more *unequally* divide its Parallels, according as the Parallels themſelves, and the Places to which the *Horizons* reſpectively belong, are leſs or more diſtant from the *Equator*. Wherefore, the diurnal Motion of the Sun, when it is not in the *Equator*, being in ſome one of its Parallels thus leſs or more unequally divided by the reſpective *Horizons*, it thence comes to paſs, that the Day and Night are leſs or more unequal at *the ſame time of the Year* (excepting the two *Equinoxes*) *in different Places*, according as the ſaid Places are leſs or more diſtant from the *Equator*; and alſo that the Day and Night are leſs or more unequal at *different Times of the Year* in the *ſame* Place, according as the Sun is leſs or more Diſtant from the *Equator*. All which is evidently to be ſhewn upon the Globe.

Laſtly,

Chap. IX.

26. *Of a parallel Sphere.*

Lastly, Under the very Poles of the *Equator*, or of the World, the *Horizon* and *Equator* run parallel one to the other, which Position is therefore called a *parallel Sphere*. The property of this Sphere is, that therein it is Day for Half the Year together, and Night for the other Half. For the *Equator* and *Horizon* being here Parallel, as long as the Sun stays on the same Side of the *Equator*, so long must it stay above the *Horizon* of that Pole, and consequently, so long together is it Day at the respective Pole, and Night at the opposite Pole. This is also evidently shewn upon the Globe, being placed so, as that its *Equator* and *Horizon* become parallel one to the other.

27. The Revolution of the Equator, *the Measure of* a Nuchthemeron, *or of 24 Hours.*

It remains to observe in reference to the *Equator*, that a Revolution thereof is the Measure of a (*) *Nuchthemeron*, or the Space of 24 Hours. Accordingly, whilst any Point of the artificial *Equator* moves

(*) It is a *Greek* Word signifying the Space of one *Day* and *Night* taken together.

Chap. IX. from the artificial *Meridian* round to the same Side of the said *Meridian* again; the Index, which is fastned to the north Pole of the Globe, will move quite round the Hour-circle fastened upon the *Meridian* about the said Pole. And by comparing the Motion of the *Equator* with that of the Hour-Index, it will sensibly appear, (if the Globe be made true) that as the whole Circumference of the Heavens, divided into 360 Parts, called Degrees, pass under the *Meridian* of any Place in a *Nucthemeron* or 24 Hours; so 15 Degrees of the Circumference of the Heavens pass under the same *Meridian* every Hour. For according to the Rule of Proportion, as 24 Hours, are to 360 Degrees, so 1 Hour, is to 15 Degrees.

28. *The* Zodiack, *why divided into* twelve *Signs, and each Sign into* thirty *Degrees.*

Proceed we next to observe in reference to the *Zodiack* or *Ecliptick*, that, the Reason, which induced the Old *Astronomers* to divide it into *twelve* Signs, is thought to be (*) prin-

(*) Some conceive the Reason to have been, because the Number *Twelve* has many aliquot Parts.

cipally

cipally this; *viz.* because the Moon goes twelve Times round the *Zodiack*, whilst the Sun goes once. And for the like Reason it seems to be, that, whereas one Revolution of the Sun round the *Zodiack*, is called the *Solar* Year, there are reckoned twelve Revolutions of the Moon round the *Zodiack* to make up the *Lunar* Year. *Lastly*, The Reason why each Sign of the *Zodiack* was distinguished into thirty Degrees, seems to be this, because the Moon always overtakes the Sun in (†) about thirty Days after she has left him. Chap. IX.

And because the Sun *graditur*, i. e. goes, in a Day and Night or 24 Hour's Space, near upon one of these thirty Parts of a Sign; hence the said Parts are thought to be stiled by the *Latins*, *Gradus*, and so by us, *Degrees*. And from the Circle of the *Zodiack*, or more particularly of the *Ecliptick*, came this Name to be transferred to the like Divisions of all, not only astronomical, but also other mathematical Circles. 29. Degrees, *whence so called.*

(†) See *Chap.* 4. *Sect.* 3.

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30. *How to find on the Globe, what* Sign *answers to each* Calendar Month.

Agreeably to the 12 Signs of the *Ecliptick*, the Solar year is also divided into twelve Months, called *Solar* Months; each being the Space wherein the Sun goes through a Sign, and so containing almost $30\frac{1}{2}$ Days. How these Solar Months strictly so called, answer to the common Calendar Months, or (which amounts to the same) what Degree of the *Ecliptick* the Sun is in each Day of the 12 Calendar Mouths, is to be seen on the upper Surface of the broad wooden Circle of the Globe commonly called its *Horizon;* for thereon the 12 Signs of the *Ecliptick*, and the 12 Calendar Months are so placed, both according to the *Julian* and *Gregorian* Account, as that the Days of these may duly answer to the respective Degrees of those.

31. *The Divisions of the* Zodiack *or* Ecliptick *are to be known, not by the* Constellations *or* Signs *them-*

In reference to the 12 Divisions of the *Ecliptick* on the Surface of the Body of the Globe, it is to be observed, that neither the Constellations themselves, nor their Names, but their Characters shew, which Division of the *Ecliptick* is esteemed respectively to belong to each Sign, or goes

goes under the Name of each Sign. Thus the Character ♈ is placed at the Beginning of that Diviſion, which is eſteemed to belong to *Aries*; and the ſaid Diviſion of 30 Degrees between ♈ and ♉, is that which is denoted by the Sign of *Aries*; whereas the Conſtellation ſo called, is now, great or moſt Part of it, out of that Diviſion; and the Word *Aries* is affix'd to the ſaid Conſtellation almoſt at the End of the ſaid Diviſion. So the Diviſion between ♊ and ♋, is that which is denoted by the Sign of *Gemini*, though the Conſtellation ſo called, is almoſt entirely out of that Diviſion, and conſequently, the Word *Gemini* affixed to the Conſtellation.

ſelves, but by their Characters.

The Reaſon hereof is this. The Conſtellations themſelves (*) continually (though very ſlowly) changing their Situation in the *Zodiack* or *Ecliptick*, in Conformity thereto, continually to change the Names of the ſeveral Diviſions, would create great 32.

And the Reaſon thereof.

(*) To what this Change of Situation is owing really, is obſerved, *Chap.* 7. *Sect.* 5.

Chap. IX. Confusion in *Astronomy*; forasmuch as it would make it an intricate Matter rightly to distinguish what Parts of the *Zodiack* belonged to the several Signs in different Ages of the World. Wherefore to avoid such Confusion, it has been with great Prudence judged Expedient, not to make any Change as to the Names of the Divisions, though the Constellations themselves do in Process of Time change their Places; but always to look on that which is esteemed the first Division of the *Zodiack* as belonging to *Aries*, at least to let it go always under the Name of *Aries*, (and so of the rest) though that Constellation it self (and so of the rest) have now so changed its Situation, as to be mostly, or in great Part out of its respective Division; and will in Process of Time be removed farther and farther from it.

33. *Of the twelve other Circles of the Globe*, viz.

Besides the Circles hitherto mentioned, there are usually drawn on the Surface of the celestial Globe, twelve other Circles; six whereof cross perpendicularly the *Ecliptick* between its Signs, the other six cross perpendicularly

larly the *Equator* at every like (*viz.* 30 Degrees) Distance, beginning to reckon from the first of *Aries*. Chap. IX

The six former are called Circles of *Latitude*, because that Arch of such a Circle, which is intercepted between any *Phænomenon* or Point of the Heavens and the *Ecliptick*, is the Measure of the said *Phænomenon*'s or Point's Latitude, *i. e.* Distance from the *Ecliptick* northward or southward. For the *Ecliptick* being the Circle in the Heavens of principal Regard, therefore, by it the Heavens are distinguished into two Hemispheres, one northern, the other southern. 34. *The six Circles of* Latitude.

By the same Circles is also measured the *Longitude* of any *Phænomenon* or Point in the Heavens. For by the Help of these Circles, any *Phænomenon* in the Heavens is referred to the *Ecliptick*, the said *Phænomenon* being understood to be in that Point of the *Ecliptick*, which is intersected by such a Circle passing through the said *Phænomenon*; and the Arch of the *Ecliptick* between the first of *Aries* and the said Point of Intersection, is the Measure of the said *Phænomenon*'s Longitude, 35. *Which are also Circles of* Longitude.

Chap. IX. Longitude, or Distance from the first of *Aries* reckoned according to the Series of the Signs.

36. *And six* Circles of Declination; *among which are the two* Colures.

By the six other Circles, any *Phænomenon* or Point in the Heavens is referred in like Manner to the *Equator*; and they are called Circles of *Declination*, because that Arch of such a Circle, which is intercepted between the said *Phænomenon* and *Equator*, is the Measure of its Declination, *i. e.* of its Distance from the *Equator*, northward or southward. Among these Circles, the two of chief Note are the two (*) *Colures*; one whereof crosses the two *Equinoctial* Points, and is therefore called the *Equinoctial* Colure; the other crosses the two *Solstitial* Points, and is therefore called the *Solstitial* Colure.

37. *The principal Circles of the Globe, usually reckoned* Ten, *and distinguished into six* greater, *and four* lesser *Circles.*

And thus we have described the several Circles, and more remarkable Points of the celestial Globe. It remains to observe, that of all the forementioned Circles, these are usually

(*) The Import and Reason of this Name is not well accounted for by any Writer of *Astronomy*, as I know of.

reckoned

reckoned the ten principal Circles of the Globe, *viz.* the *Horizon*, the *Meridian*, the *Equator*, the *Zodiack* or *Ecliptick*, the two *Colures*, the two *Tropicks*, and the two *Polar* Circles. And these are distinguished into *greater* and *lesser* Circles; the six former being greater Circles, as being concentrical with the Globe it self, and so dividing, each of them, the Globe into two Hemispheres or equal Parts; the four latter being lesser Circles, as being not concentrical with the Globe, and so dividing, each of them, the Globe into two unequal Parts. Chap. IX.

38. *Of the* terrestrial *Globe.*

All the ten Circles last mentioned, are usually drawn on the terrestrial Globe; as also Circles crossing perpendicularly the *Equator* at every ten Degrees, and other Circles running parallel to the *Equator* at every ten Degrees. The former are called Circles of *Longitude*, the latter Circles or Parallels of *Latitude*; forasmuch as those serve to shew the Longitude of Places, (*i. e.* their Distance from some one of the said Circles taken at Liberty, and commonly called the first

Chap. IX. first *Meridian*, all these Circles of Longitudes being also *Meridians* ;) these serving to shew the Latitude of Places, or their Distance from the *Equator*. Besides these Circles forementioned, there are also usually drawn on the Surface of the terrestrial Globe, *Rumbs*, i. e. Circles crossing one another in some certain Points of the Globe, where there is a Vacancy, and representing the several Winds, or 32 Points of the Compass, set down also on the outward Rim of the *Horizon*, both of the celestial and terrestrial Globe. But the main Difference between these two Globes, is this, that on the Surface of the celestial Globe are described the Constellations, and other fixed Stars in their due Situation : on the Surface of the Terrestrial Globe are described the several Parts of the Earth and Sea in their due Situation.

39. *An Observation concerning the Difference between the* natural Appear-

Proceed we now to the Use of the celestial Globe, or to shew how the diurnal *Phænomena* of the celestial Lights are represented thereby. For the clearer Apprehension whereof it seems requisite to observe, that there

is

ranges *of the celestial Lights, and the artificial Representation of them upon the celestial Globe.*

is this Difference in general between the natural Appearances of the celestial Lights, and the artificial Representation of them by the Globe, *viz.* that the said celestial Lights do naturally appear to us as in the *Concave* or inner Surface of the Heavens, whereas they are represented upon the *Convex* or outer Surface of the celestial Globe. Wherefore to make the artificial Representation to answer more exactly to the natural Appearance, either the Spectator must be conceived to be placed within the celestial Globe at its Center, and the Body of the Globe to be transparent like the Heavens, and in such a Position of the Eye, the celestial *Phænomena* on the Surface of the Globe will appear to the Eye in a concave Surface, as they do naturally; or else the Spectator is to be conceived as placed without the concave or inner Surface of the Heavens; and consequently as viewing, from somewhere above, the correspondent convex Surface of the Heavens; and upon such a Supposition, the celestial *Phænomena* would naturally appear to us in a

convex

Chap. IX. convex Surface, as they are represented by the Globe. Now we being placed upon the Convex, or outer Surface of the Earth, and the several Parts of the Earth and Sea being represented likewise on the convex Surface of the terrestrial Globe; therefore there is an exact Agreement in this Particular between the natural Position of the several Parts of the Earth and Sea, and their artificial Representation by the terrestrial Globe, without the Help of any such Fiction, as has been afore observed requisite, to adjust the natural Appearance of the celestial *Phænomena*, to their artificial Representation by the celestial Globe.

CHAP.

CHAP. X.

Of the more useful Problems solved by the Celestial GLOBE.

Chap. X.

PROBLEM I.

To find the Sun's PLACE *in the* ECLIPTICK *for any Day given,* v. g. *Oct.* 13. Old Style.

IN the *Julian* Calendar (placed next to the *Ecliptick*) on the *Horizontal* wooden Circle of the Globe find the Day given, to which adjoins the Degree of the *Ecliptick,* where the Sun is that Day. Thus to *Oct.* 13, adjoins the first Degree of *Scorpio,* the Sun's Place for that Day.

The Sun's Place being thus found by the *Ecliptick* on the *Horizon,* the same Degree of the *Ecliptick* on the Surface of the Globe is to be taken, in order to solve any of the following Problems.

PRO-

PROBLEM II.

To find the Sun's DECLINATION *at any Time given,* v. gr. *Oct.* 13. Old Style.

HAving (by *Problem* 1.) found the Degree of the *Ecliptick,* wherein the Sun is at the Time given, bring the ſaid Degree to the graduated Edge of the *Meridian* of the Globe; the Degrees of the ſaid *Meridian,* intercepted between the *Equator* and the Sun's Place, ſhews the Sun's Declination. Thus, *Oct.* 13. the Sun is in the eleventh Degree of the ſouthern Declination.

As in this, ſo in the following Problems, by bringing any Point of the Globe to the *Meridian,* is underſtood the bringing it to the *graduated Edge* of the *Meridian* of the Globe, as being that which repreſents the true *Meridian.*

In like manner, the *Latitude* of a Place is found upon the terreſtrial Globe, by bringing the Place to the graduated Edge of the *Meridian* and reckoning the Degrees of the *Meridian* between the Place and the *Equator.* For as the Diſtance of any Point in the Heavens from the *Equator* is *Aſtronomical Declination,* ſo the Diſtance of any Point on the Earth from the *Equator* is *Geographical Latitude.* Which is requiſite to be here known, foraſmuch as although the two foregoing Problems reſpect indifferently *all* Latitudes and Places, the following Problems reſpect only *particular* Places, the *Phænomena* relating thereto varying according to the different Latitude of Places.

PRO-

PROBLEM III.

To rectify the GLOBE *to any* Latitude *given.*

MOVE the respective Pole (*viz.* the north Pole, if the Latitude given be northern; the south Pole, if southern) above the *Horizon,* till there are so many Degrees of the *Meridian* between the said Pole and the *Horizon,* as answer to the Latitude given. Thus the north Pole being elevated 51 Degrees and an Half, the Globe is rectified for the Latitude of *London.*

PROBLEM IV.

To find what STARS *never rise, or never set in any Place or Latitude given.*

THE Globe being (by *Problem* 3.) rectifyed to the Latitude given, such Stars as go not under the *Horizon* of the Globe, during its whole Revolution, they never set in the Latitude given. And such Stars as rise not above the *Horizon* of the Globe, during its whole Revolution, they never rise in the Latitude given. Thus the little *Bear*, the *Dragon*, *Cepheus*, and *Cassiopeia*, never set in the Latitude of *London*; as also the great *Bear*, except the lower Part of its right Foot. On the other hand, the *Peacock*, the *Indian*, the *Toucan*, the *Hydrus*, the *Dorado*, the *Chamæleon*, the southern *Triangle*, the *Apus*, never rise in the Latitude of *London*.

PRO-

PROBLEM V.

To rectify the GLOBE, *ſo, as that it may be ready duly to* repreſent the diurnal PHÆNOMENA, *at any Place, and Time given,* v. gr. *at* London, *Oct.* 13. Old Style.

THE Globe being rectifyed (by *Problem* 3.) to the Latitude of the Place given, bring the Sun's Place in the *Ecliptick* for the Day given (found by *Problem* 1.) to the *Meridian*, and make the Hour-Index to point juſt to 12 on the Hour-Circle. The Globe in ſuch its Poſition will actually repreſent the Poſition of the Heavens, in Reſpect of the Place given, at the *Noon* or 12 a Clock of the Day given. And conſeqnently by the due Motion of the Globe, may be repreſented the Poſition of the Heavens, in Reſpect of the Place

Chap. X. given, at *any other Part* of the Day given.

Thus the north Pole being elevated $51\frac{1}{2}$ Degrees, which is the Latitude of *London*, and the first Degree of *Scorpio* (which is the Sun's Place, *Oct.* 13. Old Style,) being brought to the *Meridian*, the Globe will represent the Position of the Heavens in Respect of *London*, at Noon, *Oct.* 13. Old Style; that is, such Stars as are at or near the *Meridian* or *Horizon* (&c.) of the Globe, will then be respectively at or near the *Horizon* (&c.) of *London*. And consequently by the due Motion of the Globe, may be represented the Position of the Heavens in Respect of *London*, at any other Hour of the same Day; and thereby may be found the Time of the Sun's Rising or Setting, *&c.* that Day, as is shewn in the following Problems. Only it must be remembred, that in Order to solve such Problems, as relate to the Time of any such *Phænomenon*, the Hour-Index must always be put exactly to 12 on the Hour-Circle, before the Sun's Place be moved from the *Meri-*

dian;

dian; and also special Care must be taken, that the Hour-Index moves duly round with the Body of the Globe.

Chap. X.

PROBLEM VI.

To find the Time of the SUN's *Rising and Setting, and its Amplitude, at any Place or Time given.*

THE Globe being (by *Problem* 5.) duly ordered and prepared, turn the Globe, till the Degree of the *Ecliptick*, wherein the Sun is for the Day given, comes to the East-Side of the *Horizon*; the Hour-Index will then shew upon the Hour-Circle the Time of the Sun's Rising: and the Degrees of the *Horizon*, intercepted between the true east Point, and that Point of the *Horizon* the Sun's Place comes to, shew its Morning *Ampli-*

Chap. X. *tude*, this being the Distance of the Point of the *Horizon* where the Sun rises, from the true east Point of the *Horizon*. In like manner, the Degree of the *Ecliptick*, wherein the Sun is, being brought to the west Side of the *Horizon*, the Hour-Circle will shew the Time of the Sun's Setting; and the Degrees of the *Horizon*, intercepted between the true west Point, and that Point of the *Horizon* which the Sun's Place is brought to, shew its Evening *Amplitude*, or how far the Sun sets distant from the true west Point. Where it is to be noted, that the Sun sets so long before or after six in the Evening, as it rises after or before six in the Morning; and in like manner, the Sun sets so far distant (northward or southward, according to the respective Time of the Year) from the true west Point, as it rises from the true east Point.

Thus it will be found by the Globe, that at *London*, *Oct.* 13. the Sun rises much about 7, and sets much about 5 a Clock; as also, that its *Amplitude* is 18 Degrees, the Sun rising

riſing ſo many Degrees to the South of the true eaſt Point, and ſetting ſo many Degrees ſouth of the weſt Point.

The Time of the Sun's Setting, being doubled, will give the Length of the Day; and the Time of the Sun's Riſing, being doubled, will give the Length of the Night. Thus, *Oct.* 13. the Day in the Latitude of *London*, is much about ten Hours long; and the Night much about 14 Hours long.

PROBLEM VII.

To find the Time of the SUN'S *Riſing and Setting by its* Aſcenſional Difference.

THAT Degree of the *Equator*, which, reckoned from the Beginning of *Aries*, riſes or ſets with the

Chap. X. the Sun in a right Sphere, is called the Sun's *right Aſcenſion.* And that Degree of the *Equator,* which, reckoned in like manner, riſes or ſets with the Sun in an oblique Sphere, is called the Sun's *oblique Aſcenſion.* And the Difference between its right and oblique Aſcenſion, is called its *aſcenſional Difference.*

The oblique Aſcenſion of the Sun is found (the Globe being firſt rectified by *Problem* 5.) by bringing the Sun's Place to the Eaſt or Weſt Side of the *Horizon,* and there noting what Degree of the *Equator* comes to the ſame Side of the *Horizon,* together with the Sun. The right Aſcenſion of the Sun, is likewiſe found by (putting the Globe into a right Sphere, and then noting what Degree of the *Equator* comes together with the Sun to the ſame Side of the *Horizon*; or more readily and without changing the Globe from an oblique into a right Sphere, by) noting what Degree of the *Equator* comes up to the *Meridian,* together with the Sun: (for the *Equator* always cuts the *Meridian* at right Angles, as it does the

Horizon

Horizon in a right Sphere; and consequently, the ſame Degree of the *Equator*, that would come, together with the Sun, or any Degree of the *Ecliptick*, to the *Horizon* in a right Sphere, will come, together with the Sun, to the *Meridian* in any oblique Sphere.) The quantities of the right and oblique Aſcenſion being thus found, the aſcenſional Difference is found by ſubſtracting the leſſer out of the greater.

Now the right Aſcenſion of the Sun being that Degree of the *Equator*, which riſes and ſets with the Sun in a right Sphere, *i. e.* to ſuch as live juſt under the Celeſtial (or upon the Terreſtrial) *Equator*, to whom the Sun always riſes at ſix, and ſets at ſix; hence the aſcenſional Difference (turned into Time by reckoning one Hour for every 15 Degrees, and ſo proportionably) ſhews how long the Sun riſes and ſets afore or after ſix, according to the Time of the Year.

Thus

Thus the Sun's right Aſcenſion, *Oct.* 13. is much about 208; and his oblique Aſcenſion on that Day in Reſpect of *London,* is much about 223; and conſequently, the aſcenſional Difference is 15, which anſwers to one Hour in Time. Wherefore, the Time of the Year conſidered, the Sun riſes much about an Hour after ſix, *i. e.* much about ſeven; and ſets much about an Hour before ſix, *i. e.* much about five; agreeably to what was found by *Problem* 6.

PROBLEM VIII.

To find the SUN's Altitude *at any Place and Time given.*

THE Globe being rectifyed by *Problem* 5th, the Degrees of the *Meridian* reckoned from (the South Side of) the *Horizon* to the Sun's Place, give the Sun's *Meridian* Altitude.

tude. Thus, *Oct.* 13. the *Meridian* Altitude of the Sun at *London*, will be much about 27 Degrees.

The Altitude of the Sun is found at any other Time of the Day given, by turning the Globe (rectifyed also by *Problem* 5.) till the Hour-Index points to the Time assigned; and then fastening the Quadrant of Altitude on to the *Meridian* at the *Zenith*; (i. e. at so many Degrees from the *Equator*, as is the Latitude of the Place given;) and bringing the said Quadrant so fastened to the Sun's Place in the *Ecliptick*: the Degrees intercepted on the Quadrant between the Sun's Place and the *Horizon*, shew the Sun's Altitude at the Time assigned. Thus, *Oct.* 13. the Sun's Altitude at nine in the Morning, will be about 17 Degrees in Respect of the *Horizon* of *London*. And the same will be its Altitude at three in the Afternoon. For it is to be noted, that at Times equally distant (before and after) from 12, the Sun's Altitude is also equal.

PRO-

PPROBLEM IX.

To represent the Face or Appearance of the Heavens, or to shew the Situation of the fixed Stars, at any Time of the Night, in Respect of any Place and Night given.

THE Globe being rectified by *Problem* 5th, and (by the Needle) set so, as that its cardinal Points answer the cardinal Points of the Compass, turn the Globe till the Hour-Index points to the time of the Night assigned. Such Stars as appear at or near the *Meridian* or *Horizon* (and so of any intermediate Point) of the Globe, will appear likewise at or near the *Meridian* or *Horizon* of the Place given; (and so of any intermediate Point in the Heavens.)

Thus, *Oct.* 13. at Ten at Night, the glorious Constellation *Orion* will appear on the East Side of the *Horizon* of *London*; the Star *Rigel* in the left Knee of *Orion* being just at the *Horizon*; the three Stars in the same Constellation, called by our common People the *Yard*, a little above the *Horizon*. About twenty Degrees (on a vertical Circle) above the uppermost of these appears the bright Star in *Taurus*, called *Aldebaran*, and the *Bull's Eye*; and somewhat above this in the same Constellation, the Celebrated Stars called the *Hyades*, and the *Pleiades*, these being in the Back, those in the Forehead of *Taurus*. Just under the *Meridian* Southward appears the Star called *Andromeda*'s *Head*, and at or near the *Meridian* the Constellations of *Cassiopea*, *Cepheus*, *Pegasus*, &c. Between the *Meridian* and the West Side of the *Horizon* appears the Constellations of the *Swan*, *Harp*, &c. And at or near the West Side of the *Horizon*, the Constellations of *Antinous*, *Serpentarius*, the *northern Crown*, &c.

Hence

Hence it is obvious, that this Problem is of good Use to find out and know the several Constellations, and the more remarkable Stars in each Constellation.

PROBLEM X.

To find the Hour of the Night, the Altitude of any Star being given, or first found by some Instrument for that Purpose.

THE Globe being rectifyed according to *Problem* 5. and the Quadrant of *Altitude* duly fixed to the *Meridian*, move the Globe till the said Quadrant cross the Star in the given Altitude; then the Hour-Index will shew the Hour of the Night.

Thus,

Thus, *Oct.* 13. the Altitude of *Aldebaran*, or the Bull's Eye, is found to be 27 Degrees, 30 Minutes. Wherefore moving the Globe till the Quadrant of Altitude crosses the said Star in $27\frac{1}{2}$ Degrees of Altitude, the Hour-Index will then Point to Ten at Night.

Here it is obvious, that if the Star be in the *Meridian*, then there is Occasion only to turn the Globe (rectifyed by *Problem* 5.) till the said Star comes to the *Meridian* of the Globe : for then the Hour-Index will shew the Hour.

PRO-

PROBLEM XI.

To find the Beginning of the (Crepusculum, i. e.) *Twilight, or the Time of the Day-break, at any proper Time of the Year.*

THE Globe being (by *Problem* 5.) rectified, elevate that Degree of the *Ecliptick,* which is diametrically opposite to the Sun's Place at the Time given, 18 Degrees above the West Side of the *Horizon*; and the Hour-Index will shew the Time sought. Thus, *Oct.* 13. Day breaks, or the Twilight begins about a Quarter before five at *London.*

The Reason of elevating the Degree of the *Ecliptick,* diametrically opposite to the Sun's Place, 18 Degrees above the West Side of the *Horizon,* is this; because, thereby the Degree of the *Ecliptick* wherein the Sun is at the Time given, is depressed 18 Degrees below the East Side of the

the *Horizon*. At which Depreſſion it is obſerved by *Aſtronomers*, that the morning Twilight begins; as alſo, that the evening Twilight ends at the like Depreſſion of the Sun, under the weſt Side of the *Horizon*. Whence it is obvious, that the Beginning of the morning Twilight being found, it is obvious to know, when the evening Twilight ends; this ending ſo much after or before ſix in the Evening, as that begins before or after ſix in the Morning. Thus, *Oct.* 13. the evening Twilight ends about a Quarter after ſeven, at *London*, or any Place in the ſame Latitude.

It is to be further noted, that the morning Twilight beginning, when the Sun is 18 Degrees below the eaſt Side of the *Horizon*; and the evening Twilight ending, when the Sun is 18 Degrees below the weſt Side of the *Horizon*, it thence follows, that, during that Part of the Year, wherein the Sun's Depreſſion is never ſo much as 18 Degrees, there is no Beginning of the morning Twilight, or Ending of the evening Twilight, but one continued Twilight from Sun-ſetting

Chap. X. to Sun-rising. Now that Part of the Year, wherein there is such a continued Twilight in the Latitude of *London,* is while the Sun is passing from about the fifth Degree of *Gemini,* to the twentieth of *Cancer,* i. e. from about the 15th of *May,* to about the 7th of *July.* For during this Space, the Sun is never depressed 18 Degrees below the *Horizon.*

PROBLEM XII.

To find the Longitude *and* Latitude *of any Star given.*

LAY one End of the Quadrant of Altitude upon the proper Pole of the *Ecliptick,* (viz. if the Star be in the northern Hemisphere of the Heavens, upon the north Pole; otherwise, on the south Pole,) and the graduated Edge thereof upon the Center of the Star, so will the Quadrant cut the *Ecliptick* in the Star's *Longitude,*

Longitude, (i. e. its Diſtance from the firſt of *Aries*,) and the Degrees of the Quadrant intercepted at the ſame Time, between the Star, and the *Ecliptick*, will give its *Latitude*, this being no other than the Star's Diſtance from the *Ecliptick*. Thus the Longitude of the Star called *Lucida Lyræ*, will be found to be 283 Degrees and its Latitude about 60 Degrees Northwards.

It is obvious, that the Sun, being always in the *Ecliptick*, never hath any Latitude; and its Longitude is found without any more ado, than by computing the Number of the Degree it is in from the firſt of *Aries*. Thus, *Oct.* 13. the Sun is in the 190th Degree of *Longitude*, that being the Diſtance or Number of the firſt Degree of *Scorpio*, where the Sun then is, from the firſt of *Aries*.

There are ſome other Problems, which may be ſolved by the Globe; but they being of little Uſe are here omitted. And ſo we are come to the End of this Aſtronomical Treatiſe, Chap. X. wherein are contained ſuch Particulars, as ſeem more uſeful to be known by Young Students, eſpecially Young *Gentlemen*, at their firſt Inſtitution in *Aſtronomy*.

FINIS.

THE Young Gentleman's CHRONOLOGY,

Containing such

Chronological ELEMENTS, as are most useful and easy to be known.

BY

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THE

PREFACE.

