AN

HUMBLE ADDRESS

To the Right Honourable the

LORDS,

And the reſt of the Honourable

COMMISSIONERS,

Appointed by Act of Parliament to judge of all Performances Relating to the

LONGITUDE;

Wherein it is demonſtrated from Mr. FLAMSTEED's Obſervations, that by the late incomparable Sir ISAAC NEWTON's Theory of the *Moon*, as it is now freed from ſome Errors of the Preſs, the LONGITUDE may be found by *Land* or *Sea*, either Night or Day, when the *Moon* is viſible, and in proper Weather, within very few Miles of Certainty.

By R. W. The Author of

VIATICUM NAUTARUM,

Now lying before the Honourable COMMISSIONERS.

LONDON: Printed for *T. Page*, *W.* and *F. Mount*, at *Tower hill*; *John Osborn* and *Thomas Longman* in *Pater-noſter-row*: and *James Anſdell*, Bookſeller in *Liverpool*, 1728.

May it pleaſe your

HONOURS,

YOU will remember, that ſome time ago there was preſented to your Hands, a Treatiſe relating to the *Longitude*, Entituled *VIATICUM NAUTARUM*; Wherein the Author encouraged from the great Encomiums given of Sir *Iſaac Newton*'s Theory of the *Moon*, by Three very celebrated Mathematicians, undertakes thereby to diſcover the *Longitude* at Sea. He does not now retract what he then advanced; but rather begs Leave to repeat to Your Honours, and to reinforce thoſe Methods he then propoſed of finding the *Moon*'s Place by Obſervation. For altho'a certain Gentleman refuſed to preſent the aforeſaid Book to Sir *Iſaac Newton*, objecting there was nothing New in it (which it is ſtrange he ſhould tell without peruſing it) yet, the Author knows they are all New to him, and thinks they will appear ſo to the Learned; ſince he is not an utter Stranger to the Books of *Aſtronomy* and *Navigation* now extant.

As to the *Theory* it ſelf, the Teſtimony of thoſe great Men, was of ſuch Weight with him, that he thought he might ſafely depend thereon, ſo as to venture to make Tables agreeable thereto, which with great Pains he has done, and uſed the utmoſt Fidelity and Accuracy he poſſibly could in the making of them. But hearing ſince, the very ſagacious and learned Dr. *Halley*, has by his own Obſervations found the *Theory* to be Erroneous ſometimes, even to 5 or 6 Minutes of Motion; the Author thought he had a new Task incumbent upon him, to examine the *Theory* himſelf; which accordingly he has done, and with all the Fidelity poſſible compared with Mr. *Flamſteed*'s Obſervations, whoſe Authority he ſuppoſes will be undeniable. And he finds that the *Theory* being freed from ſome Errors of the Preſs, under which it certainly labours, (as printed in Dr. *Gregory*'s *Aſtronomy*) and reſtored to its original Exactneſs, as it undoubtedly came from the Hands of its prodigiouſly ingenious Author, will reduce thoſe 5 or 6, and perhaps ſometimes more Minutes, to a few Seconds of Motion ; by which Means the *Moon*'s Place will be ſo nearly given, that the *Longitude* (if due Care be taken) may be found thereby, either preciſely exact, or within very few Miles of Certainty.

Perhaps it will be look'd upon as an unpardonable Preſumption, to attempt even the moſt minute Alteration in any of Sir *Iſaac*'s incomparable Works. This muſt certainly be allow'd, when they are proved to be His. But there is one main Error in the printed *Theory*, which would be a Reproach to his immortal Memory to let paſs for His, even a manifeſt Inconſiſtency, ſuch as will appear to any tolerable Mathematician to require an Alteration. And therefore an Alteration is made, and that a true one, as will be proved in it's proper Place. In the mean time YOUR HONOURS will be pleaſed to excuſe the Repetition of ſome of thoſe Methods of finding the *Moon*'s Place by Obſervation, ſince probably the Book may be long ſince thrown aſide, or your more neceſſary Thoughts may have thruſt them out of your Memory. The firſt whereof, if perhaps not altogether ſo practicable at Sea, yet will certainly diſcover the *Longitude* of any Sea Port ; by which the Sailor may examine his Charts, which 'tis to be feared, may in ſome Caſes want to be rectified.