THE *Art of* Chronology *has so close a Dependance upon* Astronomy, *that it is not unusual for Writers of Astronomical Treatises to comprise therein a great deal of what more properly belongs to* Chronology; *and which therefore I have here laid* *together, with the other most useful and easy Elements of* Chronology, *in a distinct Treatise from my* Astronomy. *But the Design both of the One and the Other being the same, as therefore I have given my Astronomical Treatise the Title of* The Young Gentleman's Astronomy, *so I have given this my Chronological Treatise the Title of* The Young Gentleman's Chronology: *nothing being herein insisted on, but what relates to the* common (Civil or Ecclesiastical) *Computation of Time, and to the two*

two Celebrated Era's *of the* Olympiads, *and the* Building *of* Rome, *the former chiefly used by* Greek *Historians, the latter by* Roman.

THE

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THE

THE
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CHAP. I. Chap. I.

Of a DAY; *and the Parts of Time arising from a Day by Division,* viz. Hours *and* Minutes.

BY (*) CHRONOLOGY is understood the Art or Skill of adjusting Things past to their proper Times. 1. Chronology, *what.*

Hence Chronological Institutions consist of the Explication of the seve- 2. *Distinguish'd into* two Parts.

(*) The Word *Chronology* denotes literally in the *Greek* Language a *Discourse* or *Account of Time,* being compounded of χρόνος *Time,* and λόγος a *Discourse* or *Account.*

ral

Chap. I. ral *Parts*, into which Time in general is divided; and of the ſeveral *Characters*, by which particular Times are diſtinguiſhed one from another.

3. *All other Parts of Time ariſe from a Day, either by* Diviſion, *or* Collection.

The ſeveral Parts of Time are, *Minutes*, *Hours*, *Days*, *Weeks*, *Months*, and *Years*. Amongſt which we ſhall ſpeak firſt of a Day, becauſe from it ariſe the other Parts of Time, conſidered as they are applied to common Uſe. For as Hours and Minutes ariſe from a Day by Diviſion and Subdiviſion; ſo Weeks, Months, and Years ariſe from a Day by Collection, or reckoning ſuch or ſuch a Number of Days together.

4. *A* Day, *what, primarily and properly.*

By a *Day* then, according to the primary (*) Intention of the Name, is denoted the Time of Light; and in this Senſe it is oppoſed to Night, or the Time of Darkneſs. And the Sun being made *to* (†) *rule the Day*, hence a Day, according to the primary Intention of the Name ſeems moſt properly and naturally to be determined

(*) *God called the Light Day; and the Darkneſs he called Night*, Gen. i. 5.

(†) *God made two great Lights; the greater Light to rule the Days*, Gen. i. 16.

by

by the Sun's Rising and Setting; and so to be most properly and naturally defined, the Stay of the Sun above the Horizon, or the Time between the Sun's Rising and Setting. Agreeably whereunto, Night is the Stay of the Sun below the Horizon, or the Time between the Sun's Setting and Rising. Chap. I.

5. *Another Acceptation of a Day for a* Nuchthemeron, *or* 24 *Hours.*

But the Word *Day* is frequently taken in a larger Sense, so as to comprehend also the Night, and to denote a whole Revolution of the Sun round the Earth. This Sort of Day is most aptly denoted by the *Greek* Word (*) *Nuchthemeron.*

6. *Different ways of computing the* Nuchthemeron.

The *Nuchthemeron* may be reckoned, either from Sun-setting to Sun-setting, as did the *Jews* and *Athenians*, and as the *Italians* still do; or from Sun-rising to Sun-rising, as did the *Babylonians*; or from Mid-day to Mid-day, as do the Generality of

(*) It is a compound of νὺξ *a Night*, and ἡμέρα *a Day*. The two-fold Acceptation of the Word *Day*, is distinguished usually by the Names of a *Natural* and an *Artificial* Day. But some calling that a natural Day, which others call an Artificial, hence arises great Confusion; to avoid which I judge it best, wholly to omit this Distinction.

Astrono-

Chap. I. Aſtronomers, and likewiſe the *Arabs*; or laſtly, from Mid-night to Mid-night, as did the old *Egyptians*, and *We* of this Iſland, together with the *French*, *Germans*, and other *Europeans* ſtill do.

7. *Of an* Hour. Proceed we now to the Part of Time, called an *Hour*. And hereby is principally denoted the 24th Part of a *Nuchthemeron*. Now a *Nuchthemeron* being the Space of an entire Revolution of the Sun about the Earth, during which the Equator makes alſo an (†) entire Revolution, hence it

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(†) In ſtrictneſs the Equator makes ſomewhat more than one Revolution, during a *Nuchthemeron*; viz. ſo much more as anſwers to the Sun's apparent proper Motion in the Ecliptick during the ſaid Space of Time. Now this Overplus being various, *viz.* 57 Minutes in the Sun's Apogee, and 61 Minutes in its Perigee, hence Aſtronomers take the Mean between the two fore-mentioned Numbers for a ſtanding Meaſure through the whole Year, and ſo compute that to every *Nuchthemeron* there anſwers $59'.\ 8''$, and almoſt $20'''$, over and above a Revolution (or the 360 Degrees) of the Equator. But now the Difference between the Sun's Revolution (or a *Nuchthemeron*) and the Equator's, when at greateſt, being but 61 Minutes, or a little more than a Degree, which anſwers but to a little more than 4 Minutes in Time, hence it may be paſſed over unregarded in common Uſe; and the Hour here ſpoken of may be well enough eſteemed to anſwer juſt to 15 Degrees of the Equator.

comes

Chap. I.

comes to paſs, that as the whole Circle or all the 360 Degrees of the Equator anſwer to a whole *Nuctthemeron*, ſo a 24th Part or 15 Degrees of the Equator anſwer to a 24th Part of a *Nuchthemeron*, or ſuch an Hour. And becauſe theſe Hours are all thus uſually meaſured by 15 Degrees of the Equator, hence they are all looked on as *Equal* one to another at all Times.

8. *Of* Temporary *or* unequal *Hours.*

But the *Jews*, *Greeks*, and *Romans* did antiently divide (not the *Nuchthemeron* into 24 equal Hours, but) the Day, whether longer or ſhorter, into 12 Hours; and ſo likewiſe the Night. Whence it is obvious, that their Hours were *Unequal* one to another, except only at the two (*) Equinoxes; when the Day and Night being Equal, their Hours would likewiſe be Equal, and ſo the ſame as to Extent with our Hours, though not as to Denomination.

(*) Hence the equal Hours uſed by us are ſometimes ſtiled *Equinoctial* Hours; and the unequal Hours uſed by the *Jews*, &c. are ſtiled *Temporary* Hours, from their varying in Length according to the other various Parts of the Year.

Chap. I.

9. *How the* unequal *Hours answer to our common* equal *Hours. Which Observation is of use for understanding the* Bible-History.

For they always reckoning their first Hour of the Day from the Sun's Rising, which at the Equinoxes answers exactly to our six a Clock in the Morning, it follows that their first Hour of the Day must answer at the Equinoxes to our seven a Clock in the Morning; and consequently their third Hour to our nine a Clock in the Morning; their sixth to our twelve a Clock at Noon; their ninth to our three a Clock in the Afternoon, *&c.* And although there is not so exact a Correspondence between the Hours used by them and us, at other Times of the Year, yet the fore-mentioned Observation is of good Use for the better Understanding the several Hours of the Day mentioned in the Sacred History.

10. *As is also the* Jewish *Division of the* Night *into* Watches, *&c.*

Upon the like Account it is not to be here omitted, that the *Jews* divided the Night (not only into twelve Hours, as is afore observed; but also) into four Quarters, called *Watches*, each Watch containing three of their Night-hours. These Watches were distinguished, either by their numeral Order, whence we expressly read in the

Chap. I.

the Sacred Hiſtory of the (*) *Second, Third,* and (†) *Fourth* Watch; or by ſome other Denomination. Thus the firſt Watch is otherwiſe ſtiled the (‡) *Head or Beginning of the Watches*; the Second, the (*) *Middle* Watch, becauſe it laſted till Mid-night; and the Fourth, the (†) *Morning* Watch. Again, the Firſt was termed (‡) the *Evening*; the Second, *Mid-night*; the Third, the *Cock-crowing*; the Fourth, the *Dawning*.

II. *Of* Minutes, *and* Seconds; *and the Difference between* Horary *and* Graduary *Minutes.*

The common Diviſion of an Hour is into *Quarters*. But Aſtronomers, and ſuch as are more accurate in accounting Time, divide an Hour into ſixty Parts, called *Minutes*; and a Minute again into ſixty Parts, called *Seconds*, as being Minutes of Minutes, and ſo ſecondary Minutes. And here it is to be obſerved, that the Word *Minute* is taken in a double Senſe, either to denote the ſixtieth Part of an Hour, which therefore is peculiarly ſtiled an *Horary Minute*; or elſe to denote the ſixtieth Part of a Degree,

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(*) *Luk.* xii. 38. (†) *Matt.* xiv. 25. (‡) *Lam.* ii. 19. (*) *Judg.* vii. 19. (†) *Exod.* xiv. 24. (‡) *Mark* . 35.

Chap. I. which therefore may be diſtinguiſhed by the Name of a *Graduary* Minute. And this *Graduary* Minute is ſubdivided by Aſtronomers into ſixty *Seconds*, and alſo each Second into ſixty *Thirds*, and each Third into ſixty *Fourths*, &c. whereas it is uſual to ſubdivide an *Horary* Minute only into Seconds. Now as 15 Degrees of the Equator anſwer to one Hour or ſixty *Horary* Minutes, ſo one Degree of the Equator or ſixty *Graduary* Minutes anſwer to four *Horary* Minutes; and ſo one *Horary* Minute to fifteen *Graduary* Minutes. And thus much for the ſeveral Parts of Time, which ariſe from a Day by Diviſion, and Subdiviſion.

CHAP.

CHAP. II.

Of the ſeveral Parts of Time, which ariſe from a Day by Collection; viz. WEEKS, MONTHS, *and* YEARS.

1. *Of a* Week *properly ſo called.*

AMong the ſeveral Parts of Time, which ariſe from a Day by Collection, it is proper to ſpeak firſt of the *Week,* not only as denoting the ſmalleſt Collection of Days, namely, no more than ſeven; but alſo as being the moſt Antient Collection, as we learn from the Sacred Hiſtory, whereby we are taught that it was inſtituted preſently after the Creation, and in Memory of God's creating the World in ſix Days, *and reſting on the Seventh from all his Works, which he had made.*

2. *The ſeven Days of the Week,* whence *take their* common Denominations.

The ſeven Days of the Week are commonly diſtinguiſhed by the Name of the Planets, accounted alſo juſt ſeven according to the Vulgar Syſtem, and placed in this Order from the Higheſt to the Loweſt, *viz. Saturn,* Chap. II. *Jupiter*, *Mars*, the *Sun*, *Venus*, *Mercury*, and the *Moon*. Now the Aſtrologers ſuppoſing the fore-mentioned Planets to preſide or rule over the ſeveral Hours of the *Nuchthemeron* according to their Order above-mentioned, hence denominate each Day of the Week from that Planet, which is ſuppoſed to preſide over the firſt Hour of the *Nuchthemeron*. Whence it comes to paſs, that the Days are denominated from the Planets according to the common Method. For aſſigning the firſt Hour of *Saturday* to *Saturn*, the ſecond will fall to *Jupiter*, the third to *Mars*, the fourth to the *Sun*, the fifth to *Venus*, the ſixth to *Mercury*, and the ſeventh to the *Moon*. And ſo the eighth Hour will fall to *Saturn* again, and alſo the fifteenth and twenty-ſecond of the ſaid *Nuchthemeron*; and conſequently, the twenty-third Hour will fall to *Jupiter*, the twenty-fourth to *Mars*. By which means the firſt Hour of the next *Nuchthemeron* will fall to the *Sun*, and the firſt Hour of the next to the *Moon*, of the next to *Mars*, of the next to *Mercury*, of the next to *Jupiter*, of the next to *Venus*; and of the next to *Saturn*

turn again, and ſo through the next Week as afore. Hence the Days of the Week came to be diſtinguiſhed in their Order by the *Latin* Names of *Dies Saturni*, *Solis*, *Lunæ*, *Martis*, *Mercurii*, *Jovis*, and *Veneris*; and ſo among us by the Names of *Saturday*, *Sunday*, *Munday*, *Tueſday*, *Wedneſday*, *Thurſday*, and *Friday*. For as *Saturday*, *Sunday*, and *Munday*, plainly denote the Day of *Saturn*, the *Sun*, and the *Moon*; ſo *Tueſday*, *Wedneſday*, *Thurſday*, and *Friday*, denote the Day of *Tuiſco*, *Woden*, *Thor*, and *Friga*; which are the *Saxon* Names reſpectively anſwering to *Mars*, *Mercury*, *Jupiter*, and *Venus*.

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3. *The Days of the Week how denominated by the* Antient Chriſtians.

It is alſo not to be omitted, that, becauſe the *Eaſter* Week was formerly eſteemed the Firſt or Principal Week of the Year; and each Day thereof was a *Feria* or *Holy-Day*; hence the ſeveral Days of the Week were diſtinguiſhed in their reſpective Order, among the Primitive Chriſtians, by the Names of *feria Prima*, *Secunda*, &c. *i. e.* the *Firſt*, *Second*, (&c.) *Holy-Day*: *Sunday*, or *the feria Prima* being otherwiſe ſtiled by them *the Lord's*

Chap. II. *Day*, as being the Day of our Lord's Reſurrection.

4. *A Week ſemetimes taken to denote the Space of* ſeven Years.

Hitherto we have ſpoken of a Week in its common Acceptation, as it denotes *a Week of Days*, or *ſeven Days*. But it is not wholly to be paſt by, that as the Original or *Hebrew* Word which we render a Week, does literally denote only in general a *Collection of Seven*, and therefore may be applied to Years as well as Days, (and the ſame holds as to the correſpondent (*) *Greek* and *Latin* Words,) ſo it is actually uſed in (†) ſome Places of the Sacred Hiſtory to denote, not *ſeven Days*, but *ſeven Years*. And in Conformity to the Uſe of the ſaid Original Word, our *Engliſh* Word *Week* is uſed in the ſaid Places of Sacred Scripture to denote, not *a Week of Days*, but a *Week of Years*, or a Collection of ſeven Years.

5. *A Synodical Month, primarily called a* Month.

Proceed we next to ſpeak of *Months*, which, as they are of various Sorts, ſo are called by this one common Name, not by mere Chance, or without any Reaſon, but by Reaſon of

(*) Hebdomas *and* Septimana. (†) *So* Dan. ix. 24---27.

their

Chap. II.

their all agreeing in ſome Relation to a Month primarily ſo called. Now the (*) *Hebrew* Word, to which our Word *Month* anſwers, does literally import the Time from one *New* Moon to another; and ſo does properly denote a *Synodical Month.* And foraſmuch as this ſort of Month is moſt diſtinguiſhable by our Senſe, and ſo moſt obvious and proper to be uſed as a Meaſure of Time in the common Affairs of Life; hence it is more than probable, that, as our Word *Month* is evidently derived from the Word *Moon,* ſo it was primarily intended to denote likewiſe the Time from one New Moon to another, or a *Synodical Month.* For it is more than probable, that this Word in our Language (and ſo of the correſpondent Words in all other Languages) was firſt uſed to denote that Sort of Month, which was firſt obſerved as a Meaſure of Time. But now it is not reaſonably to be

(*) The *Hebrew* Word *Chodeſh* (is derived from a *Radix,* which ſignifies to *Renew,* and accordingly) does primarily denote the *New Moon,* or the *Day of the New Moon*; and thence it is ſecondarily taken to denote a *Month,* being the Space from one New Moon to another.

doubted

Chap. II. doubted, but the Synodical Month was first used as a Measure of Time, forasmuch as it is obvious to the bare Sense, even of the Vulgar and most illiterate Persons.

5. *The Periodical Month, why called a* Month.

As for the *Periodical Month*, or the Time wherein the Moon goes round her *Orbit*, this could not be determined without some Observation and Study; and therefore no doubt was not taken Notice of, till sometime after the Synodical Month was used. And consequently it is not to be doubted, but the Name *Month* was applied to the Time of the Moon's Periodical Course, not primarily, but secondarily, or after it had for some Time been applied to the Moon's Synodical Course. And the Reason of imposing the same Name upon the Time of that, as had been imposed afore upon the Time of this, was, because both Times agree in the general, *viz.* as they relate to the Course of the Moon, and so may both from the *Moon* be called *Months*.

6. *Of the different Lengths of the* Syno-

It has been afore (in the Astronomical Treatise, *Chap.* 4. *Sect.* 2, 3.) observed, that the Periodical Month consists of 27 Days and 7 $\frac{3}{4}$ Hours; and

and the Synodical Month of 29 Days and 12 $\frac{3}{4}$ Hours. And the Reaſon of this Difference has been there accounted for.

dical *and* Periodical *Month.*

7. A Solar *Month, what, and why called a* Month.

It is here to be further noted, that, becauſe during (either a Synodical or Periodical) Month of the Moon, the Sun paſſes well-nigh through a whole Sign of the Ecliptick; hence the Time of the Sun's paſſing quite through a Sign is called a *Solar* Month, as nearly anſwering to the Space of a *Lunar* Month, eſpecially the Synodical Month. For as this Sort of *Lunar* Month is a little above 29 $\frac{1}{2}$ Days, ſo the fore-mentioned *Solar* Month is almoſt 30 $\frac{1}{2}$ Days: and conſequently the Difference between them is but about one Day.

8. Civil *Months, what, and why called* Months.

But now becauſe the fore-mentioned *Solar* and *Lunar* Months do not conſiſt juſt of whole Days, but of ſome odd Hours and Minutes over, which cannot be conſidered in the common Account of Time; therefore ſome certain Number of juſt whole Days are made uſe of inſtead of the fore-mentioned Aſtronomical Months; but however are called likewiſe *Months*, foraſmuch as they come as near as can be

Chap. II. be to the ſaid *Aſtronomical* Months, from which they are diſtinguiſhed by the Name of *Civil* Months, as being adapted to Civil or Common Uſe.

9. *A* Month of Weeks, *what.* Thus in the firſt Place, what is moſt commonly called a Month among us, is made to conſiſt juſt of twenty-eight whole Days, and ſo juſt of four whole Weeks; whence it is peculiarly ſtiled *a Month of Weeks*. It is obvious, that in Order to render the Computation of Time from Weeks to Months more eaſy, and ſo more fit for common Uſe, it was neceſſary that the Month ſhould conſiſt juſt of ſome certain Number of whole Weeks: which being thus neceſſary, four whole Weeks were made Choice of for the Number, which ſhould conſtitute the Month; becauſe this Number comes nearer than any other Number of Weeks, to the ſeveral Aſtronomical Months afore-mentioned.

10. *The* Civil *Synodical Month, what.* The Aſtronomical Synodical Month is adapted to Civil or Common Uſe, by making the Civil Synodical Month to conſiſt alternately of (*) twenty-

(*) A Civil Synodical Month conſiſting of thirty Days, is called *Plenus*, i. e. a Full Month; and a Civil Synodical Month conſiſting but of twenty-nine Days, is called *Cavus*, i. e. an *Hollow* or *Defective* Month.

nine

nine and thirty whole Days; for 29 + 30 = 59 = $29\frac{1}{2} \times 2$, that is, two Civil Synodical Months are equal to two Aſtronomical Synodical Months, omitting in both the odd Minutes. And conſequently, according to this Method, the New Moon will keep to the firſt Day of every ſuch Civil Month for a long time together, when once adjuſted thereto. This was the Month in Civil or Common Uſe among the *Jews*, *Greeks*, and *Romans*, till the Time of *Julius Cæſar*, and is ſtill ſo among the *Turks*. Chap. II.

In like manner, the Aſtronomical Solar Month may be adapted to common Uſe, by making the Civil Solar Months to conſiſt alternately of thirty and thirty-one Days, excepting one Month of the twelve, which ſhould conſiſt of thirty Days every four Years; the other three Years it muſt conſiſt only of twenty-nine Days. This is illuſtrated by the adjoining Scheme or Table of the Solar Months. 11. *The Solar Months might be* uniformly *adapted to Civil or Common Uſe.*

Months

Chap. II.

Months.	Days.	Months.	Days.	Months.	Days.
March	31	*Quintilis*	31	*November*	31
April	30	*Sextilis*	30	*December*	30
May	31	*September*	31	*January*	31
June	30	*October*	30	*February*	29
				And every fourth Year,	30

For according to this regular and uniform Method, there will be 365 Days in the twelve Solar Months for three Years together, and every fourth Year 366 Days, juſt as it is now.

12. *The Solar Months how came to be inſtituted, as* in Uſe among us.

It is evident then, that the Civil Solar Months might be thus uniformly conſtituted. And indeed they were ſo conſtituted in the main at firſt by *Julius Cæſar*, who brought the Solar Months into common Uſe among the *Romans*, whereas they uſed afore the Civil Lunar Month, as was (†) obſerved when we were ſpeaking of the ſaid Lunar Month. The Alteration was made afterwards, when (as the fifth Month, which had afore been called from its Rank, *Quintilis*, was new named *Julius* in Honour of the Emperor of that Name; ſo) the ſixth Month, which had afore been called

(†) *Sect. 10th. of this Chapter.*

from

from its Rank, *Sextilis*, was new named *Augustus* in Memory likewise of the Emperor of the same name; and not only so, but (whereas this Month consisted afore but of thirty Days, and so was a Day shorter than the foregoing Month of *July*,) there was a Day more added to it, that so the Honour paid to *Augustus* might not seem to fall short of the Honour paid to *Julius*, even in this Punctilio. Now this Alteration being made as to the Month of *August*, it (according to the alternate Method at first instituted, and still preserved in the following Months) made an Alteration in all the following Months, except *January*, which upon this Alteration should have had but thirty Days according to the alternate Method primarily instituted. But this Month being so named in Honour of *Janus*, esteemed by the *Romans*, the God of Time, on the like Consideration that it seem'd proper to lengthen the Month of *August* by a Day, it might seem not proper to lessen the Month of *January* by a Day, but rather to continue it still thirty-one Days long, and to make *February*, which afore was twenty-nine, Chap. II.

Chap. II. nine, and every fourth Year thirty Days long, to be commonly but twenty-eight, and every fourth Year but twenty-nine Days long. And ſo the Solar Months came to ſtand, as they do now in our *Calendar*, (whence they are called the *Calendar* Months) in reference to the Names and Number of Days aſſigned to each, ſet down in ſhort in the following Table.

Months.	Days.	Months.	Days.	Months.	Days.
March	31	*July*	31	*November*	30
April	30	*Auguſt*	31	*December*	31
May	31	*September*	30	*January*	31
June	30	*October*	31	*February*	28
				But every fourth Year,	29

By comparing this and the foregoing Table, will be illuſtrated whatever has been here ſaid, either concerning the firſt Inſtitution of the Solar Months among the ***Romans*** by *Julius Cæſar*; or concerning the Changes that have been ſince introduced. And alſo it will appear, that the whole Number of Days, contained in the twelve Solar Months taken together, hath been all along the ſame, *viz.* 365 Days, and every fourth Year 366 Days. The former of which Sums is the

the Time, wherein the Sun ſeems to pass through the twelve Signs, (†) omitting the odd Hours and Minutes, and the latter Sum is the Time, wherein the Sun ſeems to paſs through the twelve Signs, adding thereto the odd Hours and Minutes which were omitted the three foregoing Years, and ſo many Minutes more as make the ſaid odd Hours and Minutes equal to a whole Day in four Years.

Chap. II.

13. *A* Twelve-Month, *how Equivalent to a Year.*

Now as theſe twelve Solar or Calendar Months make up the Civil Solar Year in uſe among us (in which Senſe it is, that a *Twelve-Month* is uſed by us as an Equivalent Term to a *Year*) ſo what has been ſaid concerning the Sums of 365 and 366 Days being contained in the twelve Calendar Months taken together, will be more particularly explained, when we come preſently to ſpeak of the Civil Year in uſe among us; after that we have made ſome ſhort Obſervations concerning the Year in general.

(†) See *Sect.* 16. *of this Chapter.*

Chap. II,

14. *A* Year, *what, in general. It is properly taken to denote a* Solar *Year.* By a (†) *Year* then (the only Part of Time remaining to be treated of) is denoted in general a Revolution of a Celestial Light round the Heavens by (what is esteemed) its proper Motion. Thus an entire (apparent) Revolution of the fixed Stars is stiled the *Great Year*; and the Time wherein *Saturn, Jupiter,* and *Mars,* go round their *Orbits,* is respectively stiled the Year of *Saturn, Jupiter,* and *Mars*; and accordingly the Time of the Moons going round her *Orbit,* commonly called her Periodical Month, is sometime stiled her Year. But by a Year is principally and properly denoted the Time, wherein the Sun appears to move round the Ecliptick, which is 365 Days, 5 Hours, and very near $49\frac{1}{2}$ Minutes.

15. *A* Lunar *Year, what.* Now because during the Time of one *Solar* Year, there are twelve Synodical Months; hence twelve Syno-

(†) As the *Latin* Word *Annus* primarily denotes a Circle (whence *Annulus* signifies a Ring) and is thence taken to denote a Year, as being a Circle of Time, which being once gone round is begun again; so the *Greek* Word ἐνιαυτὸς, and the *Hebrew* Word *Shanah* is of the like Importance.

dical

dical Months constitute (what is called a *Lunar* Year; which therefore consists of 354 Days, 8 Hours, and a little more than 48 Minutes. So that the exact Difference between the Astronomical Solar and Lunar Year is 10 Days, 21 Hours, and 1 Minute.

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But whereas the Hours and Minutes above the whole Days of a Solar Year, can't be taken Notice of in Civil or Common Use; therefore the Civil Solar Year in use among us, is made to consist only of 365 Days for three Years together, and every fourth Year of 266 Days. Namely, whereas in an Astronomical Solar Year there are, above the whole Days, 5 Hours, and very near $49\frac{1}{2}$ Minutes; there are added every Year about 11 Minutes, to make up this just six Hours; and these six Hours amount just to a whole Day in four Years. 16.

The Astronomical *Solar Year, how adapted to* Civil *or Common Use.*

Each of the three Years consisting only of 365 Days, is called a *Common* Year; and every fourth Year consisting of 366 Days, is called a *Bissextile* or *Leap-Year*. The Reason of its being called *Bissextile* is, because the Day arising in four Years out of the six Hours afore-mentioned, is this 17.

A Bissextile *or* Leap-Year, *why so called.*

Chap. II. Year *intercalated*, i. e. inserted into the Calendar, by reckoning (according to the *Roman* Way, *bis sextum Kal. Martii*, i. e. by reckoning) *twice the sixth* Day before the Calends of *March*, which answers to our twenty-fourth of *February*. But although we took our Civil Solar Year from the *Romans*, yet we do not imitate them in this particular, but instead of reckoning *February* the twenty-fourth twice, we reckon this Year twenty-nine Days in *February*, whereas in common Years we reckon but twenty-eight. But although we reckon not *February* twenty-fourth twice, yet we reckon twice the Calendar Letter always belonging to *February* the twenty-fourth; namely *f*. And by this means, that which was the *Sunday* Letter from *January* the first to *February* twenty-fourth, will be so no longer, but the Letter next before it in the Order of the Alphabet, will be the *Sunday* Letter for the remaining Part of the Year. From which *Leap* or Change from one *Sunday* Letter to another, this Year came to have the Name of *Leap Year* amongst us.

It

Chap. II.

18. *The Civil Solar Year too long by eleven Minutes; and of the* Gregorian Reformation *of the Calendar caused thereby.*

It has been afore obſerved, that the Aſtronomical or true Solar Year does conſiſt of 365 Days, 5 Hours, $49\frac{1}{2}$ Minutes. Whereas to adapt it to Civil Uſe, the Solar Year is conceived to conſiſt of 365 Days, and juſt ſix Hours; (which ſix Hours in four Years make up juſt another whole Day;) ſo that the Civil Solar Year is about eleven Minutes longer than the true Solar Year. Hence it comes to paſs, that the Seaſons, or (which comes to the ſame) the Equinoxes and Solſtices, depending on the true Solar Year, do not keep always to the ſame Time or Part of our Civil or Common Year, but vary every Year about eleven Minutes, (*viz.* $10'$, and $48''$,) and conſequently about a whole Day in 133 Years. Wherefore from A. D. 325, when the famous *Nicene Council* was held, to A. D. 1582, wherein Pope *Gregory* the XIII. reformed the Calendar, there was found to have aroſe a Variation of ten Days; the Vernal Equinox, which at the Time of the *Nicene Council* fell about the 21ſt of *March*, in A. D. 1582, being found to fall on *March* the 11th. Hereupon the forementioned *Pope*, Chap. II. intending to bring back the Equinox to the Time of the Year it fell upon at the *Nicene Council,* ordered *October 5th,* (in the Year 1582.) to be reckoned *October 15th,* thereby suppressing ten Days, and making the following *March 11th* to be reckoned *March 21st*; and so the Vernal Equinox, which otherwise would have been reckoned to fall on *March 11th,* to fall on *March 21st,* as at the Time of the *Nicene Council.* And that the like Variation might not happen again, the said *Pope* ordered, that once in 133 Years a Day should be taken out of the Calendar; or (which comes to the same) that three Days should be taken out every four Hundred Years, after this Method, *viz.* whereas, according to the Account afore (and still by us) used, *every* Hundredth Year from the Nativity of our Saviour is a *Leap-Year*; from thenceforth only every *four* Hundredth Year should be a *Leap-Year*; and the other Hundred Years should be common Years.

19. Old-Style *and* New Style, *what.* As the Account afore in use, is thence called the *Old Style*; as also the *Julian Account* or *Julian Year,* from *Julius Cæsar,* by whose Authority

ty it was firſt introduced among the *Romans*, forty-ſix Years before Chriſt, according to the Common Account by the Years of our Lord: So this Form of the Civil Solar Year introduced by the forementioned Pope *Gregory*, is from him called the *Gregorian Account*; as alſo from its being (comparatively with the former) newly introduced, the *New-Style*. And this is uſed in *Italy*, *France*, *Spain*, and where-ever the *Pope*'s Authority is acknowledged; and as it had been received from the firſt by the *Popiſh* Countries of *Germany*, ſo towards the End of the laſt Century it was received alſo by many of the *Reformed* People of *Germany*, as to their Civil or Common Account of Time. For as to their Eccleſiaſtical Account, or finding the (*Eaſtern Moon*, or) Time of *Eaſter*, theſe do or did till (*) very lately follow the *Rudolphine Tables* of *Kepler*. The *Old-Style* is ſtill uſed by *Us* of this Iſland, as alſo in *Ireland*, and by ſome others.

Although the Calends or Firſt of *January* is now-adays, almoſt thorough- 20.

Of the various Beginnings of the Civil Solar Year in various Countries.

(*) The Publick News-Papers have in general given Account of ſome Reformation or Alteration made lately in this Reſpect by the Proteſtants in *Germany*.

Chap. II. out all *Europe*, commonly looked on as the Beginning of the Year, whether *Julian* or *Gregorian*; yet there are ſome, who reckon the Beginning of it from ſome other Part of the Year. Thus the *Venetians*, *Florentines*, and *Piſans* in *Italy*, and the Inhabitants of *Triers* or *Treves* in *Germany*, reckon the Beginning of the Year from the Vernal Equinox. The Church of *England*, in Conformity to the Antient Uſage of the Chriſtian Church, reckons her Eccleſiaſtical Year from the Feaſt of the Annunciation, commonly called by us *Lady-Day*. And our Civil Year, according to our Law, takes alſo its Beginning from the ſame Day; though the common People, and others among us in Matters not requiring the Nicety of a Legal Date, reckon the Beginning of our Year from the firſt of *January*.

21. *The* Aſtronomical *Lunar Year, how adapted to* Civil *Uſe*; *and firſt of the* Wandring *Lunar Year*.

It has been afore obſerved, that the Lunar Year, ſtrictly or according to Aſtronomical exactneſs, conſiſts of 354 Days, 8 Hours, and a little more than 48 Minutes. But to adapt this alſo to Civil Uſe, the Civil Lunar Year is eſteemed to conſiſt only of 354 whole Days. So that the Difference between

between the Civil Lunar Year of 354 Days, and the Civil Solar Year of 365 Days, is an eleven Days; the former being ſo much ſhorter than the latter. Hence it comes to paſs, that ſuch as uſe the Civil Lunar Year, without any regard to the aforeſaid Difference, their Year, ſuppoſing it to begin now in Spring, will after eight Years Time begin in Winter; and after eight Years more in Autumn, and ſo after that in Summer; and laſtly, after about thirty three Years in all, will begin in Spring again. Hence it is called *Annus Lunaris Vagus*, or the *Wandring Lunar Year*; becauſe its Beginning thus *wanders* through the ſeveral Seaſons, and that in the Memory of Man. And this is the Sort of Year uſed by the *Turks*. Chap. II.

22. *Of the* fixed *Lunar, or* Luna Solar *Year.*

Others, though they uſed or uſe the Civil Lunar Year, yet remedy the fore-mentioned Inconveniency of its thus changing the Time of its Beginning, by having Regard to the fore-mentioned Difference of eleven Days, between the Civil Solar and Lunar Year; namely, by intercalating ſo many Months, as the ſaid Difference of

Chap. II. of eleven Days ariſe to in ſuch a number of Years. By which means the Lunar and Solar Year are kept ſo adjuſted one to the other, as that the Beginning of the Lunar Year will keep in a manner fixed to the ſame Part of the Solar Year. Hence this Sort of Year is called the *fixed* Lunar Year; as alſo the *Luni-Solar* Year; and it is uſed by the *Jews*, and the Church of *Rome* in her Eccleſiaſtical Account. And thus much for the ſeveral *Parts*, into which Time in general is diſtinguiſhed.

CHAP.

CHAP. III.

Of the ſeveral CHARACTERS *of Time in general; and particularly of the* CYCLE of the MOON, *and the* EPACTS.

PRoceed we now to ſpeak of the ſeveral *Characters*, whereby particular Times are diſtinguiſhed one from the other. And theſe are either *Natural* or *Inſtituted* by Men. 1. *The Characters of Time two-fold.*

The Natural Characters of Time are ſuch as depend on Natural Cauſes, and are theſe; *viz. New Moons, Full Moons, Eclipſes,* either of the Sun (as they are commonly call'd) or Moon, the two *Equinoxes,* the two *Solſtices,* the *Cycle of the Moon,* and the *Epacts* of the Moon. All which have been ſufficiently ſpoken of in the foregoing Treatiſe of Aſtronomy, except the *Cycle* and *Epacts* of the Moon; which are therefore to be here explained. 2. *The Natural Characters of Time, what.*

The

Chap, III.

3. *Of the* Cycle of the Moon. The *Cycle* of the Moon then is to be esteem'd a (†) Natural Character of Time, because it depends on a Natural Cause, *viz.* the Motion of the Moon: which is such, that, after nineteen Years very nearly, the New Moons and Full Moons are observed to fall on the same *Nuchthemeron* of the *Julian* Year, as they did nineteen Years afore. Hence this Cycle is otherwise termed the *Cycle of nineteen Years.*

4. *Of the* Golden Number, *or* Prime. The New Moons being observed to fall out thus, they were wont formerly to calculate or find out the Time of the New Moons (without the Help of Astronomical Tables) after this manner. They observed, on what Day of each Calendar Month the New Moon fell, in each Year of this Cycle; and to the said Days they set respectively the Number of the said Year. Thus observing, that the New Moons, in the first Year of this Cycle, fell on *January* 23*d*, *February* 21*st*, *March* 23*d*,

(†) Some esteem this, not a *Natural*, but an *Instituted* Character of Time. But not so properly, since it depends on a *Natural* Cause.

&c.

&c. they ſet the Number 1 to the ſaid Chap. III.
Days. And in the like manner, obſerving that, in the ſecond Year of this Cycle, the New Moons fell on *January 12th*, *February 10th*, *March 12th*, &c. to the ſaid Days they ſet the Number 2. And after this Method they went through all the nineteen Years of this Cycle ; as may be ſeen (*) in the Calendar adjoining to the End of this Chronological Treatiſe. The Numbers thus ſet to the Days whereon the New Moons fell in each Year, are called the *Golden Numbers*, either becauſe they were formerly wont to be writ in Gold, or elſe becauſe of their Golden or great Uſe. Any one of theſe Golden Numbers is otherwiſe called the (†) *Prime*, becauſe the ſaid Numbers were placed in the Prime or Firſt Column of the Calendar, as they ſtill are in our Church Calendar, and in the Calendar adjoining to this Treatiſe : Or elſe

(*) As alſo in the Calendar of the Common Prayer-Book.

(†) It is called by this Name in the Directions belonging to the *Table for finding Eaſter for ever* in the Common-Prayer-Book.

becauſe

Chap. III. becauſe each Golden Number denotes *Luna Prima*, or the Firſt Day of the New Moon, according to which way of ſpeaking the Full Moon is frequently ſtyl'd *Luna Quartadecima*, as falling on the Fourteenth day after the New Moon incluſively. The Golden Numbers being thus placed, it was eaſy to find, what Day of any Month in any Year given the New Moon will fall upon, it being known to what Year of the Moon's Cycle the Year given anſwered. Thus ſuppoſe, A. D. 354, to be the Year given, which anſwers to the 13*th* year of the Moon's Cycle; and ſuppoſe it be enquired, what day of *March* the New Moon fell upon that Year, I look for the Number 13 in the Month of *March*, and find it ſet to the 11*th* Day; whereby is ſhewn, that the New Moon fell that Year on that Day of *March*.

5. *How to find the* New Moons *at preſent by the Golden Number.*

And by this Method the New Moons could be found with Accuracy enough at the Time of the *Nicene Council*, foraſmuch as the Golden Number did then ſhew the Day (*i. e.* the *Nuchthemeron*) within which the New Moon fell out. And hereupon

is

is founded the *Rule* of the *Nicene Council* for finding *Easter*, of which more in Chapter 7*th*. It is here to be obſerved, that the Golden Numbers do not now ſhew the Days, whereon the New Moons fall. For the Cycle of the Moon is leſs than nineteen *Julian* Years, by 1 Hour, 27 Minutes, and almoſt 32 Seconds. Whence it comes to paſs, that, although the New Moons fall again upon the ſame *Days*, as they did nineteen Years afore, yet they fall not on the ſame *Hour* of the Day or *Nuchthemeron*; but 1 Hour, 27 Minutes, and almoſt 32″ Sooner. And this Difference ariſing in about 312 years to a whole Day, hence the New Moons after every 312 Years fall a whole Day (*i. e. Nuchthemeron*) ſooner. Upon this Score the New Moons fall now four Days ſooner, than they did at the Time of the *Nicene Council*. Which being obſerved, the Day (*i. e.* the *Nuchthemeron*, though not the Hour of it) on which the New Moons fall, may be now found by the Golden Number. For Inſtance, I would know on what Day of *January* the New Moon will fall next Year, *viz.*

1712.

Chap. III. 1712. This, by the Rule delivered in the following Paragraph, will be found to be the third year of the Moon's Cycle. I look therefore for the Golden Number 3, and find it (in the Calendar) placed to *January* the 1*ſt*, and again to *January* the 31*ſt*, ſo that about the Time of the *Nicene Council*, there were two New Moons in the Month of *January*, every third year of the Moon's Cycle. Whereas, according to the fore-mentioned Obſervations, each of the ſaid two New Moons falling now four Days ſooner, the firſt of them falls upon *December* 28*th* of this preſent Year, 1711; and only the other falls in the *January* following, *viz.* on *January* 27*th*, 1712.

6. *To find what* Year of the Moon's Cycle any *given* Year of Chriſt *anſwers to.*

It remains now to ſhew, how it is to be found, what Year of the Moon's Cycle any given Year of Chriſt anſwers to. And this is done by (*) adding 1 to the given Year of Chriſt, and then dividing the Sum by 19. If 19 juſt divides the Number of the Year given, then it is the 19*th* or laſt Year of the Moon's Cycle; If 19

(*) The Reaſon of adding 1 is, becauſe the *Æra* of Chriſt began in the ſecond Year of this Cycle.

does

does not just divide the said Number, but somewhat of the said Number remains over, then the said Remainder shews the Year of the Moon's Cycle. For instance, I would know to what Year of the Moon's Cycle A. D. 1712 answers. And by this Rule I find it to answer to the third Year of the Cycle; for 1712 + 1 being divided by 19, there will remain 3. And thus much for the Cycle of the Moon.

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7. *Of the Epacts of the Moon.*

Come we next to the Epacts of the Moon. It has been afore observed, that the Civil Lunar Year is eleven Days shorter than the Civil Solar Year. Consequently, two such Lunar Years will be twenty two Days shorter than two such Solar Years; and three Lunar Years will be shorter than three Solar Years by thirty-three Days. Now such as use the fixed Lunar (otherwise called the Luni-Solar Year, in order to adjust the said Lunar Year to the Solar, as often as the Lunar Year does thus come to be thirty three Days shorter than the Solar, do intercalate a Month of thirty Days into the Lunar Year; except only every 19th Year, *viz.* the last Year of the Moon's Cycle) when the interca-

Chap. III. lated Month conſiſts but of twenty-nine Days.

Golden Number.	Epacts
1 . . .	. XI.
2 . . .	. . XXII.
3 . . .	. . . III.
4 . . .	. . XIV.
5	. . XXV.
6	. . VI.
7	. . XVII.
8	. XXVIII.
9 . . .	. . IX.
10 . . .	. XX.
11 . . .	. . I.
12 . . .	. . XII.
13 . . .	. . XXIII.
14 . . .	. IV.
15 . . .	. . XV.
16 . . .	. . XXVI.
17 . . .	. . VII.
18 . . .	. . XVIII.
19 . . .	XXIX.

By this means the Civil Lunar and Solar Years are kept ſo adjuſted together, as that the firſt Year of the MOON's Cycle comes not ſhorter of the Solar Year than eleven Days; the ſecond Year of the ſaid Cycle not ſhorter than twenty two Days; the third year ſhorter only by three days, *&c.* as may be ſeen in the adjoyning Table. Namely, as the New Moons are the ſame (*i. e.* fall on the ſame Day) every nineteen years, ſo the difference between the Lunar and Solar Year is the ſame every nineteen Years. And becauſe the ſaid Difference is always to be added to the Lunar Year, in order to adjuſt or make it equal to the Solar Year; hence the ſaid difference reſpectively belonging to each Year of the Moon's Cycle, is called the *Epact* of the ſaid

Year

Year, *i. e.* the Number to be *added* to the said Year to make it equal to the ſolar Year. Chap. III.

Upon this mutual Reſpect between the Cycle of the Moon, and the Cycle of the Epacts, there is founded this Rule for (*) finding the Epact belonging to any Year of the Moon's Cycle. Multiply the year given of the Moon's Cycle into 11; if the Product be leſs than 30, it is the Epact ſought; if the Product be greater than 30, divide it by 30; and the Remainder of the Dividend is the Epact, *Ex. gr.* I would know the Epact for A. D. 1712, which has been already found to be the third Year of the Moon's Cycle· Wherefore three is the Epact for A. D. 1712: for 11 × 3 = 33, and 33 being divided by 30, there is left three of the Dividend for the Epact. 8. *How to* find *the Epacts of the Moon according to the* Julian *Account.*

(*) Namely in reſpect of the *Julian* Account. For in reſpect of the *Gregorian* Account there is a different Method, the Epact being different. However, the *Julian Epact* being known it is eaſy thence to know the *Gregorian Epact*. Namely, if the *Julian* Epact be greater than 11, Subſtract 11 from it: if leſs, add 30 to it, and out of the Sum Subſtract 11, and the Reſidue will be the *Gregorian* Epact. For inſtance; it has been found, that Three is the *Julian* Epact for A. D. 1712. Wherefore 3 + 30 = 33, and 33 − 11 = 22, which laſt Number (*viz.* 22.) is the *Gregorian* Epact for the ſaid Year, 1712.

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9. *To find by the Epacts,* what Day of any Month in any Year *the New Moon falls on.*

By the Help of the Epact may be found, what Day of any Month in any Year the New Moon falls on, thus: To the Number of the Month from *March* inclusively, add the Epact of the Year given; if the Sum be less than 30, Substract it out of 30; if greater, Substract it out of 60; and the Remainder will be the Day, whereon the New Moon will fall. *N. B.* If the New Moon be sought for the Month of *January* or *March*, then nothing is to be added to the Epact; if for *February* or *April*, then only 1 is to be added. *Ex. gr.* I would know what Day of *December* the New Moon will fall on this A. D. 1711, the Epact whereof is 22. By the aforesaid Rule, I find it will be *December 28th*, for $22+10=32$, and $60-32=28$.

10. *To find the* Age *of the Moon.*

The Day, whereon the New Moon falls, being thus found, it is easy from thence to infer, what the *Age of the Moon* is on any Day given. However, there is a peculiar Rule commonly made use of to this purpose, which is this: Add the Epact of the Year, the Number of the Month from *March* inclusively, and the given Day of the Month all into one Sum: which,

Chap. III.

which, if it be leſs than 30, ſhews the Age of the Moon; if it be greater than 30, divide it by 30, and the Remainder of the Dividend ſhews the Age of the Moon, or how many Days it is from the laſt New Moon. And this Method will never err a whole Day. For inſtance, I would know, what will be the Age of the Moon on *December* 31*ſt* of this Year 1711. By this Rule I find, that the Moon will then be three Days Old, *i. e.* that it will then be three Days from the laſt New Moon. For $22 + 10 + 31 = 63$, and 63 being divided by 30, there will remain of the Dividend 3. And this exactly agrees to the other foregoing Rule, whereby it was found, that the New Moon will fall on *December* 28*th* of this Year 1711.

II. *The Epacts of the Moon are to be eſteemed* Natural *Characters.*

It remains only to obſerve, that the Epacts of the Moon are juſtly to be eſteemed as (*) Natural Characters of Time; foraſmuch as they depend on a Natural Cauſe, *viz.* the Motion of the Moon. For the Reaſon, why

(*) This is inſiſted upon, becauſe the Epacts are by ſome eſteemed, not *Natural*, but *Inſtituted* Characters.

Chap. III. the Civil Lunar Year is leſs than the Civil Solar (*i. e. Julian*) Year by eleven Days, is, becauſe as the Moon goes round her *Orbit*, there are twelve Conjunctions of her and the Sun, (or twelve Synodical Months, which make up a Lunar Year) in leſs Time by eleven Days very nearly, than the Sun ſeems to go once round the Ecliptick. And in like manner, the Reaſon why the Cycle of the Epacts, as well as that of the Moon, conſiſts of nineteen Years, is, becauſe in that Interval of Time, the Moon's Motion has (much) the ſame Reſpect to the Sun, as it had nineteen Years afore. And thus much for the *Natural* Characters of Time.

CHAP.

CHAP. IV.

Of the Cycle of the SUNDAY-LETTER, *commonly called the Cycle* of the SUN.

Chap. IV.

1. *The Cycle of the Sun* improperly *so called.*

THE *Cycle of the Sun* is very improperly ſo called, foraſmuch as it relates not to the Courſe of the Sun, but to the Courſe of the Dominical or *Sunday-Letter* ; whence it ought to be called the *Cycle of the Sunday-Letter*. It conſiſts of twenty eight Years, foraſmuch as after every twenty eight Years, the Courſe or Order of the *Sunday-Letter* is the ſame, as it was afore.

2. *Of the Uſe of this Cycle.*

The Uſe of this Cycle ariſes from (*) the Cuſtom of Aſſigning in the Calendar to each Day of the Week, one of the firſt ſeven Letters of the Alphabet ; *A* being always affixed to

(*) This Cuſtom being Arbitrary, hence this Cycle not a Natural Character, but of Humane Inſtitution.

Chap. IV. *January* 1*ſt*, whatever Day of the Week it be; *B* to *January* 2*d*, *C* to *January* 3*d*; and ſo in order *G* to *January* 7*th*. After which the ſame Letters are repeated again, *A* being affixed to *January* 8*th*, &c. According to this Method, there being 52 Weeks, in a Year, the ſaid ſeven Letters are repeated 52 Times in the Calendar. And were there but juſt 52 Weeks, the Letter *G* would belong to the laſt Day of the Year, as the Letter *A* does to the firſt; and conſequently, that Letter, which was at firſt conſtituted the *Sunday-Letter*, (and the ſame is to be underſtood of the other Days of the Week) would always have been ſo; and there would have been no Change of the *Sunday-Letter*. But our Year conſiſting of 52 Weeks, and an odd Day over, hence it comes to paſs, that the Letter *A* belongs to the laſt, as well as to the firſt Day of every Year. For, although every Leap-Year conſiſts of 366 Days, and ſo of two Days over 52 Weeks, yet it is not uſual to add a Letter more, *viz.* *B*, to the End of the Year; but inſtead thereof to repeat the Letter *F*,

which

which (†) anſwers to the 24*th* of *February*, and to affix it again to the intercalated Day (as has been (*) afore obſerved) which we call *February* 25*th*. By which means the ſaid ſeven Letters of the Alphabet remain affixed to the ſame Days of a Leap-Year, as of a Common Year, through all the reſt of the Calendar, both before and after. The Letter *A* then thus always belonging to the firſt and laſt Day of the ſame Year, and conſequently to the laſt Day of the Old Year, and firſt Day of the New; it thence comes to paſs, that there is a Change made as to the *Sunday-Letter* in a backward Order, that is, ſuppoſing *G* to be the *Sunday-Letter* one Year, *F* will be the next, and ſo on: which is illuſtrated by the following Table; where it muſt be obſerved, that the great Letter is the *Sunday-Letter* for each Year.

(†) As may be ſeen in the Calendar adjoined to the End of this Treatiſe.
(*) Chap. 2. §. 17.

December

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December 1711.		January 1712.	
a . . . 24	*Monday*	a 1	*Tueſday*
b . . . 25	*Tueſday*	b 2	*Wedneſday*
c . . . 26	*Wedneſday*	c 3	*Thurſday*
d . . . 27	*Thurſday*	d 4	*Friday*
e . . . 28	*Friday*	e 5	*Saturday*
f . . . 29	*Saturday*	F 6	*Sunday*
G . . . 30	*Sunday*	g 7	*Monday*
a . . . 31	*Munday*	a 8	*Tueſday*

3. *The* Odd Day *in every Common Year makes a* ſingle *Change in the* Sunday-Letter.

As from the foregoing Table it is evident, how the odd Day above 52 Weeks in a Year does make the *Sunday-Letter* change from one Letter to the next to it in a backward Order; ſo it is obvious, that were there but this ſingle Change, *Sunday* would be denoted by each of the ſeven Letters every ſeven Years, and ſo the Cycle of the *Sunday-Letter* would conſiſt of no more than ſeven Years. But now there being in every fourth or Leap-Year two Days above 52 Weeks, hence it comes to paſs, that their is every ſuch Year a double Change made as to the *Sunday-Letter*. Namely, as the odd ſingle Day above 52 Weeks in a common Year, makes (as has been ſhewn by the foregoing Table) the firſt *Sunday* in *January* to ſhift from that which was the *Sunday-Letter* of the foregoing Year, to the next

Letter

Letter to it in a backward Order; ſo the other Day, intercalcated every Leap-Year after the 23*d* of *February*, (though it makes no change as to the Days of the *Month*, to which the Alphabetical Letters reſpectively belong; which is brought about by the Artifice of repeating the Letter *F* twice, as was before obſerved: yet it) does make a Change as to the Days of the *Week*, to which each Alphabetical Letter is to belong for the remaining Part of the Year; as is evident by the following Table containing the latter Part of *February* 1712, being Leap-Year, and the former Part of *March*. Chap. IV.

February.			March.		
23		*Saturday*	1	d	*Saturday*
24	F	*Sunday*	2	E	*Sunday*
25	f	*Monday*	3	f	*Munday*
26	g	*Tueſday*	4	g	*Tueſday*
27	a	*Wedneſday*	5	a	*Wedneſday*
28	b	*Thurſday*	6	b	*Thurſday*
29	c	*Friday*	7	c	*Friday*

As the former Table ſhewed, how it comes to paſs, that *G* is the *Sunday-Letter* for 1711, and *F* for 1712, at the Beginning of the ſaid Year, even to *February* 23*d*; ſo this later Table ſhews 4. *The* intercalated Day *makes a* double Change *in the* Sun.

Chap. IV. day-Letter *every Leap-Year.*

ſhews, how it comes to paſs, that after *February* 23*d*, not *F* as afore, but *E* is the *Sunday-Letter* for the Reſt of the Year. And conſequently as the former Table will ſerve to ſhew, how by the odd Day in a common Year, there is made every common Year a *ſingle* Change as to the *Sunday-Letter*; ſo the latter Table, compared with the former, will ſhew how by the intercalated Day of a Leap-Year there is made after *February* 23*d*, in every Leap-Year another Change of the *Sunday-Letter*, beſides the former made at the Beginning of the ſaid Leap-Year; and conſequently how there comes a *double* Change of the *Sunday-Letter* every Leap-Year.

5. *This Cycle why conſiſts of* twenty-eight *Years.*

Now as the Cycle of the *Sunday-Letter* would have conſiſted but of ſeven Years, had there been only a ſingle Change of the ſaid Letter; ſo, by Reaſon of there being a double Change of the ſaid Letter every Leap or fourth Year, it comes to paſs, that the ſaid Cycle conſiſts of four Times ſeven Years, *i. e.* the *Sunday-Letter* does not proceed in the ſame Courſe as it did afore, under twenty-eight Years; and after that Number of Years

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Years its Courſe or Order is the ſame as it was afore. Which is illuſtrated by the following Table; where it is to be obſerved, that the firſt Year, and every fourth Year after, of the Cycle is a Leap-Year, and therefore has two *Sunday-Letters* appertaining to it.

A TABLE of the Cycle of the *Sun*.

1 GF	5 BA	9 DC	13 FE	17 AG	21 CB	25 ED
2 E	6 G	10 B	14 D	18 F	22 A	26 C
3 D	7 F	11 A	15 C	19 E	23 G	27 B
4 C	8 E	12 G	16 B	20 D	24 F	28 A

To find what Year of this Cycle any given Year of our Lord anſwers to, and conſequently, what is the *Sunday-Letter* for the Year given, work thus: To the Year of our Lord given (*) add 9, and divide the Sum by 28. If 6.

To find the Cycle of the Sun for any given Year of Christ.

(*) The Reaſon of adding 9, is becauſe the *Æra* of Chriſt began in the Tenth Year of this Cycle.

any

Chap. IV. any of the Dividend remains, the ſaid Remainder ſhews the Year of the Cycle ſought; if nothing remains of the Dividend, then it is the laſt or 28*th* Year of the Cycle. For Inſtance, I would know, what Year of the Cycle of the Sun, A. D. 1712 anſwers to, By the foregoing Rule I find it to anſwer to the 13*th* Year of the ſaid Cycle; (for 1712 + 9 = 1721, and 1721 being divided by 28, there will be left 13;) and by the Table of this Cycle I find the *Sunday-Letters* for the ſaid Year, being a Leap-Year, to be *FE*, viz. *F* from the Beginning of *January* to *February* 23*d*, and after that *E* for the Reſt of the Year, according to the (*) *Julian* Account.

7. *To find, what* Day of the Week *the firſt Day of any Month falls upon.*

It may not be altogether unuſeful to obſerve further, that each of the firſt ſeven Alphabetical Letters always (as is afore noted) belonging to the ſame Day of each Month in the Year, hence the two following *Engliſh* Verſes

(*) Having found the *Sunday-Letter* according to the *Julian* Account, the *Gregorian Sunday-Letter* will be the third in a backward Order from the *Julian*. Thus FE being the *Julian Sunday-Letters* for 1712, being Leap-Year, CB will be the *Gregorian Sunday-Letters* for the ſame.

ſhew

ſhew by the firſt Letter of each Word, what Letter belongs to the *firſt* Day of each Month ; the Order of the Words anſwering to the Order of the Months thus : Chap. IV.

Jan. Feb. March, April, May, June,
At Dover *Dwells* George Brown *Eſquire,*
July, Aug. Sept. Oct. Nov. Dec.
Good Chriſtian Faith, And Doctor Fryar.

Wherefore the *Sunday Letter* being known, it is eaſy by the Help of the foregoing Verſes to tell, what Day of the *Week* the firſt Day of any Month falls upon ; namely, by conſidering the *Order* or *Diſtance* of the Letter belonging to the firſt Day of the given Month from the given *Sunday-Letter*. *Ex. gr.* I would know, what Day of the Week the firſt of *February* 1712 will be, when the *Sunday Letter* will be (at that Part of the ſaid Year) *F*. By the foregoing Verſes I know *D* is the Letter belonging to *February* 1*ſt*, and therefore *F* being the *Sunday-Letter D*. (as being two in the Alphabetical Order before *F*) muſt denote *Friday*, which is agreeably two Days before *Sunday*.

In

Chap. IV. In like manner, if it be enquired, what Day of the Week *March* 1*ſt* will fall upon in 1712, when the *Sunday-Letter* will be changed from *F* to *E*. It being known by the foregoing Verſes, that *D*, is the Letter that belongs alſo to the firſt of *March*, it follows that, as *D* is the Letter next before *E*, ſo *March* 1*ſt* muſt fall on (that Day of the Week which is next before *Sunday*, viz.) *Saturday*.

8. *To find what Day of the* Week *any* other *Day of the Month* (*beſides the firſt*) *falls upon.*

It being thus to be known, what Day of the Week the *firſt* Day of any Month falls upon; thereby may be eaſily known alſo, what Day of the Week any *other* Day of the ſame Month falls upon; namely, by conſidering, that the 1*ſt*, 8*th*, 15*th*, 22*d*, and 29*th* Day of any Month always fall upon the ſame Day of the Week; and then reckoning, how far diſtant the Day propoſed is from any of the aforeſaid Days. For inſtance, I would know, what Day of the Week *March* 18*th* falls upon next Year, *viz.* 1712. It being afore known, that the firſt Day of *March* will then fall on *Saturday*, it follows, that *March* 15*th* will be likewiſe on *Saturday*; and therefore *March* 18*th* (as being three Days

after

after *March* 15*th*) will fall on *Tuesday*, as being three Days after *Saturday*. And therefore, by the *Sunday-Letter* and the foregoing Verſes, may be found, what Day of the *Week* any Day of the *Year* in general will fall upon. And thus we have largely ſhewn the Uſe of the Cycle of the Sun, or of the *Sunday-Letter*. Chap. IV.

CHAP. V.

Of the INDICTION, *and* JULIAN PERIOD.

I. *Of the* Indiction. THE Indiction is a Cycle of fifteen Years, which has no Relation to any Celestial Motion, but was instituted wholly on a Political or Civil Account, *viz.* in respect to certain Taxes (as is the most received Opinion) which were to be paid every fifteen Years. When this Cycle was first instituted, is not left upon Record; but it is evident from History, that it has been in Use ever since the Time of *Constantine* the Great, or from A. D. 312. It was used both by the *Greeks* and *Romans*, but after (†) a manner somewhat different. The *Roman* Indiction is still used by the *Pope* in his Bulls, *&c.* And the Year of the *Roman* Indiction answer-

(†) The *Greek* Indiction begins from the first of *September*, the *Roman* Indiction from the first of *January*. And the former is used in the *Acts of Councils*, and the *Novels* of the Emperors.

ring

ring to any given Year of Christ is found, by (*) adding 3 to the given Year of Christ, and dividing the Sum by 15. The Remainder of the Dividend, if any there be, shews the Indiction; if nothing remains, then it is the 15th or last Year of the Indiction. The principal Reason of taking Notice of this Cycle in this Treatise, is because it conduces to the Understanding of the *Julian Period*, of which we shall speak next. Chap. V.

2. *Of the Julian Period.*

The *Julian Period* is no other than a greater Cycle, made up of the three forementioned Cycles of the Moon, Sun, and Indiction, multiplied one into the other, and so consisting of 7980 Years. For the Cycles of the Moon and Sun, *viz.* 19. and 28, being multiplied together make (†) 532; which being multiplied again by 15, the Cycle of the Indiction, makes 7980,

(*) The Reason of adding 3, is, because A. D. 1. began in the fourth Year of the said *Roman* Indiction.

(†) This Number of Years, arising from the Cycles of the Moon and Sun being multiplied together, is peculiarly stiled the *Dionysian* Period, and also the *Victorian* Period, from Persons of the like Names, who introduced the Use thereof.