The Method is this ; Suppoſe two *Fixed Stars* to have the ſame Right Aſcenſion, or to come to the Meridian preciſely at the ſame time, and let one of them be ſuppoſed in or near the Equinoctial, the other to have 60 or 70 Degrees of Declination ; the greater the better, provided they be both betwixt the Zenith and the Horizon. Now it is undeniably certain, that theſe Stars will never be in the ſame Azimuth or Vertical Circle, but when they are upon the Meridian ; for the higher Star will till then be always to the Eaſtward of the lower, and afterwards to the Weſtward ; and in 2 or 3 Seconds a Variation may be perceived. When therefore theſe Stars are in one Azimuth, which may be eaſily known by a Plumb-Line, ſuch as ſhall hereafter be deſcribed ; one may exactly know the True or Apparent Time of the Night, by having their Right Aſcenſion exactly known from the Tables, truly made from Mr. *Flamſteed*'s Catalogue, and adjuſted to the Year 1726. by his Rules of of Variation. Likewiſe, having their Declination given with the ſame Exactneſs, by taking the Meridian-Altitude of either Star; but rather the higher, as being free from the Errors of Refraction, (and Parallax, they have none unleſs an Annual.) You may exactly find the Latitude by ſuch a Teleſcopic Quadrant, as will be hereafter fully deſcribed. Theſe, one would be inclined to think are no contemptible DATA. And if the Center of the Moon were ſuppoſed in the place of the higher Star, the Caſe would be the ſame; for her Motion Eaſtward in her own Orbit is as nothing, or bears no Proportion to the quickneſs of the change of the Azimuth. This it is deſired may be particularly taken Notice of and remembred, for a further Uſe to be made of it.

All that hath been here ſaid will appear plainly by Figure 1, where ZHNO repreſents the Meridian, HO the Horizon, Z the Zenith, N the Nadir, being the Poles of the Horizon, ÆQ the Equinoctial, P the North Pole thereof, S the South, (*s*) a Star in the Equinoctial, (*t*) a Star having 70 deg. of Declination, P s t S an Hour Circle or Meridian, at 4 Minutes diſtance from the other Meridian, making an Angle with it of a Degree or 60 Minutes in the Equinoctial, tho here it be drawn bigger that it may be diſtinguiſhed the better; Z s N and Z t N two Azimuth or Vertical Circles, Z Æ 10 degrees equal to H P the Latitude of the Place. Now here are given in the Spherical Triangle Z P s, (*1ſt,*) the Angle Z P s being 60 min. (*2d,*) the Side PZ Complement of the Latitude, being 80°, (*3d,*) the ſide P s being 90°, it is required to find the Angle P Z s, being the Azimuth from the North, and conſequently its Supplement O Z s will be its Azimuth from the South. Likewiſe in the Triangle Z P t there are given, the Angle Z P t the ſame as before 60′, and the ſide P Z as before 80°, the ſide P t is 160°; to find the Angle P Z t, whoſe Supplement to 180° the Angle O Z t, is the Azimuth from the South. Working therefore by a known Problem in Spherical Trigonometry, the Angle O Z s will be found to be 5° 45′, and the Angle O Z t 0° 24′, the Difference 5° 21′, is the Quantity of the Azimuth's Variation in 4 Minutes of Time. As therefore 5° 21′ or 321′, is to 4 Minutes or 240 Seconds; ſo is 31′ 16″ the mean Apparent Diameter of the Moon, (according to Sir *Iſaac's Theory*) to 24 Seconds.

So that were the *Moon* in the Place of the higher Star, it's whole Body would paſs the other Star in 24 ſec. of Time. And if the Moment were carefully obſerved, when the Weſtern Limb of the *Moon* and the lower Star were exactly cover'd by the Line; as likewiſe the Eaſtern Limb, the middle Time between theſe would be the Moment, when

the

the *Moon's* Center and the Star were exactly in the ſame Azimuth. For a ſmall Thread would divide the *Moon's* Diameter into at leaſt Twelve eaſily diſtinguiſhable Parts, and Two Seconds of Time may in this Caſe be pardonably called a Moment.

Your Honours may by this Time perceive the Deſign of this Method, which is briefly thus; the Sailor will find in the End of this Book a Catalogue of ſuch *Fixed Stars* (put together by Pairs) as come to the Meridian nearly at the ſame Time, perhaps ſome at a Minutes Diſtance or little more; out of which he may pick out ſome, that may ſuit his Latitude. For Inſtance; if he be in the Latitude of 15, 20, 25, 30 deg. South, or the like, he may find that the *Virgins Spike*, and the 2d in the *Great Bears Tail* marked (ζ) in *Bayer's Uranometria* will be proper for his Purpoſe, which Book by the way will inſtruct him to know all theſe Stars without a Maſter. Now the Difference of Right Aſcenſion in theſe two Stars being but 2 Minutes or 8 Seconds of time; when he finds them both exactly united with his Line, 'tis but ſtaying 8 Seconds, and *Virgins Spike* will be upon the Meridian, whoſe Right Aſcenſion given will tell him the True or Apparent time of the Night in the Place of Obſervation, and if at the ſame time he carefully takes the Altitude; her Declination will give him the exact Latitude. Here it may not be impertinent to obſerve, that if a Ship were in 15° of South Latitude, the Variation of the Azimuth of theſe two Stars, would after they were in the ſame Vertical, be 9° 48′ 07″ in 4 Minutes of Time.