Chap. V. the Space of the *Julian Period*. It is called the *Julian Period*, becauſe it was adapted by the Author or Inventor of it, *Joſeph Scaliger*, to the *Julian* Year, and its forementioned Cycles. It is of excellent Uſe in Chronology, or Diſtinguiſhing of Times; becauſe the ſame Years of the Cycles of the Moon, Sun, and Indiction, which belong to any one Year of this *Julian Period*, will never fall together again till after 7980 Years, and conſequently not as long as the World ſtands, according to the Opinion probably received concerning (†) the Duration of the World. And as this Period will probably not expire before the *End* of the World, and thereby conſequently may be diſtinguiſhed the Times of all *Future* Events; ſo it extends backwards (*) before the *Begin-*

(†) Namely, That it ſhall endure but 6000 Years. Of which about 4000 Years being expired before our Saviour's Nativity, and ſomewhat above 1700 Years being expired ſince, there remains but about 300 Years more for the World to laſt, according to the ſaid Opinion.

(*) Namely, *Julian* Period 4714, anſwering to A. D. 1. and our Saviour being Born but about the 4000th Year of the World, it thence follows, that the *Julian* Period muſt be conceived to commence or begin about 700 Years before the Creation.

ning

ning of the World, and thereby conſequently may be diſtinguiſhed the Times of all *Paſt* Events from the very Creation. Hence Chronologers do endeavour to adjuſt all other Accounts of Time, and conſequently all Tranſactions and Events recorded in Hiſtory, to the *Julian Period*.

3. *To find, what Year of the* Julian Period *anſwers to any given* Year of Chriſt.

To find, what Year of the *Julian Period* any given Year of Chriſt anſwers to, work thus. To the given Year of Chriſt add 4713, (becauſe ſo many Years of the *Julian Period* were expired before A. D. 1.) and the Sum gives the Year of the *Julian Period* ſought. For inſtance, I would know, what Year of the *Julian Period* A. D. 1712 anſwers to. Now $1712 + 4713 = 6425$, the Year ſought of the *Julian Period*.

4. *To find, what* Year of Chriſt *anſwers to any given Year of the* Julian Period.

On the contrary, having the Year of the *Julian Period* given to find what A. D. anſwers thereto, work thus. From the Year of the *Julian Period* given, ſubſtract 4713, (for the Reaſon above-mentioned,) and the Reſidue will be the A. D. ſought. For inſtance, I would know, what A. D. anſwers to the *Julian Period* 6425.

Chap. V. Wherefore $6425-4713=1712$, the A. D. ſought.

5. *To find what Year before Chriſt anſwers to any given Year of the* Julian Period, *leſs than* 4714.

If the Year of the *Julian Period* given be 4713, or leſs than it, then Subſtract the ſame from 4714, (which is the Year of the *Julian Period*, that anſwers to A. D. 1.) and the Reſidue will ſhew, how long afore (the Beginning of the common Computation from the Nativity of) Chriſt the given Year of the *Julian Period* was. For inſtance, the City of *Rome* is ſaid to have been built, *J. P.* 3960. I would know therefore, how long it was built before Chriſt. Now $4714-3960=754$. Wherefore *Rome* was built 754 Years before (the Beginning of the common *Æra* of) Chriſt.

6. *To find the* Cycle of the Sun, Moon, *or* Indiction, *anſwering to any Year of the* Julian Period.

To know what Year of the Cycle of the Sun, Moon, or Indiction, anſwers to any Year given of the *Julian Period*; divide the given Year reſpectively by 28, or 19, or 15. The Remainder of the firſt Diviſion will ſhew the Year of the Sun's Cycle; the Remainder of the ſecond Diviſion will ſhew the Year of the Moon's Cycle; and of the third Diviſion, the Year of the Indiction. If nothing remains in each Diviſion, then it is the

laſt

last Year of each Cycle respectively. Chap. V.

On the contrary, to know what Year of the *Julian Period* answers to any given Year of the Cycle of the Sun, or Moon, or Indiction; multiply the Cycle of the Sun into 4845, the Cycle of the Moon into 4200, the Cycle of the Indiction into 6916. The Sum of the Products being divided by 7980, the Remainder will shew the Year of the *Julian Period* sought. 7. *And the contrary.* +

And thus we have gone through the several Characters of Time, whose Computation after a certain Number of Years begins anew; whence each of them is stiled, either a *Cycle*, as the Cycle of the Sun, Moon, and Indiction; or a *Period*, as the *Julian Period*. 8. Cycles *and* Periods, *why so called.*

Chap. VI.

CHAP. VI.

Of EPOCH'*s or* ÆRA'*s*; *and especially of the* ÆRA *or Year of* CHRSIT, *the* ÆRA *of the* OLYMPIADS, *and the* ÆRA *of the* BUILDING OF ROME.

1. *Of* Epoch'*s or* Æra's.

WE are now to speak of those Characters of Time, whose Computation does not begin a-new after a certain Number of Years, but is still continued on further and further from their respective Heads or single Beginnings. And these are distinguished from the circular Characters of Time already described, by the Name of (*) *Epoch*'s or *Æra*'s.

2. *Of the* Æra *of* Christ, *used by Us and other Christians.*

There are several *Epoch*'s or *Æra*'s made use of, both formerly and at present, in the several Parts of the World.

(*) These Words are frequently used promiscuously. Some take an *Æra* to denote properly any *continued Computation*, and an *Epoch* to signify properly the *Beginning* of the said Computation; the *Greek* Word ἐποχὴ denoting (as it were) a Pause or Stop in Time, from whence Time is computed. As to the Etymology of *Æra*, there is no good Account of it.

World. That of principal Concern to us Chriſtians is the *Æra* of *Chriſt*, or the common Way of computing Time from the Nativity of Chriſt; according to which this preſent Year is reckoned the 1711*th* from the *Nativity* of Chriſt, or rather from the *firſt of January* next following the Nativity of Chriſt, according to the common Computation generally receiv'd in *Chriſtendom*, or *Europe*. The *Æra* or Way of Reckoning from *Chriſt*, was firſt introduced by one *Dionyſius*, ſurnamed (†) *Exiguus*, ſomewhat more than 500 Years after Chriſt: Since which Time Chriſtians have reckoned their Years, either from the Birth or Incarnation of our Bleſſed Saviour; whereas before they were wont to reckon ſome other Ways. According to *Dionyſius*, the Author of the *Æra* computed from Chriſt, our Lord was conceived on the 8*th* of the Calends of *April* (now called *Lady-Day*) in the firſt Year of this *Æra*; and was Born about the then Winter-Solſtice next following; that is, *Decemb.* 25. And this Account was at firſt univer- Chap. VI.

(†) He was ſo ſurnamed from his little Stature.

ſally

Chap. VI. ſally received among Chriſtians: but is now a-days uſed only in *England* and *Ireland*, where not only the Eccleſiaſtical, but alſo the Civil Year, is ſtill reckoned according to Law, from the *Feaſt of the Annunciation*, or *Lady-Day*, as it was at firſt by *Dionyſius* himſelf. Whereas in other parts of *Chriſtendom*, as is afore obſerv'd, and even in *England* as to common Affairs which require not a Legal (Eccleſiaſtical or Civil) Date, the Year of Chriſt is reckoned now a-days, not from the *Annunciation* or *Lady-Day*, but from the *Firſt of January* next before the *Lady-Day* from which the Legal Date of our Eccleſiaſtical or Civil Year begins. It is alſo to be obſerv'd, that the Common Account by *A. D.* introduced by the foreſaid *Dionyſius Exiguus* does not agree exactly to the *True Years of Chriſt*'s *Age*. Foraſmuch as according thereto, *Herod the Great* muſt be Dead before our Saviour was Born, which is contrary to the Goſpel Hiſtory. How much the Difference between the True and Common Account is, the Learned are not agreed. But I prefer that Opinion, which makes the common Ac-

count

count *too little* by *two* Years. So that whereas this present Year is *Commonly* esteem'd *A. D.* 1711, it is *Truly A. D.* 1713, or the 1713*th* Year from the *Birth of Christ* or *January* 1. next ensuing. Chap. VI.

3. *Of the* Æra *of the* World, *or* Creation.

There is also another *Æra* frequently made Use of by Christian Writers, namely, the *Æra* of the *Creation*, which is generally agreed to have been about 4000 Years before Christ. And because to say such or such a Thing fell out in such a Year of the *World*, does not give us so clear an Idea of the Distance of the said Occurrence from us, as it does to say, that it happened in such or such a Year *before Christ*; therefore, the Computation from the Creation of the World begins to be laid aside, even in Matters relating to the Sacred History of the Old Testament, and instead thereof the Occurrences of the Old Testament are now a-days computed by their Distance *before* Christ. Thus instead of saying, that the *Universal Deluge* happened *A. M.* or in the Year of the *World*, 1656, it is thoughr more Instructive to say, that it happened 2294 Years *before* Christ, this

last

Chap. VI. laſt Manner of Computation giving us a clearer Notion of the Time when the Flood happened in reſpect of its Diſtance from us. For we being wont to reckon our Time *from Chriſt*, and ſo reckoning this preſent Year to be the 1711*th* from Chriſt; when we are told, that the Flood was 2294 *before* Chriſt, we can from thence eaſily gather, that the Flood was about 4000 Years ago in reſpect of this preſent Time. And on the ſame Conſiderations, it appears to be much the beſt or eaſieſt and cleareſt Way for us, to compute likewiſe all Occurrences, mentioned in any other as well as the Sacred Hiſtory, by their Diſtance either *before* or *after* Chriſt; and ſo to make the *Nativity of Chriſt* the Univerſal *Head* or *Epoch* of all Chronology, counting therefrom all Occurrences either *Backwark* or *Forward*.

4. *Of the* Æra *of the* Olympipiads.

The moſt Antient and Renowned *Epoch* uſed by the Heathens is that of the *Olympiads* or *Olympick Games*, which were inſtituted by one *Iphitus*, in the Fields of *Olympia*, a City or Town of the Region *Elis* in the *Peloponneſe*; and which laſted five Days, the laſt whereof fell on the Full Moon, which was next after the Summer Solſtice.

ſtice. Theſe Games were celebrated every four Years, *that is,* there were three Years between the Years wherein the next preceding and the next following *Olympiad* was celebrated. Hence by a compleat *Olympiad,* is denoted the Space of four Years; the Year wherein the *Olympiad* was celebrated, being ſtiled the firſt Year of the ſaid *Olympiad,* and ſo on. The Celebration of the firſt *Olympiad* is referred to the 3938*th* Year of the *Julian Period*; and conſequently to the 777*th* Year *before Chriſt,* viz. to the Calends of *July,* in the Summer of the ſaid Years. Wherefore,

5. *To find the Year of the* Julian Period *anſwering to any Year given of the* Olympiads.

Any Year of the *Olympiads* being given, to find the correſpondent Year of the *Julian Period,* work thus; Multiply the compleat *Olympiads* by 4, and to the Product add the Year (if it be given) of the *Olympiad* running, and alſo 3937, the Sum is the Year of the *Julian Period* ſought. For Inſtance, *Rome* is ſaid to be built, according to *Varro*'s Account, in the fourth Year of the ſixth *Oylmpiad.* Wherefore I multiply 5 (the Number of the compleat *Olympiads*) by 4, which makes 20, and thereto I add

4 more

Chap. VI. 4 more, (the Year given of the *Olympiad* running, or *6th Olympiad*,) and alſo 3937. All which together amounts to 3961, the Year ſought of the *Julian Period*.

6. *And thereby to find the correſpondent Year of* Chriſt.

Having found the Year of the *Julian Period* anſwering to any given Year of the *Olympiads*, thereby may alſo be found the correſpondent Year (reſpectively) before or after Chriſt. Namely, if the Year found of the *Julian Period* be leſs than 4713, then ſubſtract the ſame from 4713, and the Remainder will ſhew the correſpondent Year *before* Chriſt: But if the Year found of the *Julian Period* be greater than 4713, then ſubſtract 4713 from it, and the Remainder will ſhew the correſpondent Year *after* Chriſt. Thus, it being found, that *Rome* was built in *Julian Period* 3961, I ſubſtract 3961 from 4713, and there remains 752, the correſpondent Year *before* Chriſt wherein *Rome* was built.

7. *Another Way to find the* Year of Chriſt *anſwering to any* Olympick Year.

But if there be no Occaſion to find the correſpondent Year of the *Julian Period*, the Year before or after Chriſt, reſpectively anſwering to any given Year of the *Olympiads* may be found thus. Multiply (as afore) the compleat *Olympiads*

piads by 4, and to the Product add the Year given (if any be ſpecified) of the *Olympiad* running. This Sum, if it be leſs than 776, ſubſtract it from 776, and the Remainder will ſhew the correſpondent Year *before* Chriſt: but if the Sum be greater than 776, then ſubſtract 776 from it, and the Remainder will ſhew the correſpondent Year *after* Chriſt. Thus I would know what Year of Chriſt anſwers to the fourth Year of the ſixth *Olympiad*, wherein *Rome* was built according to *Varro*. Wherefore (as afore) 5 × 4 = 20, and 20 + 4 = 24. Which Sum being leſs then 776, I ſubſtract it from 776, and there will remain 752, the correſpondent Year *before* Chriſt, as was found before by the other Method.

8. *To find, what* Olympick *Year anſwers to any given Year of the* Julian Period.

Any Year of the *Julian Period* being given, to find what *Olympick* Year anſwers thereto, work thus: From the Year given ſubſtract 3937, and divide the Remainder by 4, the Quotient will ſhew the compleat *Olympiads*, and the Fraction or Remainder of the Dividend will ſhew the Year of the *Olympiad* running. If there be no ſuch Remainder, then it is the laſt or fourth Year of the *Olympiad* running *Ex. gr.* I would know, what *Olympick*

Chap. VI. *pick* Year anſwers to *J. P.* 3961. From 3961, I ſubſtract 3937, and there remains 24; which divided by 4, gives 6 in the Quotient, and leaves no Fraction of the Dividend. Wherefore the *Olympick* Year ſought, is the fourth Year of the ſixth *Olympiad*.

9. *Of the* Æra *of* U. C. *or the* Building of Rome.

As the Account by the *Olympiads* was, the principal *Æra* among the *Greeks*; ſo the principal *Æra* among the *Romans* was, that of the (*) *U. C.* or *Building of Rome*; which, according to *Varro* began *Julian Period*, 3961, but according to the *Faſti Capitolini* in the following Year, *viz. Julian Period* 3962. Wherefore

10. *To find the Year of the* Julian Period *anſwering to any given Year of* U. C.

Any Year of *U. C.* being given, add thereto 3960, and you'll have the correſpondent Year of the *Julian Period*, according to *Varro*'s Account; or add 3961, and you'll have the correſpondent Year of the *Julian Period*, according to the *Capitoline* Account.

On the contrary, from the given Year of *Julian Period*, ſubſtract 3960, and the Reſidue will give the Year of *U. C.* according to *Varro*; or ſub-

(*) *U. C.* are the Initial Letters of *Urbs Condita*, and ſo are put to denote in ſhort the *Building of the City*, viz. *Rome*.

ſtract

ſtract 3961 and the Reſidue will be the Year of *U. C.* according to the *Capitoline* Account. Chap. VI.

Foraſmuch as *Rome* is computed to have been built 752 Years before Chriſt; therefore from 752 ſubſtract any given Year of *U. C.* leſs than the ſame, and the Reſidue will ſhew the correſpondent Year *before* Chriſt: Or if the Year given of *U. C.* be greater than 752, then ſubſtract 752 from it, and the Reſidue will ſhew the correſpondent Year *after* Chriſt. Thus the Regal State of *Rome* is computed to have ended in *U. C.* 245, to which anſwers the Year 507 *before* Chriſt: for 752—245=507. And the Removal of the Imperial Seat from *Rome* to *Conſtantinople* by *Conſtantine* the Great, is computed to have happened *U. C.* 1084, and ſo 332 Years *after* Chriſt: for 1084—752=332. 11. *To find the Year* before *or* after Chriſt, *anſwering to any given Year of* U.C.

As for other *Epoch*'s or *Æra's*, they being of leſs Note and Uſe to us, it will be ſufficient to ſhew in ſhort, how long before or after Chriſt each of them began. 12. *Of other* Epoch's *or* Æra's.

Chap. VI.

	Before Christ.
The *Destruction of Troy*, is computed to fall in with (*) *Julian Period*, 3531, and so the *Æra* taken from thence to begin.	1183
The *Æra* of *Nabonassar* King of *Babylon*, from the Beginning of whose Reign the *Chaldeans* and *Egyptians* reckoned their Years, began *February* 26. *J. P.* 3967, and consequently	747
The *Æra* (†) of the Death of *Alexander* the Great, began *Novemb.* 12, *J. P.* 4390, and so	324

(*) Herein is followed the Opinion of *Dionysius Halicarnassus*, and *Diodorus Siculus*.

(†) Some distinguish between the *Alexandrean Æra*, and the *Philippean*, making the *Philippean* (so called from *Philip Aridæus*, Brother to *Alexander* the Great) to begin from the Death of *Alexander*, or more exactly from the 12th of *November* following the Death of *Alexander*, and so *Julian Period*, 4390; and the *Alexandrean* to begin not till twelve Years after *Alexander*'s Death, *viz. October* 1*st*, *Julian Period*, 4402. This latter *Æra* is esteemed by some learned Men to be the same with the *Æra Seleucidarum*, otherwise called *Æra Contractum*, and the *Years of the Greeks* in the Books of the *Maccabees*.

The

Chap. VI.

	Before Christ.
The *Æra* of the City *Antioch*, used by *Eusebius*, *Evagrius*, *Cedrenus*, &c. began from the Autumn *J. P.* 4665, and so	49.
The *Æra* of the *Julian Reformation* of the Calendar, began *January* 1, *J. P.* 4669, and so	45.
The *Æra Actiaca*, so denominated from the Victory obtain'd by *Augustus* over *Anthony* at *Actium*, began *August* 29, *J. P.* 4684, and so	30.
	After Christ.
The *Dioclesian Æra*, or *Æra* of the (*) Martyrs, otherwise called the *Æra* of the *Abissinians*, began *August* 29, A. D.	284.

(*) So called from the Multitude of Christians that suffered *Martyrdom* in the *Dioclesian* Persecution.

	After Christ.
The *Æra* of the *Hegira*, or Flight of *Mahomet* from *Mecca* to *Medina*, used by the *Turks* and *Arabs*, began *July* 16, A. D.	622
The *Æra* of *Yezdegird*, or the *Persian Æra*, began *July* 16, A. D.	632

From this Table of the Beginnings of the forementioned *Æra*'s, it is easy to find out the Year before or after Christ, which answers to any Year given of any of the said *Æra*'s, which are computed by *Julian* Years; as are the *Æra*'s of the Destruction of *Troy*, of the *Julian* Reformation, of *Dioclesian*, &c. But it is more difficult to do so in respect of the *Æra* of *Nabonassar*, of *Alexander*'s Death, and of the *Hegira*, because they are computed by Years different from the *Julian* Years. It will be sufficient to our present Design to observe here, that 1461 *Nabonassar* Years,

Years, make only 1460 *Julian* Years; Chap. VI.
and the same is to be understood of the *Alexandrean* Years, as being of the same Kind with the *Nabonassars*.

CHAP. VII.

Of the Method to find EASTER-DAY, *according to the* NICENE *Rule, (as still followed by our Church,) by the Help of the Golden Numbers affixed to the Calendar. To which is adjoined the* ROMAN *Method of* DATING, *or denoting the Days of the Month.*

I. *The* Nicene *Rule for finding* Easter-Day.

THE Rule prescribed by the Fathers of the *Nicene Council* for the finding of *Easter,* and which is still followed by the Church of *England,* is thus expressed in our Common-Prayer-Book: (*) *Easter-Day is always*

(†) It is observable that the *Nicene* Fathers in prescribing this Rule did not act Arbitrarily, but conformed themselves as near as the Difference of Circumstances would permit, to the Rule prescrib'd by God for observing the Passover. Namely the Rule for the *Jewish* Passover was, that it should be kept on the *Fourteenth Day,* which is much the same as on the *Full Moon* of the first Ecclesiastical Month called *Nisan.* And the *Nicene* Rule for *Easter* is, that it shall be kept on the *Sunday* next after the *Fourteenth Day* or *First Moon* of our First Ecclesiastical Month, or that part of our *March,* which answers to the Jewish Month *Nisan.*

the

the first Sunday after the first Full Moon, which happens next after the One and Twentieth Day of March. And if the Full Moon happens upon a Sunday, Easter-Day is the Sunday after. Chap. VII.

According to this Rule, *Easter-Day* may easily be found by the Help of the Golden Numbers (*) duly affixed to the Calendar, and by retaining in Memory, and applying to Practice, what has been said of the Golden Numbers, and Dominical Letter, *Chap.* 3d and 4th. 2. *To find* Easter-Day *according to the said Rule, by the Help of the* Golden Numbers.

For Instance, I would know, what Day *Easter-Day*, will fall upon the next Year, *viz.* 1712. In order hereto, first I enquire what is the *Golden Number* for the given Year, and I find it to be three, according to the Rule given *Chap. III. Sect.* 6. Then I enquire what is the Dominical or *Sunday* Letter for the given Year, and (according to the Rules given, *Chap. IV. Sect.* 5, 6.) I find that there will be

(*) In our old large Common Prayer-Books, great Care was taken duly to affix the Golden Numbers to their proper Days; and to that End black Lines were drawn between every Day of the Calendar. But of late Years no such Care is taken, insomuch that it is not to be known with any certainty what Days the Golden Numbers do answer to in the Church-Calendars, of late printed without such black Lines.

Chap. VII. two *Sunday* Letters next Year, it being Leap-Year. Of which two Letters, *viz. FE*, the latter *E* will be the *Sunday* Letter after *February* 23*d*, and ſo that whereby I am to be guided in finding out *Eaſter-Day*.

Now becauſe the Full Moon, on which *Eaſter* depends, is (according to the *Nicene* Rule) that which happens next after the 21*ſt of March*; and becauſe the ſaid Full Moon is (agreeably to *Exod.* xii. 6.) to be eſteemed the 14*th Day* after its New Moon incluſively, (*i. e.* the Day of the ſaid New Moon, being reckoned the firſt of the 14th, and the Day of the Full Moon the laſt,) hence the ſaid *Eaſter* New Moon can never fall *before the* 9*th of March*, nor *after the* 5*th of April*. Wherefore I look for the Golden Number 3 between *March* 9*th*, and *April* 5*th*, and find it placed to *March* 31*ſt*, which therefore was the Day on which the *Eaſter* New Moon fell at the Time of the *Nicene* Council, in the 3d Year of the Moon's Cycle: and conſequently is eſteemed ſo ſtill by us. Wherefore the *Eaſter* Full Moon (being fourteen Days after incluſively) will be *April*

13*th*;

13*th*; which being ſhewn by the Letter E affix'd to it to be a *Sunday*, therefore, by the *Nicene* Rule, *Eaſter*-Day muſt be the *Sunday* after, *viz.* *April* 20*th*. And in like manner may *Eaſter-Day* be found for any other given Year, by the Help of the Calendar adjoined to the End of this Chapter; and conſequently Tables may be made, ſhewing the Day, whereon *Eaſter* will fall, for any Term of Years.

3. *Of the* Roman *way of* Dating, *or denoting the Days of the Year.*

It remains now only to obſerve, that in Order to render the following Calendar more uſeful, therein is ſet down the *Roman* Manner of *Dating*, or denoting the ſeveral Days of the Year. Where it is to be noted, that the *Roman* Numbers between the Words *Kalends*, *Nones*, *Ides* and *Calends* of the ſucceeding Month, do reſpectively refer always to the following Word. Thus the Number IV over-againſt *January 2d*, refers to the following *Nones*, and denotes as much as the 4*th* Day of, or before the *Nones* of *January*. So XI ſet to *January 22d*, denotes the 11*th* of, or before the *Calends* of *February*.

Wherefore any *Roman* Date given, may be turned into *our* Date, by finding

Chap. VII. finding in the Calendar the Date given, (ſuppoſe 3 *Id. Februar.*) and ſeeing what Date of ours anſwers thereto, (*viz. February the* 11*th.*) And on the other Hand any Date of ours being given, *v. g. January* 31*ſt*; it may be turned into the *Roman* Date, by finding the *Roman* Date affixed thereto, *viz. Prid. Kal. Febr.*

January				February			
Golden Number	Day of Month.	Weekly Letters.	Roman Date.	Golden Number.	Day of Month.	Weekly Letters.	Roman Date.
3	1	A	Calendæ		1	D	Calendæ
	2	B	IV	11	2	E	IV
11	3	C	III	19	3	F	III
	4	D	Prid.	8	4	G	Prid.
19	5	E	Nonæ		5	A	Nonæ
8	6	F	VIII	16	6	B	VIII
	7	G	VII	5	7	C	VII
16	8	A	VI		8	D	VI
5	9	B	V	13	9	E	V
	10	C	IV	2	10	F	IV
13	11	D	III		11	G	III
2	12	E	Prid.	10	12	A	Prid.
	13	F	Idus.		13	B	Idus.
10	14	G	XIX	18	14	C	XVI
	15	A	XVIII	7	15	D	XV
18	16	B	XVII		16	E	XIV
7	17	C	XVI	15	17	F	XIII
	18	D	XV	4	18	G	XII
15	19	E	XIV		19	A	XI
4	20	F	XIII	12	20	B	X
	21	G	XII	1	21	C	IX
12	22	A	XI		22	D	VIII
1	23	B	X	9	23	E	VII
	24	C	IX		24	F	VI
9	25	D	VIII	17	25	G	V
	26	E	VII	6	26	A	IV
17	27	F	VI		27	B	III
6	28	G	V	14	28	C	Prid. Cal.
	29	A	IV				
14	30	B	III				
3	31	C	Prid. Kal				

March.				*April.*			
Golden Number	Day of Month.	Weekly Letters.	Roman Date.	Golden Number.	Day of Month.	Weekly Letters.	Roman Date.
3 . .	. 1	D	Calendæ		1	G	Calendæ
	2	E	VI	11 .	. 2	A	IV
11 . .	. 3	F	V	19 .	3	B	III
	4	G	IV	8 .	. 4	C	Prid.
19 . .	. 5	A	III		5	D	Nonæ
8 . .	. 6	B	Prid.	16 .	. 6	E	VIII
	7	C	Nonæ	5 .	. 7	F	VII
16 . .	. 8	D	VIII		8	G	VI
5 . .	. 9	E	VII	13 .	. 9	A	V
	10	F	VI	2 .	. 10	B	IV
13 .	. 11	G	V		11	C	III
2 .	. 12	A	IV	10 .	. 12	D	Prid.
	13	B	III		13	E	Idus.
10 . .	. 14	C	Prid.	18 .	. 14	F	XVIII
	15	D	Idus.	7 .	. 15	G	XVII
18 . .	. 16	E	XVII		16	A	XVI
7 . .	. 17	F	XVI	15 .	. 17	B	XV
	18	G	XV	4 .	. 18	C	XIV
15 . .	. 19	A	XIV		19	D	XIII
4 .	. 20	B	XIII	12 .	. 20	E	XII
	21	C	XII	1 .	. 21	F	XI
12 . .	. 22	D	XI		22	G	X
1 .	. 23	E	X	9 .	. 23	A	IX
	24	F	IX		24	B	VIII
9 . .	. 25	G	VIII	17 .	. 25	C	VII
	26	A	VII	6 .	. 26	D	VI
17 . .	. 27	B	VI		27	E	V
6 . .	. 28	C	V	14 .	. 28	F	IV
	29	D	IV	3 .	. 29	G	III
14 .	. 30	E	III		30	A	Prid. Kal.
3 .	. . 31	F	Prid. Kal.				

Golden

May.				*June.*			
Golden Number.	Day of Month.	Weekly Letters.	Roman Date.	Golden Number.	Day of Month.	Weekly Letters.	Roman Date.
11	1	B	Calendæ		1	E	Calendæ
	2	C	VI	19	2	F	IV
19	3	D	V	8	3	G	III
8	4	E	IV	16	4	A	Prid.
	5	F	III	5	5	B	Nonæ
16	6	G	Prid.		6	C	VIII
5	7	A	Nonæ	13	7	D	VII
	8	B	VIII	2	8	E	VI
13	9	C	VII		9	F	V
2	10	D	VI	10	10	G	IV
	11	E	V		11	A	III
10	12	F	IV	18	12	B	Prid.
	13	G	III	7	13	C	Idus.
18	14	A	Prid.		14	D	XVIII
	15	B	Idus.	15	15	E	XVII
7	16	C	XVII	4	16	F	XVI
	17	D	XVI		17	G	XV
15	18	E	XV	12	18	A	XIV
4	19	F	XIV	1	19	B	XIII
	20	G	XIII		20	C	XII
12	21	A	XII	9	21	D	XI
1	22	B	XI		22	E	X
	23	C	X	17	23	F	IX
9	24	D	IX	6	24	G	VIII
	25	E	VIII		25	A	VII
17	26	F	VII	14	26	B	VI
6	27	G	VI	3	27	C	V
	28	A	V		28	D	IV
14	29	B	IV	11	29	E	III
3	30	C	III		30	F	Prid Kal
	31	D	Prid Kal				
11							

Golden

July.				*August.*			
Golden Number.	Day of Month.	Weekly Letters.	Roman Date.	Golden Number.	Day of Month.	Weekly Letters.	Roman Date.
19 . .	1	G	Calendæ	8 . .	1	C	Calendæ
8 . .	2	A	VI	16 . .	2	D	IV
	3	B	V	5 . .	3	E	III
16 . .	4	C	IV		4	F	Prid.
5 . .	5	D	III	13 . .	. 5	G	Nonæ
	6	E	Prid.	2 .	. 6	A	VIII
13 . .	7	F	Nonæ		7	B	VII
2 . .	8	G	VIII	10 .	. 8	C	VI
	9	A	VII		9	D	V
10 . .	10	B	VI	18 .	10	E	IV
	11	C	V	7 .	. 11	F	III
18 . .	12	D	IV		12	G	Prid.
7 . .	13	E	III	15 .	13	A	Idus.
	14	F	Prid.	4 .	14	B	XIX
15 . .	15	G	Idus.		15	C	XVIII
4 . .	16	A	XVII	12 .	. 16	D	XVII
	17	B	XVI	1 .	17	E	XVI
12 . .	18	C	XV		18	F	XV
1 . . .	19	D	XIV	9 .	. 19	G	XIV
	20	E	XIII		20	A	XIII
9 . .	21	F	XII	17 .	21	B	XII
	22	G	XI	6 .	22	C	XI
17 . . .	23	A	X		23	D	X
6 . . .	24	B	IX	14 .	. 24	E	IX
	25	C	VIII	3 .	25	F	VIII
14 . .	26	D	VII		26	G	VII
3 . .	27	E	VI	11 . .	27	A	VI
	28	F	V		28	B	V
11 . .	29	G	IV	19 . .	29	C	IV
	30	A	III	8 . .	30	D	III
19 . .	31	B	Prid Kal.		31	E	Prid Kal

Golden

September.				*October.*			
Golden Number.	Day of Month.	Weekly Letters.	Roman Date.	Golden Number	Day of Month.	Weekly Letters.	Roman Date.
16	1	F	Calendæ	16	1	A	Calendæ
5	2	G	IV	5	2	B	VI
	3	A	III	13	3	C	V
13	4	B	Prid.	2	4	D	IV
2	5	C	Nonæ		5	E	III
	6	D	VIII	10	6	F	Prid.
10	7	E	VII		7	G	Nonæ
	8	F	VI	18	8	A	VIII
18	9	G	V	7	9	B	VII
7	10	A	IV		10	C	VI
	11	B	III	15	11	D	V
15	12	C	Prid.	4	12	E	IV
4	13	D	Idus.		13	F	III
	14	E	XVIII	12	14	G	Prid.
12	15	F	XVII	1	15	A	Idus.
1	16	G	XVI		16	B	XVII
	17	A	XV	9	17	C	XVI
9	18	B	XIV		18	D	XV
	19	C	XIII	17	19	E	XIV
17	20	D	XII	6	20	F	XIII
6	21	E	XI		21	G	XII
	22	F	X	14	22	A	XI
14	23	G	IX	3	23	B	X
3	24	A	VIII		24	C	IX
	25	B	VII	11	25	D	VIII
11	26	C	VI		26	E	VII
19	27	D	V	19	27	F	VI
	28	E	IV	8	28	G	V
8	29	F	III		29	A	IV
	30	G	Prid Kal	16	30	B	III
				5	31	C	PridCal.

November.				*December.*			
Golden Number.	Day of Month.	Weekly Letters.	Roman Date.	Golden Number.	Day of Month.	Weekly Letters.	Roman Date.
	1	D	Calendæ	13	1	F	Calendæ
13	2	E	IV	2	2	G	IV
2	3	F	III		3	A	III
	4	G	Prid.	10	4	B	Prid.
10	5	A	Nonæ		5	C	Nonæ
	6	B	VIII	18	6	D	VIII
18	7	C	VII	7	7	E	VII
7	8	D	VI		8	F	VI
	9	E	V	15	9	G	V
15	10	F	IV	4	10	A	IV
4	11	G	III		11	B	III
	12	A	Prid.	12	12	C	Prid.
12	13	B	Idus.	1	13	D	Idus.
1	14	C	XVIII		14	E	XIX
	15	D	XVII	9	15	F	XVIII
9	16	E	XVI		16	G	XVII
	17	F	XV	17	17	A	XVI
17	18	G	XIV	6	18	B	XV
6	19	A	XIII		19	C	XIV
	20	B	XII	14	20	D	XIII
14	21	C	XI	3	21	E	XII
3	22	D	X		22	F	XI
	23	E	IX	11	23	G	X
11	24	F	VIII		24	A	IX
19	25	G	VII	19	25	B	VIII
	26	A	VI	8	26	C	VII
8	27	B	V		27	D	VI
	28	C	IV	16	28	E	V
16	29	D	III	5	29	F	IV
5	30	E	Prid Kal		30	G	III
				13	31	A	PridKal.

Having

Having shewn how to find *Easter-Day*, according to the *Julian* or Old Account, used by Us in *Great Britain* and *Ireland*, it may not be improper to adjoin here, by way of Annotation, the Method of finding *Easter-Day* according to the *Gregorian* or New Account, used in all Countries where the *Popish* Religion is established. Now this is done by Help of the Table here subjoined, wherein in the first Column are contained the *Gregorian* Epacts, that are now and will be in Use till 1800 exclusively; and in the second Column are set down the Days whereon falls the *Easter* Full Moon; and in the third Column is set down the Weekly Letter answering to the said Days of the *Easter* Full Moon. Chap. VII.

Epacts.	Full Moons.	Weekly Letters.	Epacts.	Full Moons.	Weekly Letters.
X	13 *April*	E	IX	4 *April*	C
XI	2 *April*	A	XX	24 *March*	F
XXII	22 *March*	D	I	12 *April*	D
III	10 *April*	B	XII	1 *April*	G
XV	30 *March*	E	XXIII	21 *March*	C
XXV	18 *April*	C	IV	9 *April*	A
VI	7 *April*	F	XV	29 *March*	D
XVII	27 *March*	B	XXVI	17 *April*	B
XXVIII	15 *April*	G	VII	6 *April*	E
			XXVIII	26 *March*	A

The Use of the foregoing Table is this. Having found (as is above-shewn in the Note on *Chap.* 3. *Sect.* 8. and *Chap.* 4. *Sect.* 6.) the *Gregorian* Epact and *Sunday-Letter*, over-against the said Epact in the foregoing Table is placed the Day whereon falls the *Easter* Full Moon, and thereto is affixed its respective Letter. From which therefore you are to reckon in an Alphabetical Order, till you come to the *Sunday-Letter* for that Year, and the Day of the Month answering to the said *Sunday-Letter*, is the *Gregorian Easter-Day*. Only if it happens, that the Full Moon falls on a *Sunday*, then (according to the *Nicene* Rule) the *Sunday* next following is the *Gregorian Easter-Day*. For Instance: It has been already (*viz.* in Notes on *Chap.* 3. *Sect.* 8. and *Chap.* 4. *Sect.* 6.) found, that the *Gregorian* Epact for A. D. 1712 is 22, and that the *Gregorian Sunday-Letters* are *CB*, viz. *C.* to the intercalated Day in *February* and after that B; which last Letter *B* is therefore the *Sunday-Letter*, whereby you are to be guided in finding *Easter-Day*. Now by the foregoing Table you learn, that when the *Gregorian* Epact is 22, the *Easter* Full Moon according to the *Gregorian* Account will fall on *March* 22d, N. S. (*i. e. March* 11th. O. S.) to which answers the Letter *D*, as may be seen in the foregoing Calendar. Wherefore reckoning in an Alphabetical Order from *D* to *B*, which last is the *Gregorian Sunday Letter*, you'll find, that according to the *Gregorian* Computation, *Easter Sunday* will be *March* 27th N. S. which answers to our *March* 16th; and consequently the *Gregorian Easter-Day* will fall A. D. 1712, five Weeks before our *Easter-Day*, this falling on *April* 20th, as has been afore shewn.

It only remains to observe in short, that it having been shewn, how to find both the *Julian* and *Gregorian Easter-Day*, thereby may be known the Time of all the *Moveable Festivals* in any given Year; forasmuch as they all depend on *Easter-Day*. And consequently hereby, and by what has been said of finding the Days whereon fall the New and Full-Moons, may be drawn up an *Almanack* sufficient for common Use. And thus I have laid together so much of Chronology, as seems requisite to be known by Young Gentlemen, at least at their first Institution in the said Art or Science.

FINIS.

THE
Young Gentleman's
DIALLING,

Containing ſuch

ELEMENTS of the ſaid Art, as are moſt uſeful and eaſy to be known.

BY

EDWARD WELLS, D. D. Rector of *Cotesbach* in *Leiceſterſhire.*

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THE PREFACE.

AS the Dependance of the Art of Dialling upon Astronomy, was the Reason of my Drawing up and Publishing this Treatise, at the same Time with my Astronomical Treatise; so my Design in drawing up this Treatise, and the Reason of my giving it *the Title of* The Young Gentleman's Dialling, *may be learnt from the Preface to my Treatise of* Astronomy, *entituled in like manner* The Young Gentleman's Astronomy. *I need only observe further, that I have not contented my self with laying down in this Treatise the bare* Practical *Part of Dialling, but have added thereunto the* Reasons *or* Grounds *of such Practice, as most proper to be known by Young Gentlemen; and withal have observed, in the Annotations to this Treatise, how the Grounds of Dialling may be*

most

most naturally represented even to the Eye, by the Help of a Machine or Instrument, which from its Use may be called a Dialling Sphere.

THE

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THE

THE
Young Gentleman's
DIALLING, &c.

CHAP. I.

Of DIALLING *in general.*

BY (*) *Dialling* is underſtood the Art of Shewing the Time of the Day, by the Sun's Shade falling on ſome Surface, whether Plain or not Plain. Chap. I. 1. Dialling, *what.*

(*) The Word *Dial* is derived from *Dies*, becauſe thereupon the Time of the *Day* is ſhewn. And from the peculiar Manner of ſhewing the Time of the Day upon a Dial, *viz.* by the *Shadow* of the Sun, this Art is frequently termed *Ars Scioterica*, i. e. the *Shadow-Art*, from the *Greek* Word σκιὰ, denoting a *Shadow* or *Shade*.

Plain

Chap. I.

2. Plain Dialling, *what.* Plain Surfaces are moſt uſeful, and therefore moſt uſed: for which Reaſons we will here ſpeak only of *Plain-Dialling*, i. e. of drawing Dials on Plain Surfaces, ſimply called *Planes*.

3. *The various* Names *of Dials, and the Reaſon of the ſaid Names.* Every Dial-plane (*i. e.* plain Surface on which a Dial is drawn) repreſents the Plane of ſome (†) Circle in the Heavens. If the Dial-plane repreſents

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(†) This, and the whole Foundation of Dialling, is moſt naturally, and ſo moſt clearly illuſtrated by the Help of an Inſtrument or Machine, which may be properly enough called from its Uſe a *Dialling Sphere*. It need conſiſt but of an *Horizon*, and two (Wooden or Braſs) Circles faſtened together, croſſing each other at Right Angles, and ſo as to biſect one the other. Either of theſe Circles may be taken to repreſent the *Meridian*, and the other the *Equator*. The former is to be divided into four 90 Degrees, and the latter into 360, as in other Spheres or Globes. And in like manner, as in other Spheres, the *Meridian* of this Dialling Sphere muſt be let into the *Horizon* at the North and South Points of it. There muſt be a plain Piece of Board to move up and down within the fore-mentioned Circles, ſo as to repreſent the Poſition of any Dial-plane. And through the Center or middle Point of the plain piece of Board, there muſt be made an Hole through which, when there is occaſion, a String is to be put; which String being alſo put through the two Points of the *Meridian*, which are 90 Degrees each from the *Equator*, will repreſent the Axis of the World. The Dialling Sphere being thus prepared, the Manner how the Sun by the Shade of the Style of the Dial, comes to ſhew the Time of the Day on any Dial-plane, may be ocularly demonſtrated, represents the Plane of the *Horizon*, the Dial is called an *Horizontal* Dial. If the Dial-plane represents the Plane of the Prime Vertical, then the Dial is called an *Erect Direct North* or *South* Dial, respectively as the Dial is drawn on the north or south Side of the said Dial-plane. If the Dial-plane represents the Plane of the *Meridian*, the Dial is called an *Erect Direct East* or *West* Dial, respectively as the Dial is drawn on the east or west side of such a Dial-plane. If the Dial-plane represents the Plane of any other Vertical Circle, besides the Prime Vertical and *Meridian*, then the Dial is called a *Declining* Dial; forasmuch as it does not directly face any one of the four Cardinal Points of the Heavens, but declines

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strated, by moving the *Meridian* of the Dialling Sphere, that the String representing the Axis may have such a Position as duly answers to the Latitude of the Dial; and by placing the plain Piece of Board in such a Position as to answer (the Plane of that Circle in the Heavens, which is represented by the Dial-plane; or in short, to answer) the Position of the Dial-plane. Then a Candle duly moved round the String in Imitation of the Sun's Motion, will shew by the Shade of the String, how the Shade of the Dial-Style by the Motion of the Sun, shews the Time of the Day on the Dial-plane.

Chap. I. more or leſs from them. Laſtly, if the Dial-plane repreſents the Plane of any greater Circle in the Heavens, beſides ſome Vertical Circle or the *Horizon*, then the Dial is called (not an Erect, but) an (†) *Inclining* or *Reclining* Dial, reſpectively as it is drawn, either on that Side of the Dial-plane, which inclines (or leans forward) towards the *Horizon*; or on the other Side, which reclines (or leans backward) from the *Zenith*. And amongſt theſe are the (*) *Equi-*

(†) Theſe are ſubdiſtinguiſhed into *Direct* Incliners or Recliners, and *Declining* Incliners or Recliners.

(*) The *Equinoctial* Dial is Erect in reſpect of thoſe who live exactly under the Celeſtial *Equator*; and likewiſe the *Polar* Dial is Erect to ſuch as live (if any there be) exactly under either of the two Poles of the World. For in reſpect of the former Inhabitants, the Plane of the *Equinoctial*, and of the Prime Verticle are one and the ſame; and in reſpect of the latter Inhabitants, the Plane of the Prime Vertical, and the Plane of the Circle repreſented by the Plane of a *Polar* Dial is one and the ſame. Again, the *Equinoctial* Plane is the ſame with the *Horizontal* Plane in reſpect to thoſe that are under the Poles; and the *Polar* Plane is the ſame with the *Horizontal* Plane, in reſpect of thoſe that live under the *Equator*. And the like Change is to be conceived in reſpect of other Dial-planes, as they regard ſeveral Places; every Dial-plane being an *Horizontal* Plane at ſome Place, and on the other Side every *Horizontal* Plane being a Prime Vertical, and *Meridian* (&c.) Plane at ſome other Places.

noctial

noctial and *Polar* Dials. The *Equinoctial* Dial is so called, as being drawn on a Plane, that represents the Plane of the *Equinoctial*. The *Polar* Dial is so called, as being drawn on a Plane, that represents the Plane of that Circle, which passes through the Poles of the World, and also (the Intersection of the *Equator*, and the *Horizon* at the east and west Points, *i. e.* in short) the Poles of the *Meridian*. Chap. I.

Among the several Sorts of Dials afore-mentioned, the *Equinoctial* Dial is the most easy to be drawn; this being done only by drawing a Circle, and dividing it into twenty four equal Parts, (to which right Lines drawn from the Center of the Circle, will represent the several Hour-Lines,) and erecting perpendicularly a Pin in the Center of the Circle for the Style. But because (*) the *Equinoctial* Dial, when thus drawn on one Surface of the Plane, will serve only for one 4. *Of the* Equinoctial Dial.

(*) The like is to be understood also as to the *Polar* Dial: on which Account it is of lesser Use; and therefore the Manner of describing it is omitted in this Treatise.

Chap. I. Half of the Year, namely, whilſt the Sun is on one Side of the *Equinoctial*; and therefore to make it ſerve for the whole Year, it muſt be doubly drawn, *viz.* on the lower as well as upper Side of the Plane; on Account of this and other Inconveniences, the *Equinoctial* Dial is ſeldom uſed. And therefore it had not been taken Notice of here, but that the Knowledge thereof is requiſite for the Underſtanding the Reaſon of that Method, which (as being the moſt Natural, and withal eaſy Method) is principally made Uſe of in this Treatiſe, for drawing the other Dials here ſpoken of. For, as the Reaſon why the Circle in an *Equinoctial* Dial is divided into twenty-four equal Parts, anſwering to the twenty-four Hours in a *Nuchthemeron*, is becauſe 15 Degrees, which is a 24*th* Part of the *Equinoctial* Circle in the Heavens, anſwer to one Hour's Motion of the Sun; ſo, becauſe (at the ſame Time that the Sun is conceived, by the Shade of the Axis of the World, to ſhew any Hour on the *Equinoctial* Plane, it does alſo by the ſame Shade ſhew, at the Interſection of any other Plane

Plane with the *Equinoctial* Plane, the Point of the ſaid other Plane belonging to the ſame Hour; or thus, becauſe) the Hour-points of any other Plane are thoſe Points of the ſaid Plane, which fall in with or touch the Hour-Points of the *Equinoctial* Plane, at the common Interſection of the ſaid two Planes; therefore by the Help of the *Equinoctial* Dial may be drawn other Dials, namely, the *Equinoctial* Dial being duly applied to the Plane given, the Hour Points of the *Equinoctial* Dial will fall on the correſpondent Hour-points of (the Dial to be drawn on the) Plane given.

5. *The Buſineſs of Dialling reducible to* three *Heads or Operations.*

And this will be diſtinctly exemplified as to the ſeveral Sorts of Dials above-mentioned, (excepting Inclining and Reclining Dials, as being of leſſer Uſe) after that it has been here obſerved further in general, that the whole Buſineſs of Dialling may be reduced to three general Heads or Operations. Whereof the firſt conſiſts in finding the Place of the *Subſtyle*, or where the *Style* is to be placed: the second in drawing the *Hour Lines:* the third and laſt, either, if the Dial-plane be Moveable, in duly

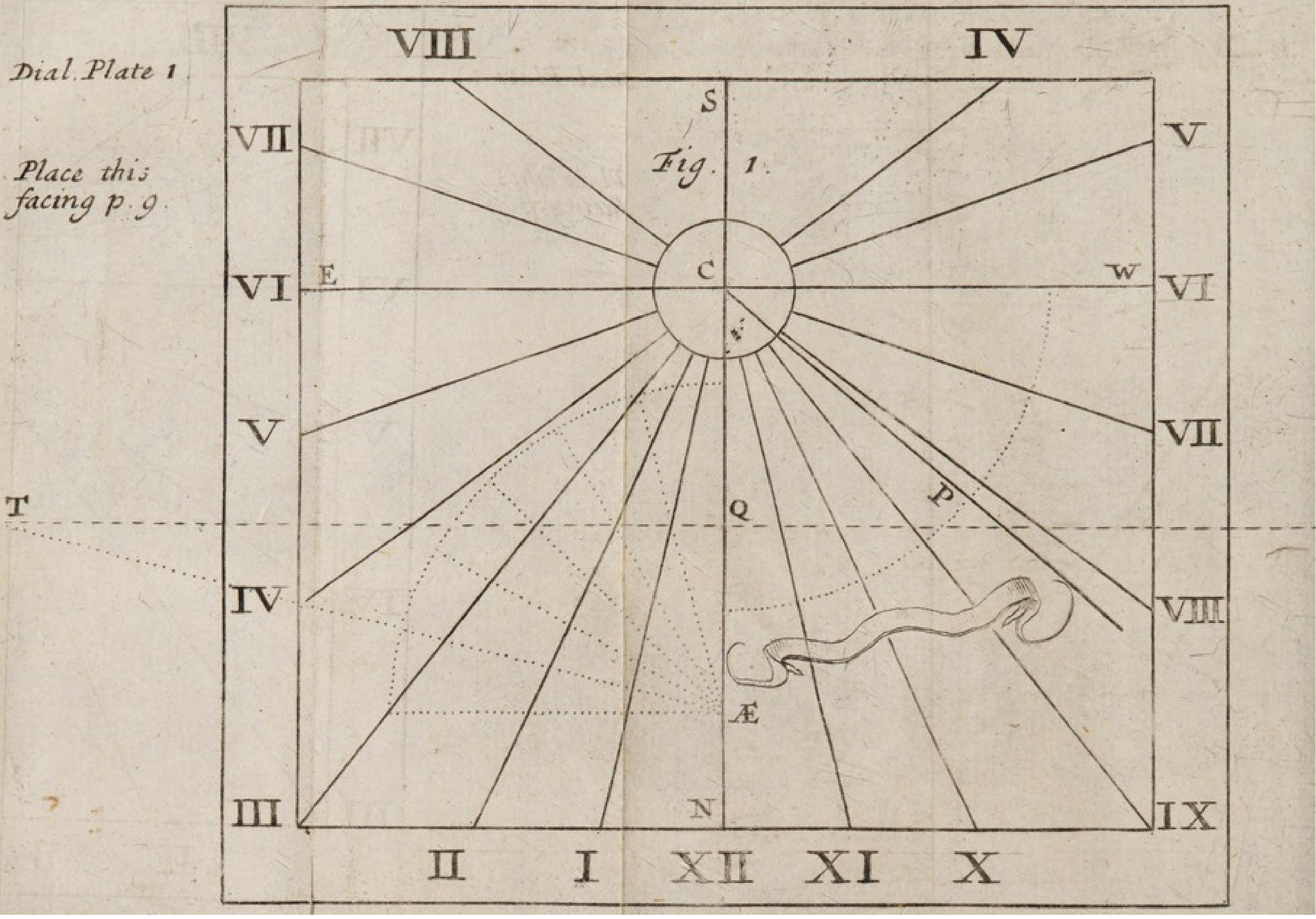
Chap. I. Placing and *Fixing* the ſame, after that the Dial is drawn thereon; or elſe, if the Plane whereon the Dial is to be drawn, be unmoveable and already fixed, in Finding the *Poſition* or Situation of the ſaid Plane, *viz.* whether it be a Direct or Declining Plane; and if the latter, how far it declines.

CHAP.

An HORIZONTAL Dial drawn by y^e help of y^e EQUINOCTIAL Dial.

Dial. Plate 1

Place this facing p. 9.



CHAP. II.

Of an HORIZONTAL *Dial.*

I Begin with the *Horizontal* Dial, as being the most Useful; forasmuch as it singly answers the whole (*) End of Dialling, by shewing the Time of the Day from Sun-rising to Sun-setting throughout the whole Year, within that *Horizon* for which it is made: whereas no other Dial does this. And having made this Observation as to the Usefulness of the *Horizontal* Dial, we proceed now to the Delineation thereof. 1. *The* Horizontal *Dial; why* first *spoken of.*

Whereas the four Cardinal Points of the Heavens are distant one from the other 90 Degrees; and whereas the *Meridian* runs from North to South, and the prime Vertical runs a-cross the *Meridian* from East to 2. *To draw the* Meridian *and* Prime Vertical *Lines of an* Horizontal *Dial.*

(*) The whole proper End of Dialling is, to shew *the Time of the Day* by the Sun's Shade. As for shewing the *Place of the Sun* in the Ecliptick (and the like) by the Shade on a Dial-plane, this does not properly belong to Dialling.

Chap. II. West; hence it follows, that, two right Lines being drawn crossing one the other at right Angles (whose Measure is each 90 Degrees) and either of these two right Lines being taken to represent the *Meridian*, the other will represent the Prime Vertical. That taken to represent the *Meridian*, may be fitly denoted by N S, as running in this Dial from North to South; the other by E W, as running from East to West. See *Fig.* 1.

3. *The* Center *of an* Horizontal *Dial, which.*

The Point, where the Lines N S and E W cross one another, denotes (*) that Point in the Plane of the *Horizon*, (as also of the *Meridian* and Prime Vertical) through which the Axis of the World passes. And because the said Point is the (†) Center (of all the said Planes, parti-

(*) This may be evidently shewn by the Help of a Dialling Sphere.

(†) The Axis of the World passing through the Center of the World, which is also the Center of all great Circles in the Heavens, and consequently of the *Horizon*, *Meridian*, and Prime Vertical; hence it follows, that That Point in the Planes of the said Circles, through which the Axis of the World passes, must be the Center of the said Planes.

cularly)

cularly) of the *Horizontal* Plane, whereon the Dial is to be drawn, and consequently the Center of the Dial it ſelf, hence it may be fitly marked or denoted by C, as *Fig.* 1. Chap. II.

4. *Of the* Subſtyle *and* Style.

The Axis of the World being the (*) common Interſection of the Planes of all *Meridians*, and therefore running from Pole to Pole along the Plane of every *Meridian*; hence the Line N S repreſenting the Plane of the *Meridian* of that Place, for which the Dial is made, muſt be the *Subſtyle*, or the Line whereon the (†) *Style*, which repreſents the Axis of the World is to be (‡) erected.

(*) This may alſo be evidently ſhewn by the Help of the Dialling Sphere.

(†) It is ſo called, becauſe it needs be, and often actually is, no more than a long ſtraight Iron Pin, like an Engraving or old Sort of writing Pin, called a *Style*. It is called alſo by a *Latin* Word, the *Index*, becauſe it tells or *ſhews* what is the Time of the Day. And it is called likewiſe by a *Greek* Word the *Gnomon*, (from γνόω to *know*) becauſe thereby is *known* the Time of the Day.

(‡) By being *erected* is underſtood here, and all along this Tract of Dialling, being placed *perpendicularly* upon the Subſtyle, ſo as not to lean any Thing more towards the Hour-lines on one Side of the Subſtyle, than towards the Hour-lines on the other Side of the Subſtyle.

Chap. II. And becauſe the Style does repreſent the Axis of the World, therefore it muſt be ſo erected upon the Subſtyle, (which is the common Interſection of the *Horizontal* and *Meridian* Planes) as therewith to make an Angle equal to the Elevation of the reſpective (North or South) Pole above the *Horizon* of the Place, or (which comes to the ſame) to the (*) Latitude of the Place. Wherefore taking C for the Center, draw (†) an Arch of a Circle from N S (on either Side) to E W. On the ſaid Arch (‡) ſet off from N S towards E W, (*viz.* at *P*, *Fig.* 1.)

(*) How the Elevation of the Pole and Latitude of the Place come to be always Equal, may be evidently ſhewn on the Globe.

(†) This Arch may be drawn, at what Extent of the Compaſſes or Diſtance from the Center you pleaſe; but it is convenient to have regard to the Largeneſs of the deſigned Dial. And alſo it is convenient to make Uſe of a *Line of Chord's*, in this, and all ſuch Operations, in Order to the ſetting off on the Arch drawn any Number of Degrees, with much more Eaſe and Readineſs than can be done otherwiſe. The Reader is here ſuppoſed to be already inſtructed in the Uſe of the Line of Chords.

(‡) That is, the Style, if it be only a long ſtraight Piece of Iron, muſt be ſo placed on the Subſtyle of the Dial, as to have the ſame Inclination thereto, as C P has

3.) ſo many Degrees as anſwer to the Elevation of the Pole; for Inſtance (*Fig.* 1.) 51 $\frac{1}{2}$ the Latitude of *London*, or Elevation of the north Pole there. The Line CP being drawn will ſhew the Style. Chap. II.

Having found the Subſtyle NS, and the Style CP, draw a long Line croſſing the Subſtyle in any Point, (which ſhall ſeem moſt convenient,) ſuppoſe Q, at right Angles. This Line repreſenting the common Interſection of the *Equinoctial* Plane and Dial Plane, is therefore called the (*) *Contingent* Line, and is denoted (*Fig.* 1.) by the Line TG. That Point in the Subſtyle, which is ſo far diſtant from Q, as the Point Q is found by the Compaſſes to be diſtant from the neareſt Point of the Style, repreſents the Center of the *Equator*, 5. *Of the* Contingent *Line, and* applying the Equinoctial Dial *to the Plane of your* Horizontal *Dial.*

has to NS. If you would have the Style a broad Plate of Iron or the like, then it muſt be made exactly equal to the Triangle NCP, In both Caſes, the lower Point of the Style, namely, wherein the Lines CN and Pn meet, muſt be placed exactly on C, as being the Point of the *Horizontal* Plane, through which paſſes the Axis, repreſented by the Style.

(*) It is ſo called, becauſe herein the two Planes are conceived to *touch one another*.

Chap. II. or that Point from which an *Equinoctial* Dial is to be delineated on the Dial-plane, and therefore it may fitly be marked Æ. Taking then Æ for the Center, at (†) any Diſtance, draw toward the Contingent a (*) Semicircle repreſenting half the *Equinoctial*, ſo as that one Half of the Semicircle (*i. e.* fourth Part of the *Equinoctial*) may be on each Side of the Subſtyle. Then divide the ſaid Semicircle into twelve equal Parts, (*viz.* ſix on each Side of the Subſtyle,) each containing an Arch of 15 Degrees, (‡) Lines drawn from Æ the

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(†) However it is convenient to be guided herein by the Length of the Line of Chords made uſe of, and by the Size of the intended Dial.

(*) This may be otherwiſe done by only drawing one Half of this Semicircle on one Side of the Subſtyle, and dividing it into ſix equal Parts; and thence transferring the ſaid ſix Diviſions to that Part of the Contingent, which is on the other Side of the Subſtyle. And this is the beſt Way for practice, being ſhorter, and not cumbring the Work with Multitude of Lines. And 'tis adviſeable to draw the ſaid Quadrant, or fourth Part of the *Equinoctial* Circle or Dial on that Side of the Subſtyle, where the Style is not drawn: becauſe then the *Equinoctial* Dial and the Style will ſtand both clear one from the other; as in the Figures hereunto belonging.

(‡) Theſe, and all other Lines or Circles or Arches of Circles are to be *obſcure* ones, *i. e.* ſuch as may be rubbed out again, excepting only the proper Hour-lines

Æ the Center of the *Equinoctial* to each Division of the Semicircle will be the Hour Lines of the *Equinoctial* Plane or Dial; among which Hour Lines, the Substyle and *Meridian* NS of the *Horizontal* Dial will also be the *Meridian* of the *Equinoctial* Dial.

Chap. II.

6. *To draw the* Hour-lines *of an* Horizontal Dial.

Having thus fitted the *Equinoctial* Dial to the *Horizontal* Plane, on which the *Horizontal* Dial is to be drawn, it will be very easy to find the Hour-points of the said *Horizontal* Dial: namely, by continuing the *Equinoctial* Hour-lines to the Contingent, and thereby seeing on what Points of the *Horizontal* Plane the Hour-lines of the *Equinoctial* Plane will fall. For the said Points of the *Horizontal* Plane are respectively the Points, on which the correspondent Hour-lines of the *Horizontal* Dial will fall, being drawn from (*) C the Center of the *Horizontal* Dial. Among

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lines in each Dial. These obscure Lines are distinguished in the Draughts hereunto belonging by being made *prick'd* Lines.

(*) The Hour-lines represent the Shade conceived to be made by the Axis of the World; which Axis being

Chap. II. mong these Hour-lines, the Line NS being both the *Meridian* and Substyle of the *Horizontal* Dial, (and so falling in with the *Meridian* of the *Equinoctial* Dial) will therefore be the twelve a Clock Line of the *Horizontal* (as well as *Equinoctial*) Dial. Which being known, the Numbers 11, 10, 9, 8, and 7, are to be affixed to the Hour-lines on the west Side of the Dial, according to their respective Order from the twelve a Clock Line. And in like manner the Numbers, 1, 2, 3, 4, and 5, are to be set to the respective Hour-lines on the east Side of the Dial. The Line EW, as representing the Prime Vertical, is always the 6 a Clock Line, both Morning

being conceived to pass through C the Center of the Dial, hence all the Hour-lines must be drawn from the said Center. Only it is observable, that it is more Ornamental, not to draw actually the Hour-lines from C (because if they were so drawn, they would be apt to run together, and blot at the point C,) but making a Circle at some small distance from C, actually to draw the Hour-lines only from the said Circle, by the Ruler duly applied to C, as *Fig.* 1. 'Tis also observable, that the Dial-plane may be of any Shape, *viz.* Round or Triangular, *&c.* as well as Square or Oblong, though this Shape is most used among us.

and

and Evening. And as for the Hours before ſix in the Morning, and after ſix in the Evening, their Lines are drawn by continuing the Lines of thoſe Hours, which are of the ſame Denomination in the contrary Part of the Day, through the Center C of the Dial. Thus the Hour-lines of 5 and 4 in the Morning are drawn, by continuing the Hour-lines of 5 and 4 in the Afternoon through C. And the Hour-lines of 7 and 8 in the Evening are drawn, by continuing the Hour-lines of 7 and 8 in the Morning thro' C. And thus the Delineation of an *Horizontal* Dial is finiſhed, (as is repreſented, *Fig.* 1.) according to the Method of Delineating the ſame by the Help of an *Equinoctial* Dial. For as to the intermediate Spaces between each Hour, (*viz.* Quarter, Half, and three Quarters,) they are had by dividing the Space between each two Hours, firſt into Half, and each Half again into Quarters.

It

Chap. II.

7.
To draw an Horizontal Dial *by a* Dialling *Scale.*

It may not be unuseful (not only for Variety, (*) but also Proof sake) to add here the Method of drawing an *Horizontal* Dial, by Dialling Scales and Tables. The former is thus: The Lines NS and EW being drawn, and the Style CP erected, as afore; the Length of the Line EW is to be determined, so as to bear a due Proportion to the Scale of Hours you are to Use. This is done by placing one Foot of the Compasses at the Beginning of the Scale of *Latitudes*, (contained in the Dialling Scale,) and opening the other Foot, till it reaches to the Number of Degrees in the said Scale of Latitude, which answers to the Latitude of the Place. This Extent is to be set off on the Line E. W. from C towards E, and also toward W; and where it Ends, it may be respectively marked *e*, *w*, as *Fig.* 2.

(*) If you have drawn your Dials right, the same Hour-lines, at equal Distance from the Center of your Dial, will be equally distant also one from the other, by which Method soever you draw them, *v. g.* The Distance between 12 and 1, (or 12 and 2, or 1 and 2, *&c.*) will be the same, at equal Distance from the Center of your Dial, whether it be drawn by the *Equinoctial* Dial, or by Scales, or by Tables.

Then

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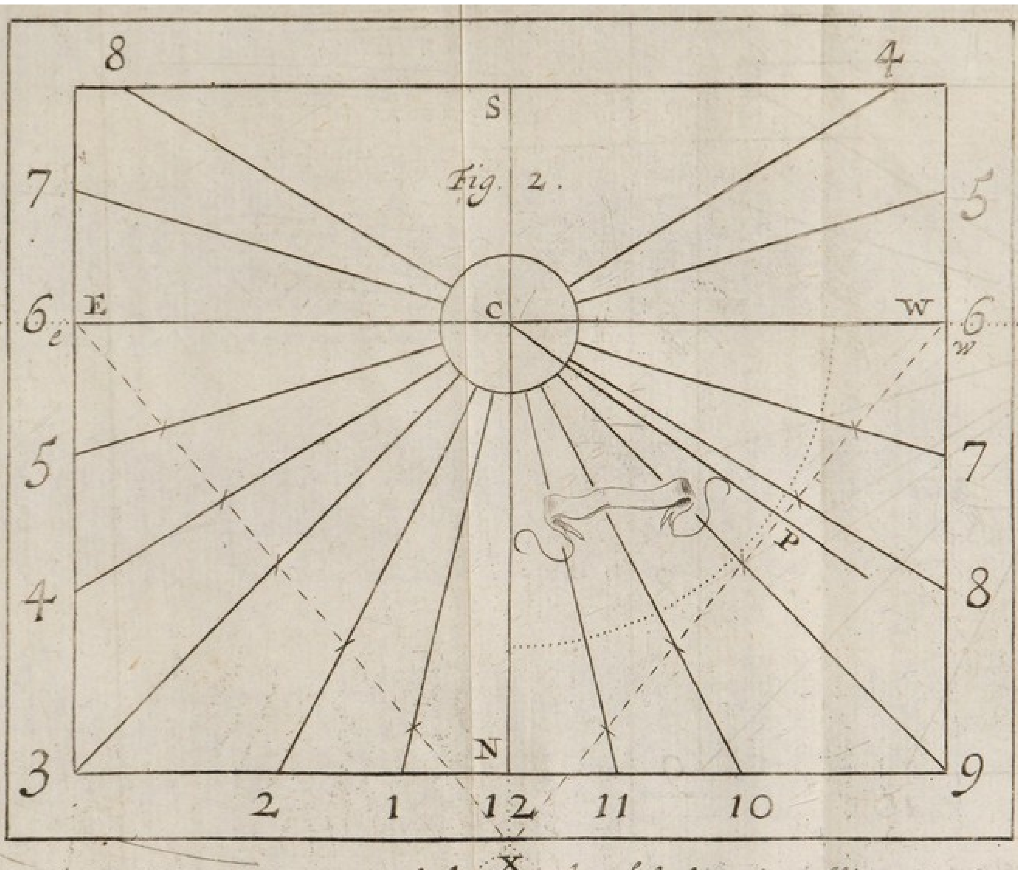

An HORIZONTAL Dial drawn by y^e help of Dialling Scales.

Chap. II.

Then out of the Dialling Scale take the whole Length of the Scale of *Hours*, with the Compaſſes; and ſetting one Foot of the Compaſſes in *e*, with the other make an Arch croſſing the Line NS towards N; and then do the like on *w*. From the Point *x* of the Line NS, where the two Arches (*) croſs one another, draw the Lines *x e* and *x w*; which will be of an equal Length with the Scale of Hours in the Dialling Scale: from which Hour-ſcale the ſeveral Hours (and the intermediate Spaces) are to be reſpectively transferred unto the Lines *x e* and *x w*. Lines drawn from C to the ſeveral Hour-points on the Lines *x e* and *c w*, will be the reſpective Hour-Lines. And ſo the Dial is finiſhed by the Scale: for the Hour-lines before 6 in the Morning, and after 6 in the Evening, are to be had, as afore.

8. *To draw an* Horizontal *Dial by Dialling* Tables.

If you would work by Dialling *Tables*, having drawn the Lines N S

(*) If the Lines drawn by the Compaſſes, ſet upon *e* and *w*, do not croſs one the other exactly in ſome Point of the *Meridian* NS, then ſome Fault has been made in ſetting off the ſaid Lines, and the Work muſt be repeated, till they do thus croſs.

and

Chap. II. and EW to what Length you pleaſe, upon C the Interſection of the ſaid Lines draw a Semicircle *e s w*, as in *Fig.* 3. Then on the ſaid Semicircle ſet off the Degrees and Minutes anſwering to each Hour (and each Quarter, Half, or three Quarters of an Hour) in the Table for *Horizontal* Dials. After which draw the Hour-lines from C to the ſeveral Hour-points in the ſaid Semicircle. The Subſtyle and Style are found, as afore.

Having ſhewn, how to draw an *Horizontal* Dial three ſeveral Ways, it remains now to ſhew how to *place aright* the ſaid Dial, when drawn, and this will be beſt ſpoken of together with the placing of other Dials, *Chap.* 5.

CHAP.

. *Plate* 2 .

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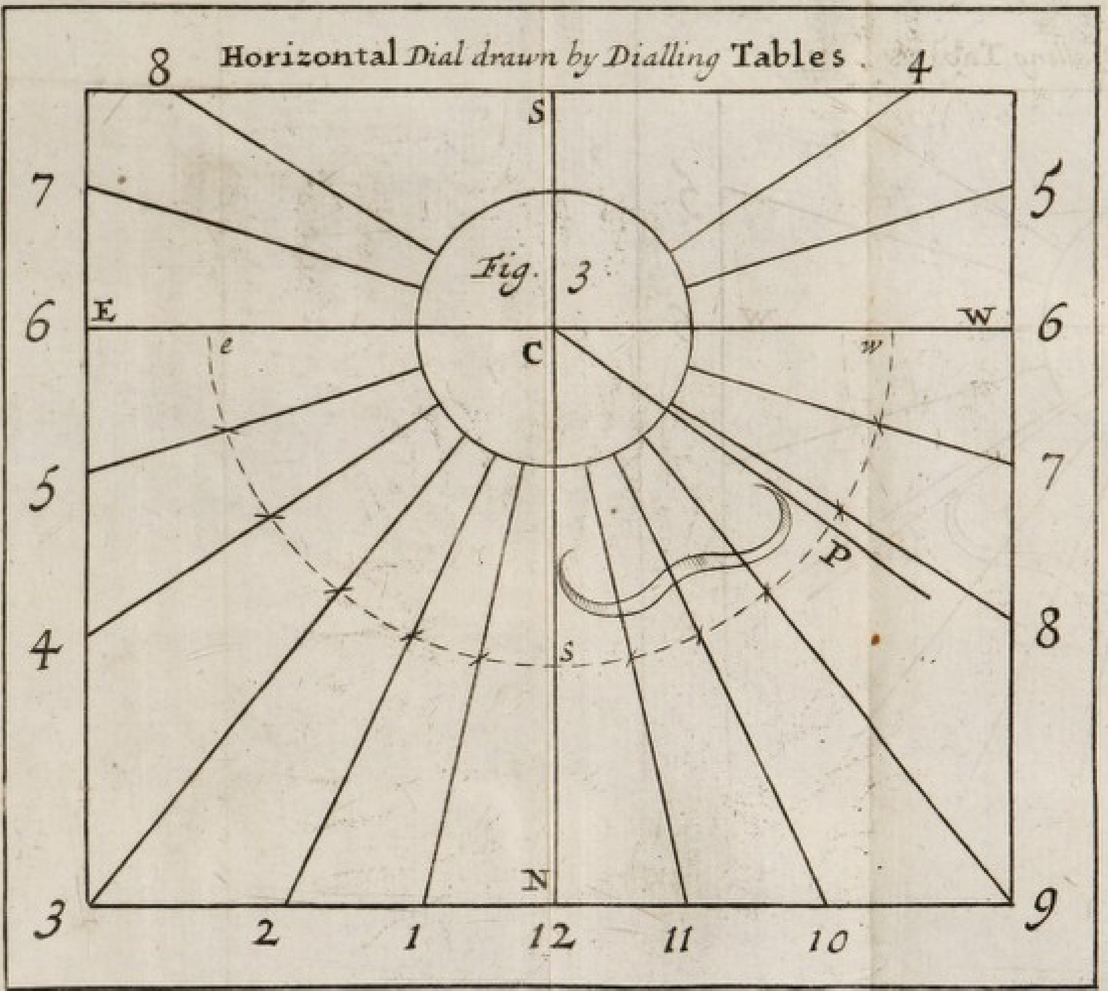
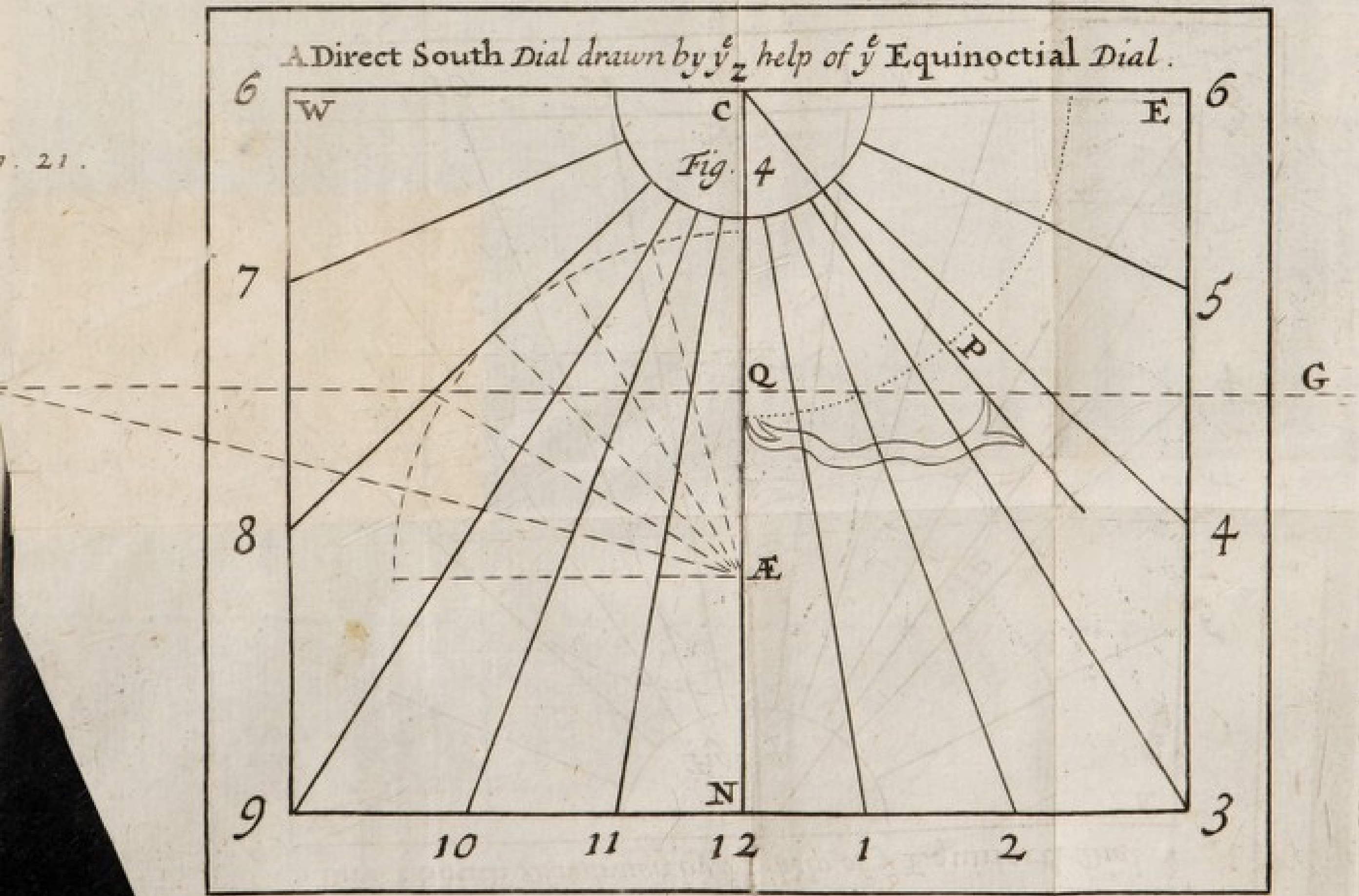
. 20 .



Horizontal *Dial drawn by Dialling* Tables .

. 21 .



A Direct South *Dial drawn by* y^e *help of* y^e Equinoctial *Dial* .

CHAP. III.

Of an (*) *Erect Direct South and North* DIAL.

THE Erect Direct *South* Dial ſhall be ſpoken of next, as being next to the *Horizontal* Dial the moſt uſeful: foraſmuch as it ſhews the Time of the Day from 6 to 6 thoughout the whole Year. 1.

A Direct South Dial the moſt uſeful next to an Horizontal Dial.

This Sort of Dial is drawn after the ſame manner, by the Help of the *Equinoctial*, as the *Horizontal* Dial, excepting the Particulars following; *viz. Firſt*, That the *Meridian* or 12 a Clock Line, (which in this, as well as the *Horizontal* Dial, is always the Subſtyle,) foraſmuch as it muſt be ſo placed as that one of its Ends muſt Point to the (†) *Zenith*, the other to the 2.

To draw a Direct South Dial, by the Help of the Equinoctial Dial.

(*) Inclining and Reclining Dials being ſeldom uſed, hence theſe Dials are frequently ſtiled only Direct *South* and *North* Dials.

(†) The *Meridian* of any Place or Dial, as it paſſes through the North and South Poles, ſo it paſſes likewiſe

Chap. III. the *Nadir*, may therefore be most properly here denoted by ZN. *Secondly*, the Style CP must be erected upon the Substyle ZN, so as to make therewith an Angle equal (not to the Elevation of the Pole, as in an *Horizontal* Dial; but) to the Complement of the Pole's Elevation. For such is the Measure of the Angle, which the (*) South Pole, represented by the Style of this Dial, makes with the Plane of the Prime Vertical. Now the Elevation of the Pole above the *Horizon* of *London* being $51\frac{1}{2}$ Degrees, its Complement is $38\frac{1}{2}$ Degrees. *Thirdly*, On this Dial there need be inscribed no Hour, either before 6 in the Morning, or after 6 in the Evening: for the Plane of this

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wise through the *Zenith* and *Nadir* of the said Place. In an *Horizontal* Dial the *Meridian* Line is to be placed with its Ends towards the North and South Points, and therefore is therein fitly denoted by NS. But in a Direct South Dial, the *Meridian* Line is to be placed so, as that its Ends may Point to the *Zenith* and *Nadir*, and therefore is here more fitly denoted by ZN.

(*) This may be evidently represented to the very Eye by the Dialling Sphere; and consequently the Reason why the End P of this Style must be placed downwards.

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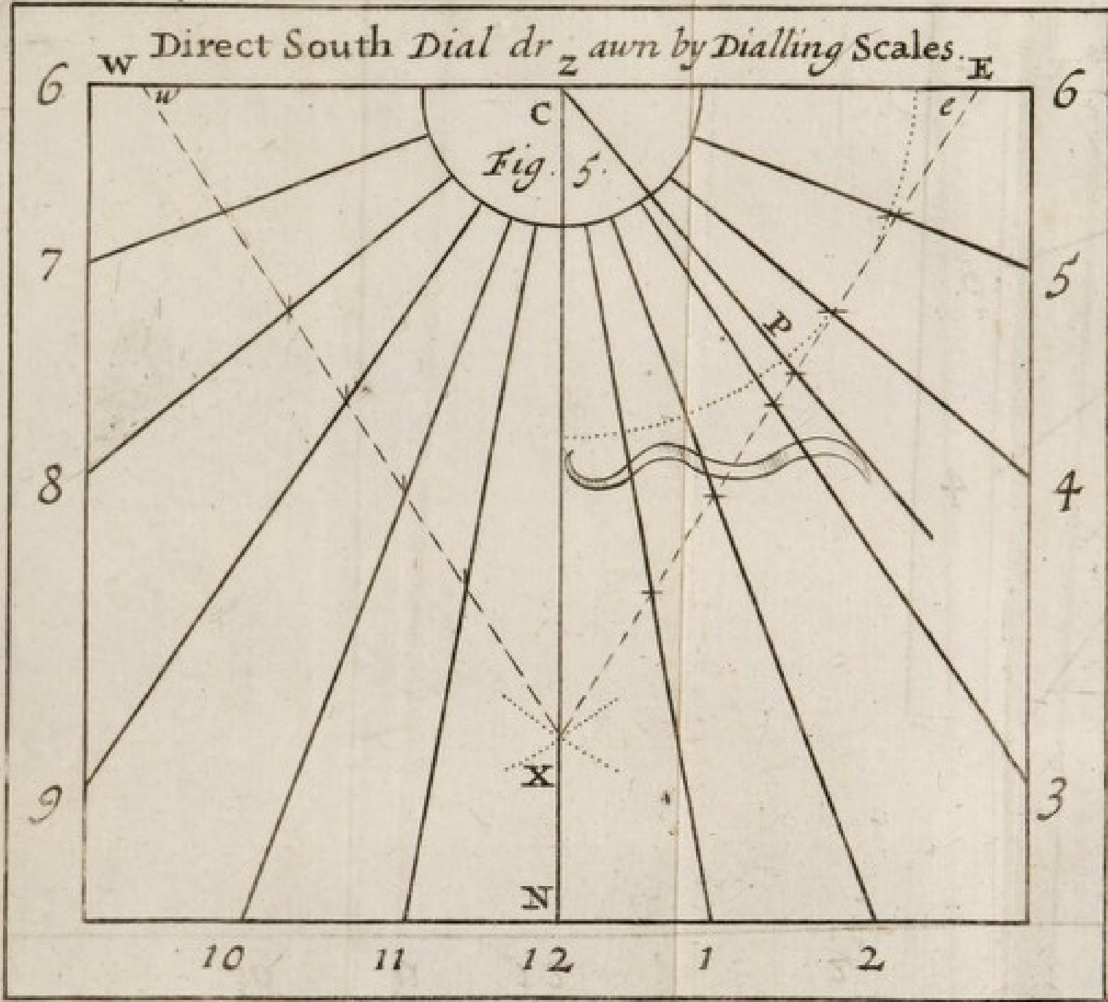

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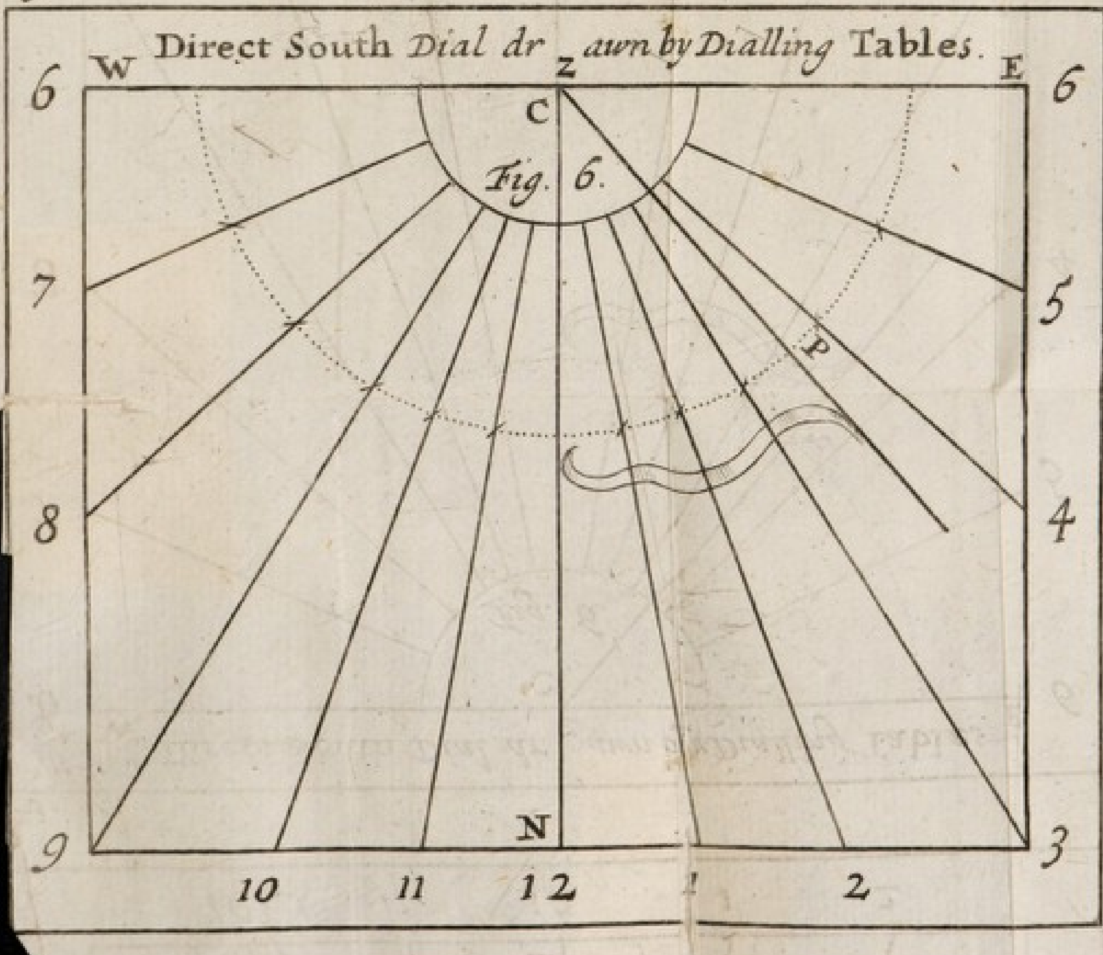


Dial repreſenting the ſouth Side of the Plane of the Prime Vertical, the Sun never ſhines upon it before 6 in the Morning, or after 6 in the Evening. See *Fig.* 4. Chap. III.

If you work (not by the *Equinoctial* Circle or Dial, but) by a Dialling Scale, then (beſides the fore-mentioned Particulars, wherein the drawing of this Dial differs from drawing an *Horizontal* Dial) it is alſo to be known, that upon the Line EW. from C towards E and W, muſt be ſet off the Extent (taken from the Scale of Latitude; not of the Latitude it ſelf, but) of the Complement of the Place's Latitude. See *Fig.* 5. 3. *To draw a* Direct South Dial *by a Dialling* Scale.

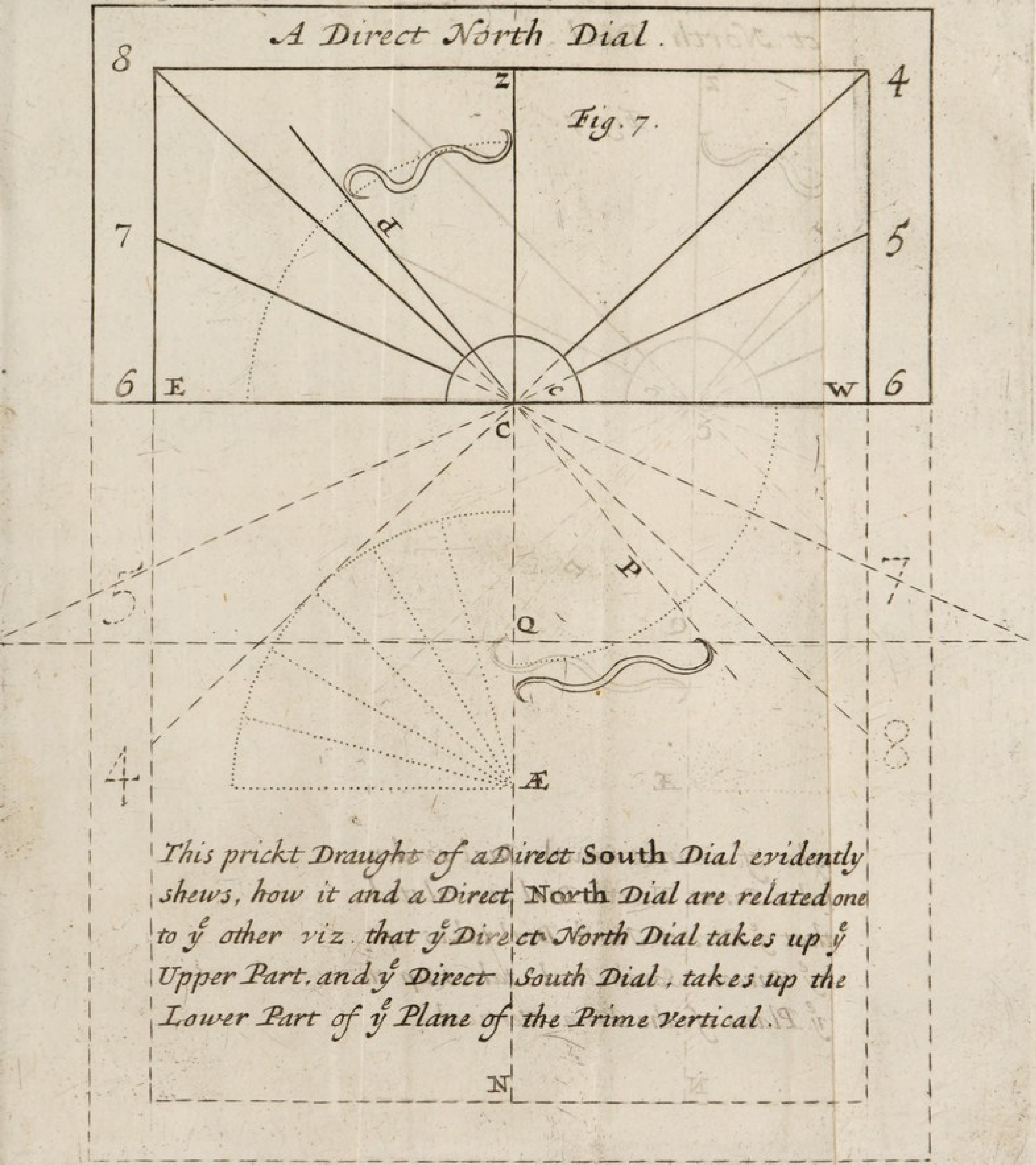
If you work by Tables, then the Degrees of the Angle, which every Hour-line makes with ZN the *Meridian* or Subſtyle, muſt be taken from the Table for a Prime Vertical or Direct South Dial. See *Fig.* 6. 4. *To draw the ſame by Dialling* Tables.

A Direct North Dial differing from a Direct South Dial primarily in this alone, that the former repreſents the north Side of the Plane of the Prime Vertical, and the latter the ſouth Side; hence the drawing of a Direct 5. *To draw a* Direct North Dial.

Chap. III. North Dial is the ſame, as of a Direct South Dial; excepting 1*ſt*, that the Hours requiſite to be inſcribed on this Dial in our Country are no more than theſe, *viz.* 4, 5, 6, in the Morning, and 6, 7, 8, in the Evening. For the Sun with us never riſes till after 3 in the Morning, and always ſets before 9 in the Evening; and from 6 in the Morning till 6 in the Evening it turns off from the North to the South Side of the Plane of the Prime Vertical. 2*dly*, Foraſmuch as the Style of this Dial repreſents the north Segment of the Axis, and ſo its End P repreſents the North Pole, therefore the End P muſt be placed looking upwards toward the North Pole. And conſequently that End of the Subſtyle, which anſwers to the End P of the Style, muſt Point towards the *Zenith*, and therefore is here properly to be denoted by Z, and the other End of the Subſtyle by N, as anſwering to the *Nadir*, contrary to the Poſition and Notation of them in a Direct South Dial. See *Fig.* 7.

As

A Direct North Dial.



This prickt Draught of a Direct South *Dial evidently shews, how it and a Direct* North *Dial are related one to ye other viz. that ye Direct North Dial takes up ye Upper Part, and ye Direct South Dial, takes up the Lower Part of ye Plane of the Prime Vertical.*

As to the Placing of a Direct South or North Dial, it will be more conveniently spoken of *Chap.* 5. Chap. III.

CHAP. IV.

Of an (*) *Erect Direct East or West* DIAL.

1. *To draw a* Direct East Dial.

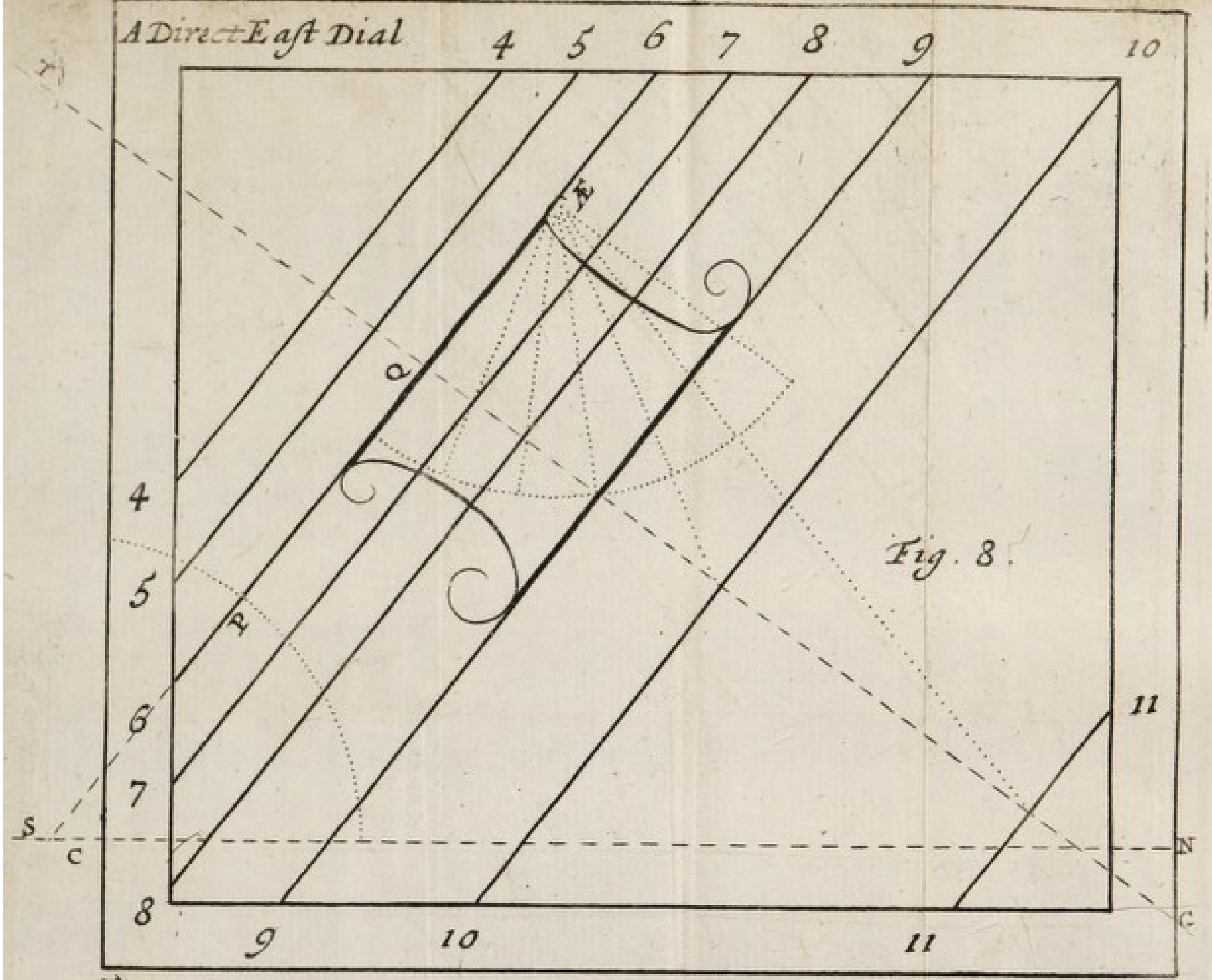
I Begin with a *Direct East* Dial, whose Plane represents the east Side of the Plane of the *Meridian*. Now to draw this Dial, there must be first drawn an *Horizontal* Line, *i. e.* a Line representing the *Horizon*, or running Parallel to it, and so level. One End of this Line will represent the north Point of the *Horizon*, and may therefore be fitly denoted by N; and the other End by S, as representing the south Point of the *Horizon*. See *Fig.* 8.

2. *To find the* Substyle.

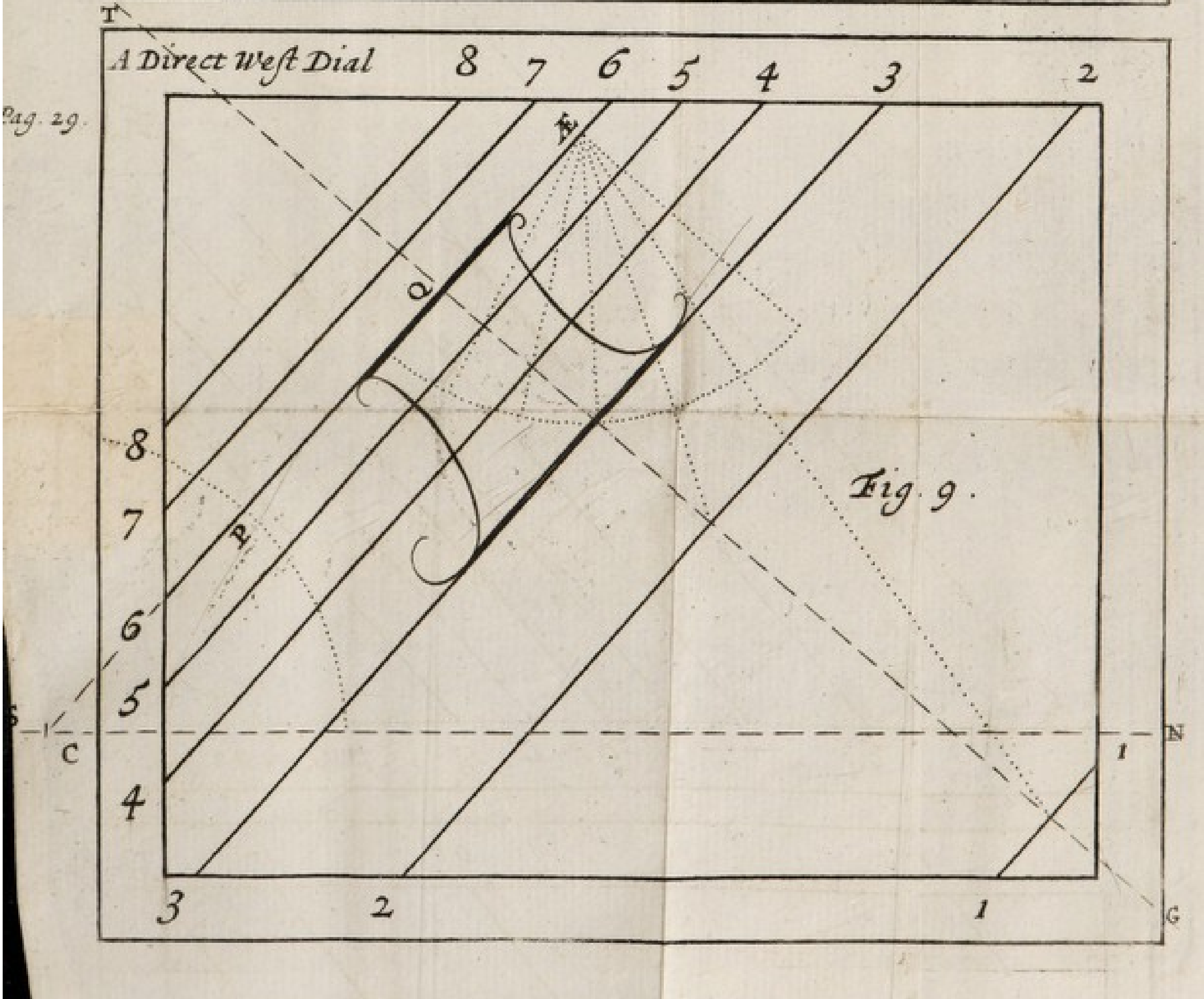
Taking any Point C towards S, the south End of the Line N S for a Center, describe an Arch toward N; and upon that Arch set off the Height P of the Pole, and draw the Line C P for the Substyle.

(*) These also are frequently stiled only *Direct East* or *West* Dials.

Having


A Direct East Dial
4 5 6 7 8 9 10
4 5 6 7 8
9 10 11
11
S C N G
Æ Q P
Fig. 8.

Pag. 29.


A Direct West Dial
8 7 6 5 4 3 2
8 7 6 5 4
3 2 1
1
T S C N G
Æ Q P
Fig. 9.

Having found the Subſtyle, draw thereon the Contingent Line T G; and then proceed to draw an (*) *Equinoctial* Dial, taking any point Æ in the Subſtyle for the Center of the ſaid *Equinoctial* Dial. That Diameter of the Semicircle (repreſenting Half the *Equinoctial* Circle) which runs Parallel to the Contingent, is here the *Meridian* of the *Equator*; from which you are to begin to divide the Semicircle into Hours, or into 6 equal Parts, each containing 15 Degrees. Through each of theſe Diviſions of the *Equinoctial* Semicircle draw Lines from Æ to the Contingent; and again through each Point of the Contingent, whereon the ſaid Lines fall, draw other Lines (†) parallel to the Subſtyle. Theſe laſt will be the Hour-lines; that which falls in with the Subſtyle C P being always the 6 a

Chap. IV.

3. *To draw the* Hour-lines.

(*) There is no Mention made of drawing a Direct Eaſt or Weſt Dial by *Scales* and *Tables*, becauſe it is in Effect done both Ways, by the Help of the *Equinoctial* Dial.

(†) Becauſe the Axis of the World runs *parallel* to the Plane of the *Meridian*, (as may be ſhown by the Dialling Sphere,) and ſo muſt be conceived to caſt its Shade parallel alſo to its ſelf.

Chap. IV. Clock Line; thoſe above it the Hour-lines of the Hours before 6, and thoſe below it the Hour-lines of the Hours after 6. Where it is to be noted, that as 4 and 5 are the only Hours before 6, which need be inſcribed on this Dial; becauſe the Sun never riſes to us till after 3; ſo the Hours to be inſcribed on this Dial after 6, are no more than 7, 8, 9, 10, and 11; foraſmuch as this Dial-plane repreſenting the Plane of the *Meridian*, the Sun ſhines not upon its Surface, but upon its ſouth Side or Edge, at 12 a Clock.

4. *To place the Style.* The Hour-lines being drawn, the Style is to be placed (*) parallel to the Subſtyle CP, and ſo far diſtant from it, as the Center Æ of the *Æquinoctial* was taken diſtant from the Contingent. And ſo the Dial is Finiſhed; as *Fig.* 8.

(*) Becauſe the Style repreſents the Axis of the World, which runs parallel to the Plane of the *Meridian*. Hence Direct Eaſt and Weſt Dials have *no Centers*, through which the Axis paſſes, and from which conſequently are to be drawn all the Hour-lines, as in *Horizontal* and Direct South and North Dials; which are therefore called *Central* Dials.

A

A *Direct West* Dial differing from a Direct East Dial primarily in this alone, that the former represents the west side of the Plane of the *Meridian*, and the latter the east side; hence the drawing of a Direct West Dial, is the same with that of a direct East Dial, excepting only the different denominations of the Hours to be inscribed on this Dial, *viz.* 1 to 8 in the Afternoon; which must be placed respectively from 6, (the Hour-line whereof always falls in with the Substyle,) as the Morning Hours are in a Direct East Dial. See *Fig.* 9.

Chap. IV.

5. *To draw a* Direct West *Dial.*

How these Dials, when drawn, are to be placed, so as to have a due Situation in respect of the Heavens, is shewn in the following Chapter.

CHAP. V.

Of duly PLACING *a Direct (East, or West, North, or South,) Dial; and of the Manner of finding, whether a Wall has a* DIRECT *or* DECLINING POSITION *or* SITUATION.

1. *A Dial is then duly* placed, *when* its Plane *answers to the* Plane of the Celestial Circle, *which it represents. In order whereto the* Dial-plane *must be placed* parallel *to its respective Celestial Plane.*

EVery Dial-plane representing the Plane of some Circle in the Heavens, therefore, when any Dial is drawn, that it may go true, it is requisite that its Plane be so placed, as to answer exactly to the Plane of the Celestial Circle, which it represents. Wherefore, if it be an *Horizontal* Dial, its Plane must be placed *Horizontally*, or parallel to the *Horizon*, i. e. exactly level. If it be any Vertical Dial, (as a direct North or South, East or West Dial,) it must be placed Vertically, *i. e.* perpendicular to the *Horizon*, or exactly Upright. Now the Instrument represented, *Fig.* 10. will shew, when any of the forementioned

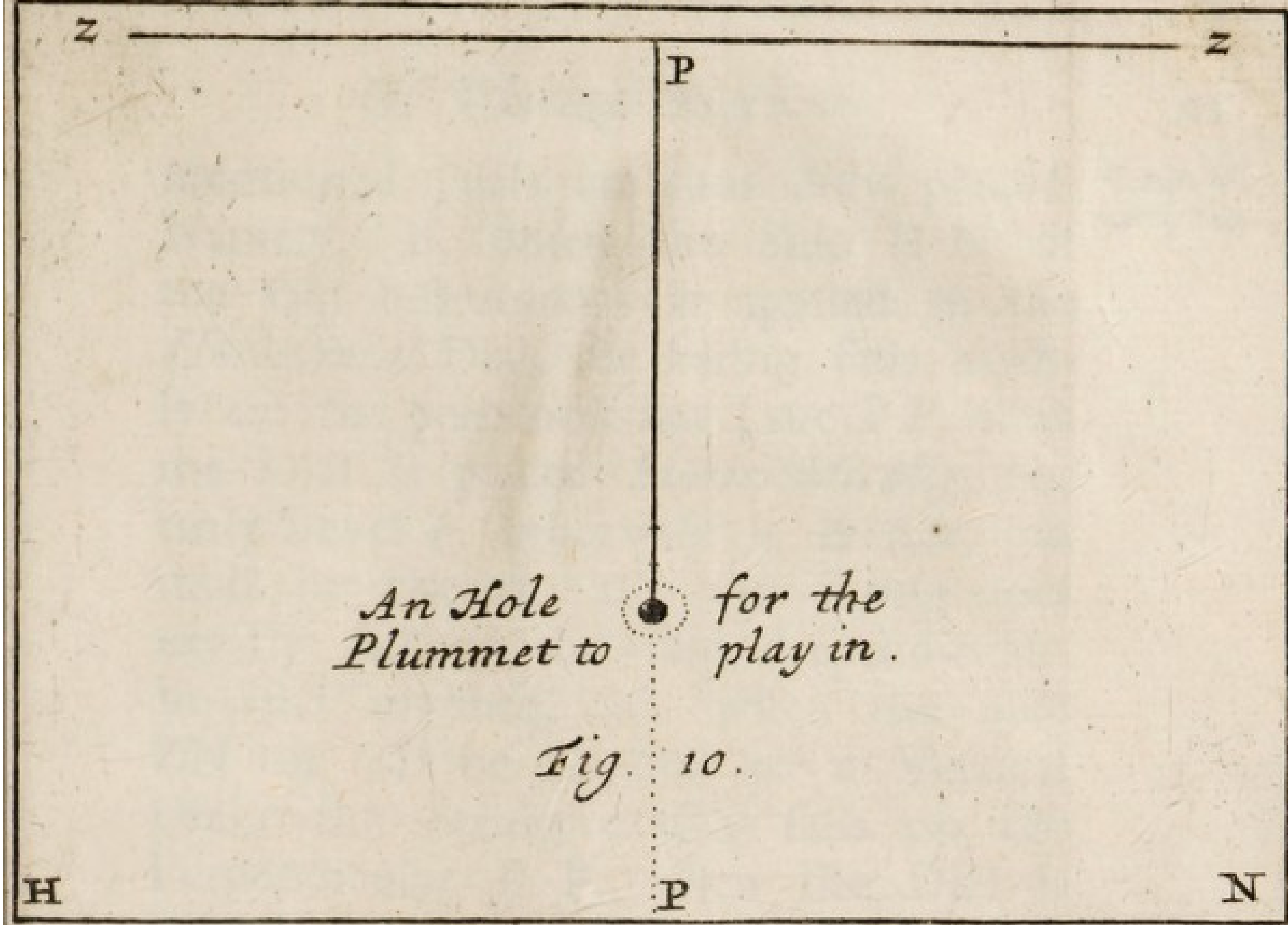


Fig. 10.

Pag. 33.

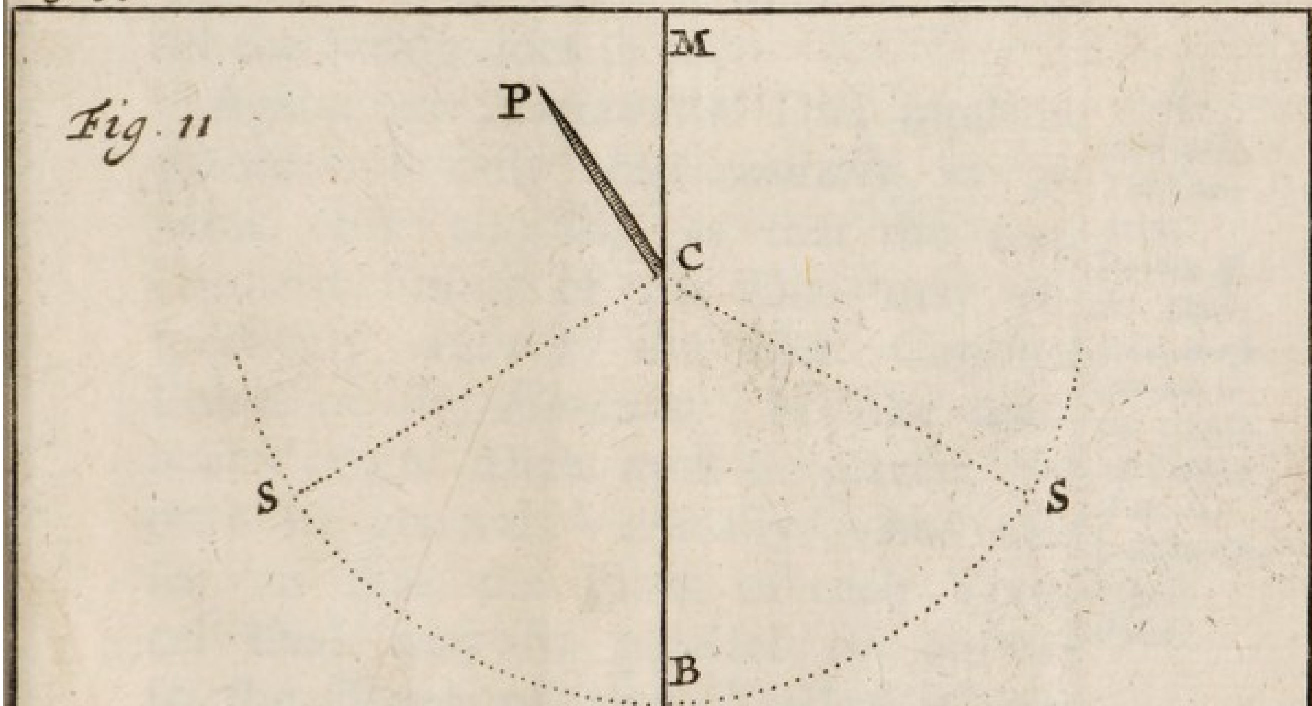


Fig. 11

A Plane, whose Meridian Line ML *is to be found*: C. *denotes ye Center or Place where ye Pin* C P. *is set up*: C S & C s *denote ye two shades of ye Pin*. B. *denotes ye middle point of the Arch* S B s

mentioned Dials are thus duly placed. Namely, if, when the Side H N of the ſaid Inſtrument be applied to the *Horizontal* Dial, the String falls exactly on the perpendicular Line P P, then the Dial is placed *Horizontically*, or truly Level; otherwiſe it is not, but muſt be altered, till the String does exactly fall on the ſaid Perpendicular. In like manner, if, when the Side ZN or ZH be applied to a Vertical Dial, the String exactly falls on the Perpendicular P P, then the Dial is placed Vertically, or truly Upright; otherwiſe it is not, but muſt be altered till the String does ſo fall.

Chap. V.

2. *And 2dly, The* Cardinal Points *of the Dial-plane muſt anſwer to the* Cardinal Points *of its reſpective Celeſtial Plane.*

Again, an *Horizontal* Dial muſt be placed not only *Horizontally* in general, but alſo ſo, as that the four Cardinal Points of the Dial may reſpectively anſwer the like Cardinal Points of the *Horizon*. In like manner Vertical Dials muſt be placed, not only in general Vertically, but alſo ſo, as that the Plane of each Vertical Dial may be parallel or anſwer to the Plane of that Vertical Circle in the Heavens, which it particularly has reſpect to. Thus the Plane of a Direct South or North Dial muſt

be

Chap. V. be ſo placed, as that it may be parallel to the Plane of the Prime Vertical, which it repreſents, and that it may reſpectively anſwer to the ſouth or north Side of the ſaid Plane of the Prime Vertical. In like manner, the Plane of a Direct Eaſt or Weſt Dial muſt be ſo placed, as that it may be parallel to, or fall in with the Plane of the *Meridian*, which it repreſents ; and that it may reſpectively anſwer to the eaſt or weſt Side of the ſaid *Meridian* Plane.

3. *To find the* Meridian Line *of any Plane or Place.*

Now in Order thus to place aright any of the fore-mentioned Dials, it is requiſite to find where the *Meridian* croſſes the Place, on which you would put the Dial. And this may be done ſeveral Ways. The moſt eaſy is by the Help of (what is called) the Mariners Needle, ſuppoſing it has none, or but little Variation in the Place where you are. For then the *Meridian* runs over, or parallel to the Length of the ſaid Needle. Another Way is by holding up a String, when the Sun is in its *Meridian* Altitude, (which is to be found by the Quadrant,) for then the ſhade of the String will repreſent the *Meridian* Line of of the Place where you are. Another Way, ſomewhat longer, but much ſurer, is this: Any Time in the Morning, when the Sun ſhines, erect any Pin or ſtraight piece of Iron or Wood, and mark where the End of its Shade falls. See *Fig.* 11. Chap. V.

Then on the Point, where the Pin was erected, as on a Center, draw a Circle paſſing through the other Point, where the End of the Pin's Shade fell. After which erecting the Pin again where it was, wait till the End of the Pin's Shade touches the Circle in ſome other Point. The Arch between the two Points of the Circle, on which the End of the Pin's Shade fell at the two ſeveral Times, being biſected or divided exactly in Half, a right Line drawn from the Center of the ſaid Circle (*i. e.* from the Point where the Pin was erected) through the Point of Biſection will be the *Meridian* Line of the Place where you are.

4. *To place aright an* Horizontal *Dial.*

The *Meridian* Line of the Place where you are, being thus found out by one or more of the fore-mentioned Ways, an *Horizontal* Dial is truly placed, Chap. V. placed, (ſo as that its Cardinal Points ſhall anſwer the like Points of the *Horizon*,) by placing the *Meridian* Line (or which is the ſame, the 12 a Clock Line) of the ſaid *Horizontal* Dial exactly upon, or parallel to the *Meridian* Line of the Place where you are. For the *Meridian* Line of the Dial being thus placed upon, or parallel to the *Meridian* Line of the Place, the North and South Points of the *Horizontal* Dial, being no other than the North and South Ends of the *Meridian* Line of the Dial, will anſwer to the North and South Points of the *Horizon* of the Place, theſe directly anſwering to the North and South Ends of the *Meridian* Line of the Place. And the North and South Points of the Dial being thus placed ſo, as to anſwer to the ſaid Points of the *Horizon*; the Eaſt and Weſt Points of the Dial (if rightly drawn) will likewiſe anſwer to the Eaſt and Weſt Points of the *Horizon*.

5. *To place aright a* Direct Eaſt *or* Weſt *Dial.*

The Method of placing aright a Direct North or South, Eaſt or Weſt (as well as of an *Horizontal*) Dial does likewiſe depend on the *Meridian*

an Line of the Place. For having Chap. VI.
found this by one or more of the Ways above mentioned, in order to place aright a direct East or West Dial, all that is to be done, is only this, *viz.* directly upon or parallel to the said *Meridian* Line of your Place, you must erect the Dial with the Face of it Eastward, if it be a direct East Dial; or Westward, if it be a direct West Dial.

In order to place aright a direct North or South Dial a little more is to be done. Namely, having found the *Meridian* Line of your Place, you must draw another Line crossing the former perpendicularly, which will be the Prime Vertical Line of the Place. Upon which therefore directly, or parallel to it, must be placed the Dial with the Face of it southward, if it be a direct South Dial; or northward, if it be a direct North Dial. 6.

To place aright a Direct South *or* North *Dial.*

Hitherto we have considered Dials, as drawn on *Moveable* Planes, or Planes not already Fixed. And on such as are usually drawn *Horizontal* Dials. But Vertical Dials, (whether 7.

Of Unmovable *or* *Fixed* Dial-*planes.*

Chap. V. ther Direct or Declining) are more usually drawn on *Unmoveable* or Fixed Planes, namely on the Sides of some Wall. Wherefore in order to draw a Vertical Dial on a Wall, it is requisite first to know, whether the Wall be a direct East or West, North or South Wall, or a Declining Wall; and if the latter, how great its Declination is.

8. *To know when a Wall is* Direct *East or West, North or South.*

Now there are several Ways delivered in Treatises of Dialling for to do this; but such as require, either a peculiar Instrument called from its Use a *Declinatory*, or else the Sun's *Azimuth* to be taken, or both. Wherefore I think the following Method is to be preferred before any other, on Account of its Easiness, and withal Exactness. To the Wall, whose Situation you would know, adjoin a Board so, as that one of its Sides may touch the Wall, and the Surface of the Board may lie *Horizontally*, and fast. Upon the Board thus prepared find the *Meridian* by the last of the three Ways abovementioned, and draw a Line on the Board representing the same, which therefore

Dial. Plate 7.

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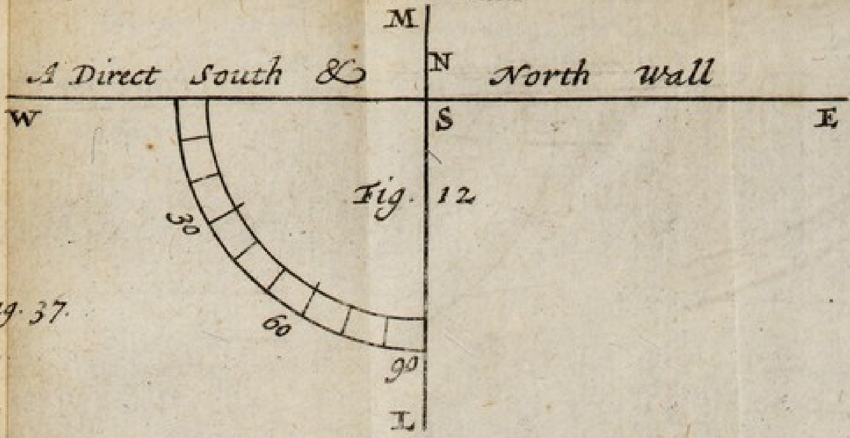

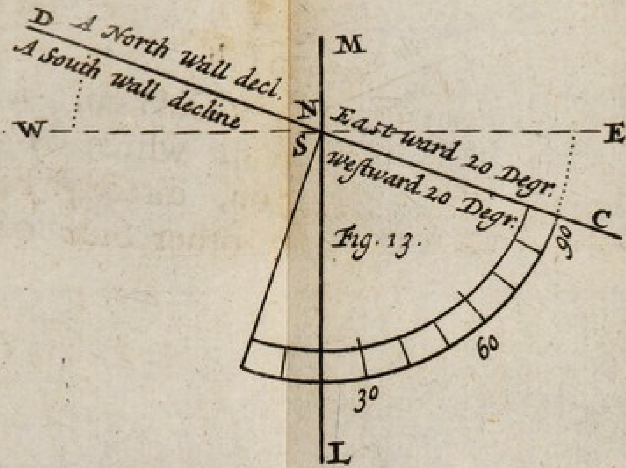

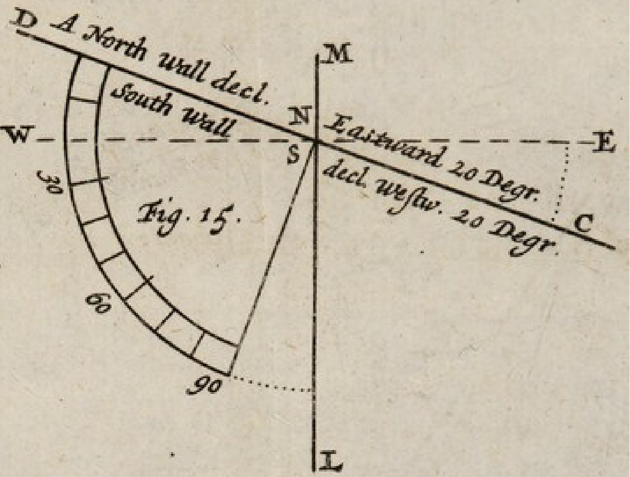

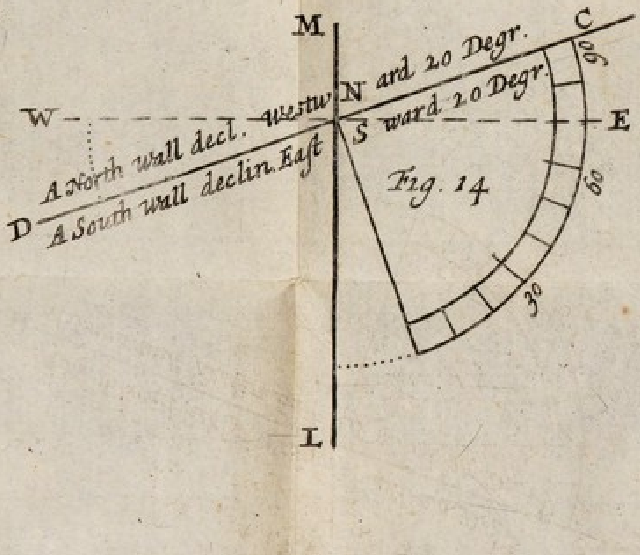

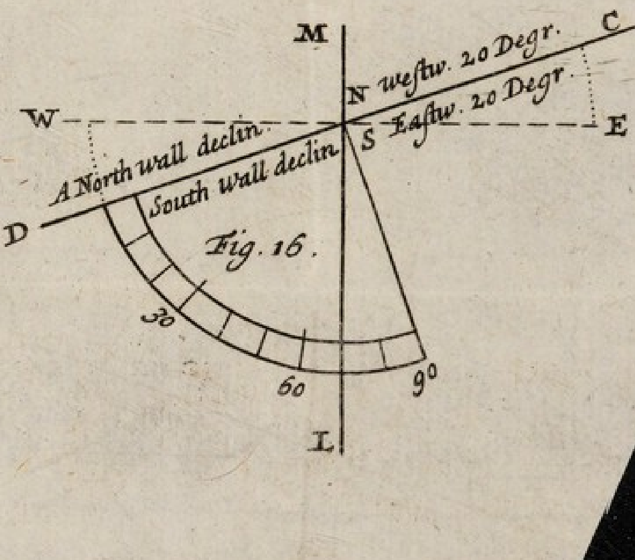

therefore we call the *Meridian* Line. Chap. V.
If the *Meridian* Line falls in with, or runs Parallel to your Wall, then it is a direct East or West Wall. If not so, then lay a Quadrant flat upon the said Board, with one of its Sides or Edges applied to the Wall, and its Center at the same Time on the *Meridian* Line. If the other Side falls upon the *Meridian* Line drawn on the Board, then the Wall is a direct North and South Wall, *i. e.* that Side of the Wall which is toward the Sun and you, directly Faces the South; and the other Side of it consequently Faces directly the North. See *Fig.* 12.

9. *To know when a Wall* declines.

But if when one Side of the Quadrant is applied to the Wall as afore, the other Side does not fall upon the *Meridian* Line on the Broad, then it is a declining Wall. And if when the right Side or Edge of the Quadrant is applied to the Wall, the *Meridian* Line of the Board is beyond, or without the other Side of the Quadrant, then the Wall in respect of its south Side declines Eastward, in respect of its north Side Westward,

(as

Chap. V. (as *Fig.* 14.) but if the *Meridian* Line of the Board be within the left Side of the Quadrant, then the Wall in reſpect of its ſouth Side declines Weſtward, in reſpect of its north Side Eaſtward, as *Fig.* 13. On the contrary, if the left Side or Edge of the Quadrant be applied to the Wall, and the *Meridian* Line on the Board be without the right Side of the Quadrant, then the Declination of the Wall in reſpect of its ſouth Side is Weſtward, in reſpect of its north Side Eaſtward (as *Fig.* 15.): but if the ſaid *Meridian* Line be within the right Side of the Quadrant, then the Declination of the Wall in reſpect of its ſouth Side is Eaſtward, and in reſpect of its north Side Weſtward, as *Fig.* 16.

10. *To find the Degrees of Declination.* Having thus found, whether the Wall declines Eaſtward or Weſtward, it remains to find, how great its Declination is. Now, as when, one Side of the Quadrant being duly applied (as afore) to the Wall, the other Side falls exactly upon the *Meridian* Line of the Board, the Wall has no Declination; ſo when the other

other Side of the Quadrant does not fall exactly upon the said *Meridian* Line, then the Number of Degrees contained in the Angle made by the said other Side of the Quadrant, and the said *Meridian* Line is the Measure of the Declination. Wherefore as often as the said *Meridian* Line falls within the Quadrant, the Number of Degrees intercepted between the said *Meridian* Line, and that Side or Edge of the Quadrant which is not applied to the Wall, is the Measure of the Wall's Declination. But if the *Meridian* Line falls without the Quadrant, then having drawn on the Board a Circle, with a Ray equal to that of the Quadrant, and upon that Point of the *Meridian* Line whereon you place the Center of the Quadrant, as the Center of the said Circle, thereupon take with the Compasses the Distance between the *Meridian*, and that Edge of the Quadrant, which is not applied to the Wall: The said Distance applied to the Division of the Quadrant into 90 Degrees, will thereby shew the Measure of the Wall's Declination.

Chap. V.

11. *Illustration by Examples.*

All that has been aforefaid, is illustrated by (*) *Fig.* 12, 13, 14, 15, and 16. In each of which the Line ML denotes the *Meridian* Line; the Line EW denotes the Plane of the Prime Vertical, or (which comes to the fame) the Plane of a direct South Wall or Dial; and confequently E denotes the true Eaft Point, W the true Weft Point, ESW the South Side of the Plane of the Prime Vertical, or a direct South Wall; ENW the north Side of the Plane of the Prime Vertical, or a direct North Wall: the Line DC denotes a declining Wall. Wherefore it is evident, that in *Fig.* 12. one Edge of the Quadrant being duly applied to EW the Wall, on the fouth Side of it ESW, the other will fall upon the *Meridian* Line, ML drawn on the Board; and thereby fhew, that the faid Wall EW has no Declination. But in *Fig.* 13. the right Edge

(*) From all thefe Figures it is evident, that the Declination of a Wall or Dial, is the Arch WD or EC of the *Horizon* intercepted between the Plane of the Prime Vertical, and of the Wall or Dial.

of

Chap. V.

of the Quadrant being applied to D C the declining Wall, and the *Meridian* Line M L falling within the other Side of the Quadrant, thereby is ſhewn, that the Wall declines weſtward, and alſo that the Meaſure of the Declination is 20 Degrees, this being the Number of the Degrees intercepted between the left Side of the Quadrant, and the *Meridian* Line M L. In *Fig.* 14. the right Edge of the Quadrant being applied to D C the Wall, and the *Meridian* Line M L falling without the left Edge of the Quadrant, I take with my Compaſſes, on a Circle deſcribed as above directed, the Diſtance between ML the *Meridian* Line, and the left Edge of my Quadrant, and applying the ſame to the Diviſion of the Quadrant into 90 Degrees, I find the Meaſure of the ſaid Diſtance to be 20 Degrees; which conſequently is the Meaſure of the Declination of the Wall D C eaſtward. And after the ſame Manner, the fore-mentioned Method of finding the Declination of a Wall may be illuſtrated in all other Reſpects.

Having thus ſhewn how to find the Declination of a Wall, it remains only to ſhew how to draw a Dial upon a declining Plane or Wall.

CHAP.

Dial. Plate 8.

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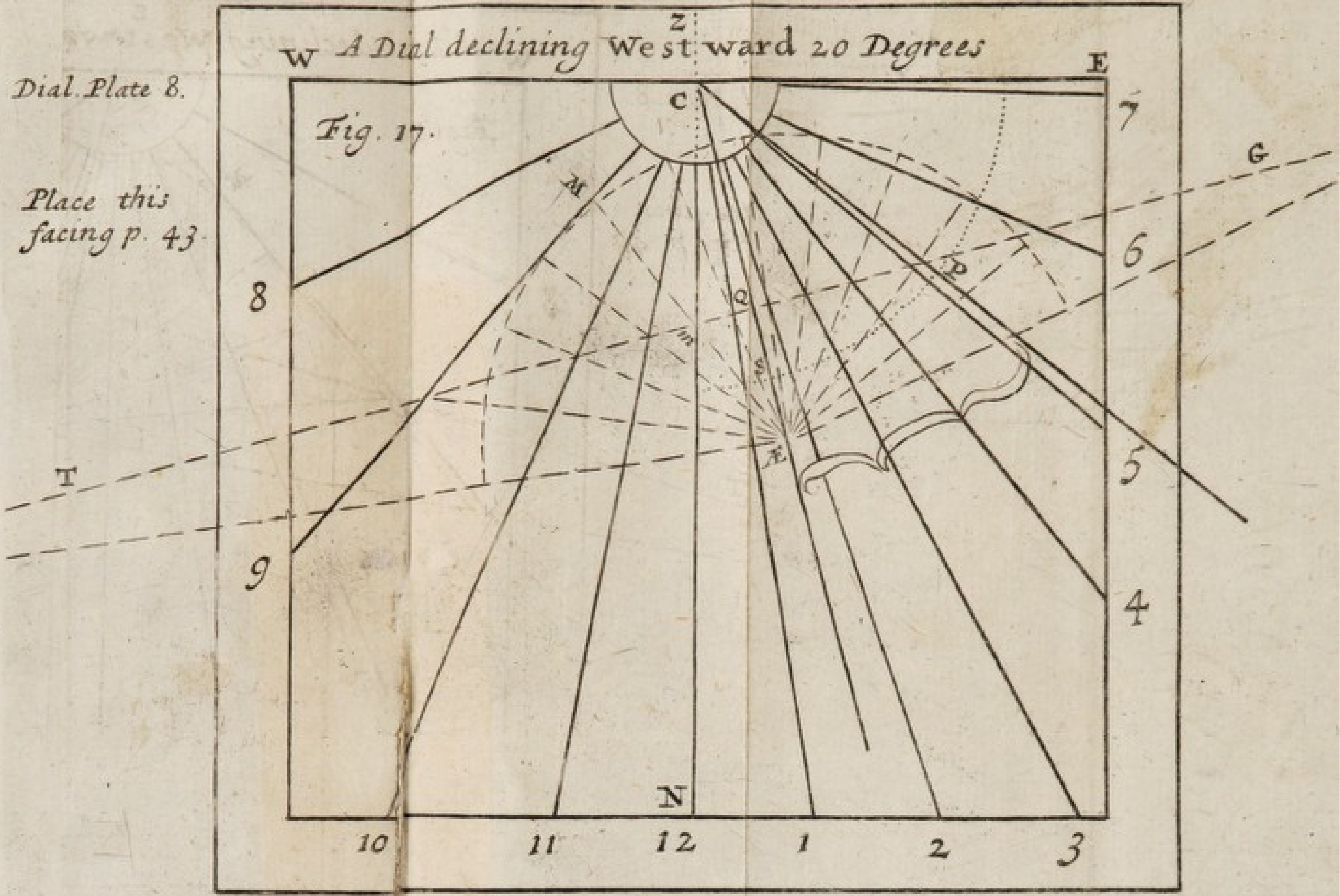
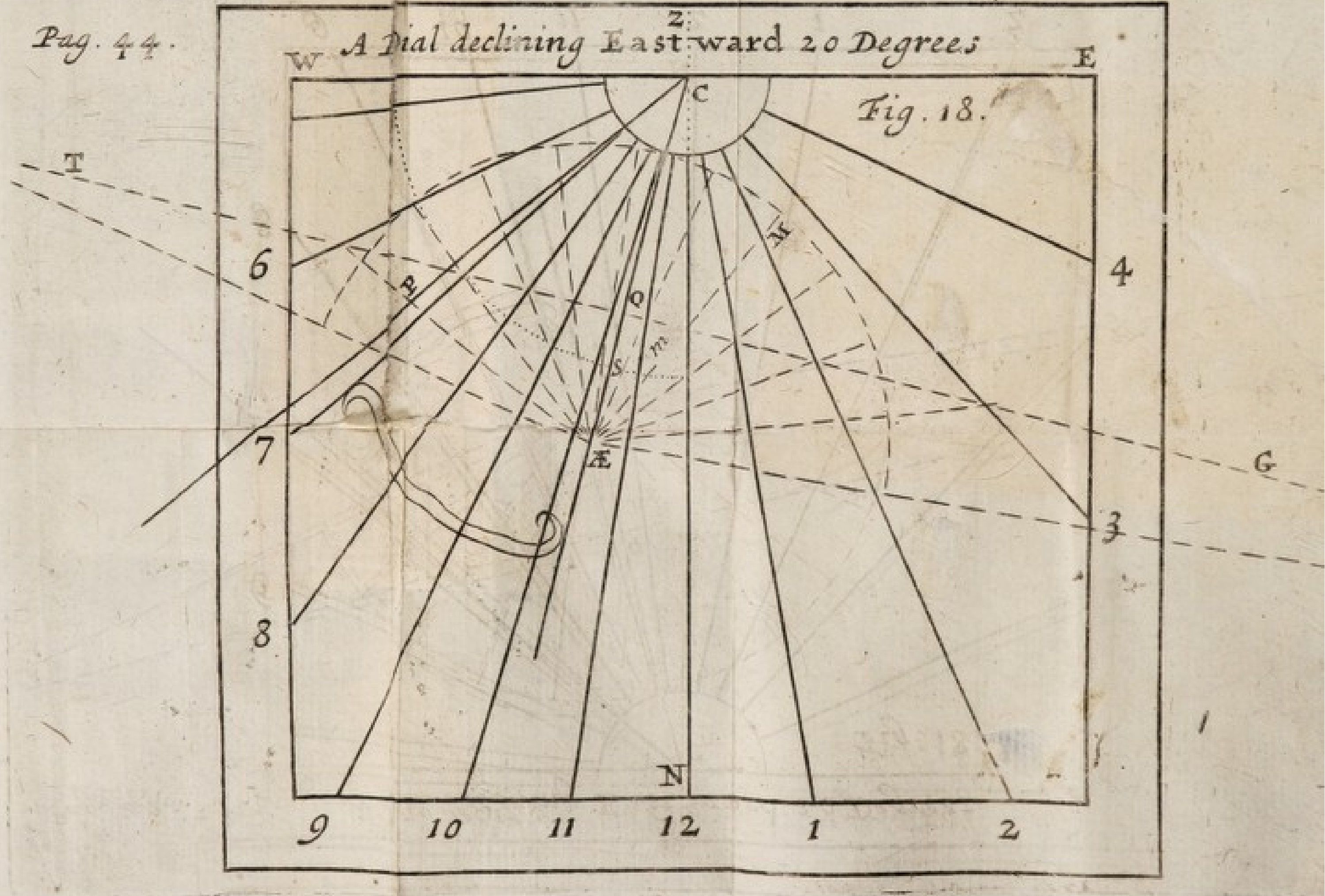
A Dial declining Westward 20 Degrees



Pag. 44.

A Dial declining Eastward 20 Degrees



CHAP. VI.

Of drawing a DECLINING *Dial.*

THE principal Difficulty in drawing a Declining Dial, is in finding the Diſtance of the Subſtyle from the *Meridian* or 12 a Clock Line, and the Height of the Style above the Subſtyle. Now to remove this Difficulty, there is adjoined to the End of this Chapter, a Table ſhewing the ſaid Particulars, anſwerable to any Degree of Declination, and which will ſerve for moſt Parts of *England*. 1. *The chief* Difficulty *in drawing a* Declining *Dial.*

Having then drawn (as in a Direct South or North Dial) two Lines croſſing each other perpendicularly, one ZN repreſenting the *Meridian*, the other EW repreſenting the Prime Vertical; if you work by dialling-Tables, turn to the ſaid Table (*viz.* Tab. III.) and ſee what is the Subſtyle's Diſtance from the *Meridian* anſwerable to the Declination of 2. *To find the* Subſtyle *and* Style *of a Declining Dial by Dialling* Tables.

Chap. VI. the Wall, which, supposing the Declination 20 Degrees, will be 15 Degrees, 5 Minutes. Then draw an Arch from ZN to EW, on the west Side of ZN, if the Declination be eastward; and on the east Side, if the Declination be westward. On the said Arch set off from ZN the found Distance of the Substyle, *viz.* at S in *Fig.* 17 and 18. The Line CS, drawn from C (the Intersection of ZN and EW, and the Center of the Dial) to S, will be the Substyle. Then in the Table see what is the Style's Height answerable to the Declination, *v. g.* of 20 Degrees, and it is 35 Degrees, 34 Minutes. Set this off from S to P, and draw the Line CP which will shew the Style.

3. *To draw the* Hour-Lines.

Having found the Substyle and the Style, draw (as afore in an *Horizontal*, and direct South or North Dial) the Contingent Line crossing the Substyle at right Angles in any Point Q: only the Substyle CS being here different from the *Meridian* ZN, mark the Point *m* of the *Meridian*, where it

Chap. VI.

it is croſſed by the Contingent. Then taking (as afore in the other Dials) the Point Æ in the Subſtyle for the Center of an *Equinoctial* Dial, draw a (*) Semicircle; one Half of it being on one Side of the Subſtyle, and the other Half on the other Side. After which draw the Line Æ M cutting rhe *Equinoctial* Semicircle in M. The Line *Æ M* will be the *Meridian* of the *Equinoctial* Dial, from which you are to begin to divide on each Side the *Equinoctial* Semicircle into *Hours*, or ſix equal Parts. Lines drawn from Æ through the ſaid Diviſions to the Contingent will be the *Equinoctial*

(*) It is to be obſerved, that in Declining Dials the entire Semircle muſt be drawn; and it is not ſufficient to draw only one Half of the Semicircle as in Direct South and North Dials, foraſmuch as the *Meridian* or 12 a Clock Line of the *Equator*, not falling in with the *Meridian* or 12 a Clock Line of the Declining Dial, (as it does in Direct North and South Dials,) hence the Diviſions on each Side the 12 a Clock Line of the *Equinoctial*, will not cut the Contingent at equal reſpective Diſtances, as in Direct North and South Dials.

Chap. VI. Hours. And consequently Lines drawn from C the Center of the declining Dial to the same Points of the Contingent, whereon the *Equinoctial* Hour-lines fall, will be the Hour-lines for the declining Dial, (as afore in an *Horizontal* and Direct North or South Dial,) and so the Dial will be finished. See *Fig.* 17. and 18.

4. *The Conclusion.* And thus I have gone through those Elements of Dialling, which I judge most requisite to be known by Young Gentlemen, at least at their first Institution in the said Art or Science. What follows, are such Dialling *Tables* as are requisite to this Treatise; which though calculated indeed for the Latitude of *Oxford*, (*viz.* 51 Degrees, 45 Minutes,) yet will serve without any sensible Difference for most Parts of *England*. The Dialling *Scales*, or rather the Way of drawing Dialling Scales, *viz.* the Lines or Scales of *Latitude* and of *Hours*, (both mentioned and made use of in this Treatise) as also of *Inclination of*

Meridians,

The Geometrical way of drawing Lines or Scales of Hours, Latitudes, Declination or Chords.

Dial. Plate 9.

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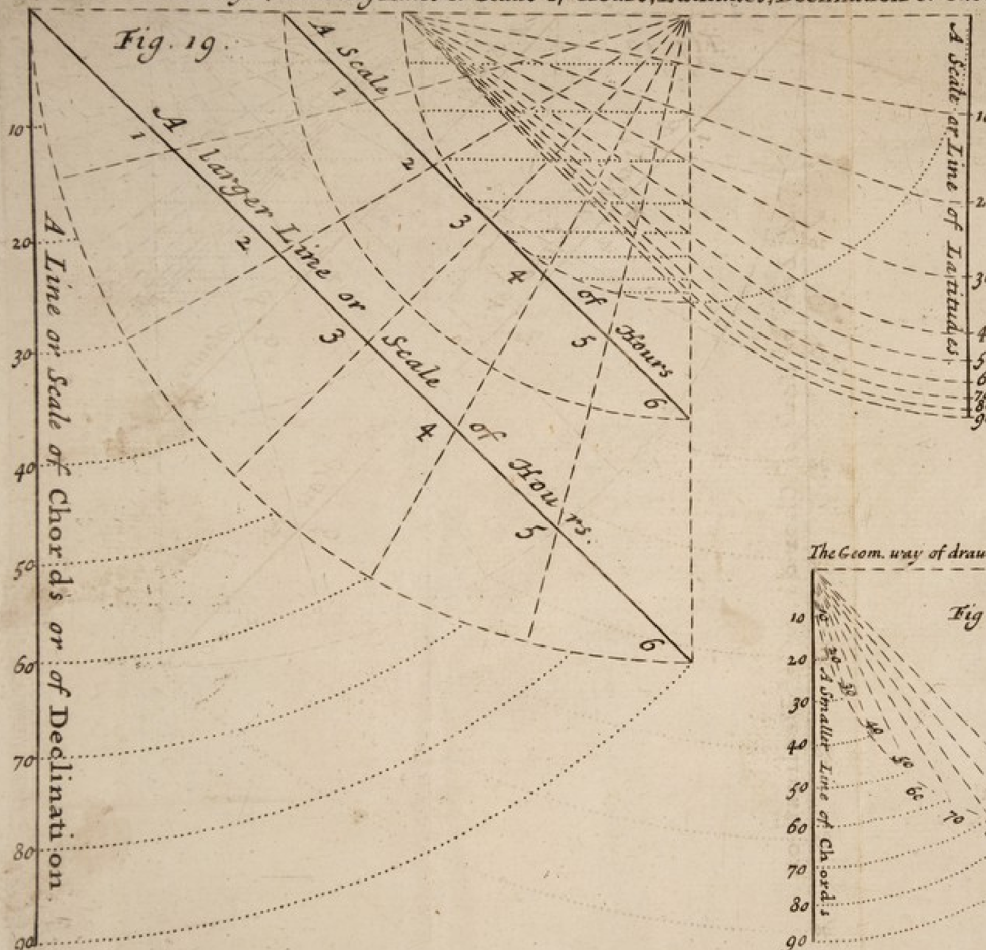
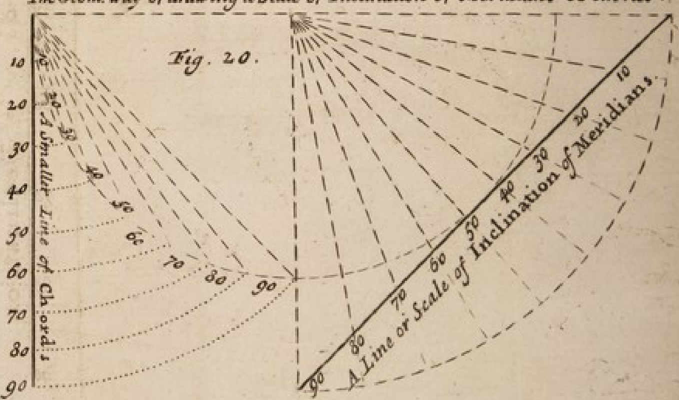
Fig. 19.



The Geom. way of drawing a Scale of Inclination of Meridians & Chords.

Fig. 20.



Meridians, and of *Declination* (not mentioned in this Treatiſe, but put into all Dialling Scales) is repreſented *Fig.* 19. and 20.

TAB. I.

Shewing what Angle every Hour-line, (as also Quarter, Half, and three Quarters of an Hour) makes with the *Meridian* or twelve a Clock Line, in an *Horizontal* Dial.

Hours.		Degree.	Minutes.
	12	00 .	00 .
	1	02 .	57 .
	2	02 .	54 .
	3	08 .	52 .
11 .	1	11 .	53 .
	1	14 .	55 .
	2	18 .	01 .
	3	21 .	10 .
10 .	2	24 .	23 .
	1	27 .	41 .
	2	31 .	04 .
	3	34 .	33 .
9 .	3	38 .	09 .
	1	41 .	51 .
	2	45 .	40 .
	3	49 .	36 .
8 .	4	53 .	40 .
	1	57 .	53 .
	2	62 .	11 .
	3	66 .	37 .
7 .	5	71 .	09 .
	1	75 .	38 .
	2	80 .	29 .
	3	85 .	14 .
6 .	6	90 .	00.

TAB. II.

Shewing the like Angles in a *Direct South* or *North* Dial.

Hours.		Degrees.	Minutes.
	12	00 .	00 .
	1	02 .	19 .
	2	04 .	40 .
	3	07 .	01 .
11 .	1	09 .	25 .
	1	11 .	52 .
	2	14 .	23 .
	3	16 .	58 .
10 .	2	19 .	40 .
	1	22 .	28 .
	2	25 .	24 .
	3	28 .	30 .
9 .	3	31 .	46 .
	1	35 .	13 .
	2	38 .	54 .
	3	42 .	49 .
8 .	4	47 .	00 .
	1	51 .	27 .
	2	56 .	13 .
	3	61 .	15 .
7 .	5	66 .	36
	1	72 .	11
	2	77 .	00
	3	83 .	58
6 .	6	90.	00.

TAB.

TAB. III.

Shewing the *Diſtance of the Subſtyle* from the *Meridian*, and the *Height of the Style* above the Subſtyle, anſwerable to the ſeveral Degrees of *Declination*.

Declination.	Subſtyle's Diſtance from the *Meridian*.		Style's Height above the Subſtyle.	
Degrees.	Degrees.	Minutes.	Degrees.	Minutes.
1	0 .	47	38 .	14
2	1 .	34	38 .	13
3	2 .	21	38 .	11
4	3 .	8	38 .	8
5	3 .	55	38 .	5
6	4 .	42	38 .	0
7	5 .	28	37 .	55
8	6 .	14	37 .	49
9	7 .	2	37 .	42
10	7 .	48	37 .	34

Decli-

TAB. III.

Declination.	Substyle's Distance from the *Meridian.*		Style's Height above the Substyle.	
Degrees.	Degrees.	Minutes.	Degrees.	Minutes.
11	8 .	33	37 .	26
12	9 .	18	37 .	16
13	10 .	2	37 .	6
14	10 .	48	36 .	55
15	11 .	32	36 .	43
16	12 .	15	36 .	31
17	12 .	59	36 .	18
18	13 .	41	36 .	2
19	14 .	24	35 .	50
20	15 .	5	35 .	34
21	15 .	47	35 .	19
22	16 .	27	35 .	2
23	17 .	7	34 .	44
24	17 .	47	34 .	26
25	18 .	15	34 .	8
26	19 .	4	33 .	49
27	19 .	41	33 .	29
28	20 .	19	33 .	8
29	20 .	55	32 .	47
30	21 .	31	32 .	25
31	22 .	6	32 .	3
32	22 .	40	31 .	40
33	23 .	14	31 .	17
34	23 .	47	30 .	53
35	24 .	19	30 .	28

Decli-

TAB. III.

Declination.	Substyle's Distance from the *Meridian.*		Style's Height above the Substyle.	
Degrees.	Degrees.	Minutes.	Degrees.	Minutes.
36	24 .	52	30 .	3
37	25 .	23	29 .	36
38	25 .	53	29 .	12
39	26 .	23	28 .	45
40	26 .	52	28 .	18
41	27 .	21	27 .	51
42	27 .	49	27 .	23
43	28 .	16	26 .	55
44	28 .	42	26 .	26
45	29 .	8	25 .	57
46	29 .	33	25 .	29
47	29 .	58	24 .	58
48	30 .	22	24 .	28
49	30 .	45	23 .	58
50	31 .	8	23 .	27
51	31 .	30	22 .	56
52	31 .	51	22 .	24
53	32 .	12	21 .	52
54	32 .	32	21 .	20
55	32 .	51	20 .	48
56	33 .	10	20 .	15
57	33 .	28	19 .	42
58	33 .	46	19 .	9
59	34 .	3	18 .	35
60	34 .	19	18 .	2

Decli-

TAB. III.

Declination.	Substyle's Distance from the *Meridian.*		Style's Height above the Substyle.	
Degrees.	Degrees.	Minutes.	Degrees.	Minutes.
61	34 .	35	17 .	28
62	34 .	50	16 .	54
63	35 .	5	16 .	19
64	35 .	19	15 .	45
65	35 .	32	15 .	10
66	35 .	46	14 .	35
67	35 .	58	14 .	0
68	36 .	10	13 .	44
69	36 .	21	12 .	49
70	36 .	32	12 .	13
71	36 .	42	11 .	38
72	36 .	51	11 .	2
73	37 .	1	10 .	26
74	37 .	9	9 .	34
75	37 .	17	9 .	13
76	37 .	25	8 .	37
77	37 .	22	8 .	9
78	37 .	37	7 .	24
79	37 .	44	6 .	47
80	37 .	50	6 .	10
81	37 .	54	5 .	41
82	37 .	59	4 .	57
83	38 .	2	4 .	19
84	38 .	6	3 .	43
85	38 .	9	3 .	5

TAB. III.

Declination.	Substyle's Distance from the *Meridian.*		Style's Height above the Substyle.	
Degrees.	Degrees.	Minutes.	Degrees.	Minutes.
86	38 .	11	2 .	29
87	83 .	13	1 .	52
88	38 .	14	1 .	12
89	38 .	14	0 .	37
90	38 .	15	0 .	0

A CATALOGUE of the ſeveral Draughts of Dials, and other Cuts, belonging to this Treatiſe.

Fig. 1. AN Horizontal *Dial drawn by the Help of the* Equinoctial *Dial.*

2. *An* Horizontal *Dial drawn by the Help of dialling* Scales.

3. *An* Horizontal *Dial drawn by the Help of Dialling* Tables.

4. *A* Direct South *Dial drawn by the Help of the* Equinoctial *Dial.*

5. *A*

5. *A* Direct South *Dial drawn by the Help of* Scales.

6. *A* Direct South *Dial drawn by the Help of* Tables.

7. *A* Direct North *Dial.*

8. *A* Direct East *Dial.*

9. *A* Direct West *Dial.*

10. *The Draught of an Instrument, whereby to find, whether a Dial-plane be truly* Horizontal, *or* Erect.

11. *The Draught of the most exact Method for finding the* Meridian *of a Place or Dial-plane.*

12, 13, 14, 15, 16. *Several Draughts representing the Method to find whether a Wall be* Direct *or* Declining; *and if declining,* how many Degrees *it has of* Declination.

17. *A Dial* declining Westward 20 *Degrees.*

18. *A Dial* declining Eastward 20 *Degrees.*

19. *The Geometrical Way of drawing Lines, or Scales of* Hours, *of* Latitudes, *and also of* Declination, *or (which comes to the same) of* Chords.

20. *The Geometrical Way of drawing* a *Line or Scale of the* Inclination of Meridians.

FINIS.

HIBERNIAN ACADEMY

PRÆMIA LAUDI