So then, As 9° 48′ 07″ or 35287″, to 4 Minutes or 240 Seconds; ſo is 31′ 16″ or 1876″ the Moon's Diameter, to 13 Seconds; therefore the time of the Night might be known to a ſecond Minute, and if the Moon were in the Place of *Virgin's Spike*, it might be known to a Second of Time, when its Center and the (2d) Star in the *Great Bears Tail* marked (ζ) in *Bayer's Uranometria* were in the ſame Azimnth or Vertical, for the whole Body of the Moon would in this Caſe paſs that Star in 13 Seconds, as by Figure 2*d*, and the Operation will plainly appear.

The Operation.

In the Triangle P Z s are given, P Z 105°, P s 99° 43′ 27″, and the Angle Z P s 1 deg. or 60 min. to find P Z s, meaſured by H a in the Horizon, the Azimuth from the North, in 4 Minutes of time.

P Z

	°	′	″		°	′	″
P Z	105 :	00 :	00	Diff.	05 :	16 :	33
P s	99 :	43 :	27	½ Diff.	02 :	38 :	16
Sum	204 :	43 :	27	½ the Ang. Z P s	30 :	00	
½ Sum	102 :	21 :	43				

	°	′	″	Co. Ar.
As S. half Zcr. P Z and P s	102	21	43	0.010188
To S. half Xcr.	2	38	16	8 662960
So Tc. half Z P s	0	30	00	12.059142
To Tang. half X of the other Angles	79	30	22	10.732290

Again,

As Sc. half Zcr. P Z and P s	102	21	43	0.669411
To Sc. half Xcr.	2	38	16	9 999539
So is Tc. half Z P s	0	30	00	12 059142
To Tang. half Z of the other Angles	89	53	33	12.728092

	°	′	″
Half Z√√	89	53	33
Half X√√	79	30	22

The Difference 10 23 11 is the Angle P Z s, the Azimuth of (s) from the North.

Likewise in the Triangle P Z z.

	°	′	″	Co. Ar
As S. half Zcr. P Z and P z	69	18	52	0 028941
To S. half Xcr.	35	41	08	9 765919
So is Tc. half Z P z	00	30	00	12.059142
To Tang. half X of the other Angles	89	11	53	11.854002

Again,

As Sc. half Zcr. P Z and P z	69	18	52	0451921
To Sc. half Xcr.	35	41	08	9909679
So is Tc. half Z P z	00	30	00	12.059142
To T. half Z of the other Angles	89	46	57	12.420742

From

	°	'	"		°	'	"
From	89	46	57	From	10	23	11
Take	89	11	53	Subtract	00	35	04
Remains	00	35	04	Remains	09	48	07
The Angle P Z z				The Difference of the Azimut			

So if he be in the like degrees of North Latitude, he will find th *Orions Right Shoulder* (α) and the latter of the bright Stars in the *Do* will be his best Directors; but the former coming to the Meridian 1 33″ or 61″ of time before the other, he must stay a Minute and 1 S cond after they are both cut by his Line, before he takes the Altitu of the former. If the higher Star's Ascension be more than the low he must take its Altitude a little before they are united, and the D ference of Ascensions reduced into time will tell him, that so much tim is past that of the higher Star's Ascension.

The next thing requisite then, will be to describe the Plumb-lin which may be after this Form (*Fig* 3.) the Side of which may be Foot, and have Hooks to hang a Langthorn on each Side, if there Occasion, by the Darkness of the Night: For by this means the Li may be seen from Top to Bottom as plain as in the Day time. The O server sitting upon Deck is to hold the Sides in his Hands, and wh the Ship rolls one way, he may command the Instrument the contrar and so keep the Line to a perpendicular Direction, especially if an A sistant taking hold of the Lead in some gross Fluid, restore it to i Steadiness, which if it continue so for a Second or two will be sufficie For the Observer sitting behind a very fine Thread, may see at on from the Zenith to the Horizon, and easily discern, when the two Sta are at the same time cover'd by the Line.

This Method surely is as practicable, as taking an Observation the common Quadrant; and one would think when the Azimuth ca not be taken this way, neither can the Altitude by that, nor the La tude found; but this must be left to Experience, which will best deci the Controversy.

To proceed therefore, and to shew the whole of this Design at once when the Sailor finds he has a clear, calm, and Star light Night, tog ther with a Conveniency of the Moon, let him prepare for an Observatio and when he finds any two of these Stars near the same Azimuth, him set up the Plumb-line with the Lanthorns, if he finds there will Occasion, and when they are both exactly cut by his Line, let him ta the Altitude of one of them; but rather the higher, as being less subje to the Errors of Refraction ; and its Declination being known, will give him the true Latitude.

Having written down the Latitude, let him next carefully watch, when the Moon's Center and any known Star come into the same Vertical, and by taking the Altitude of the Star, let the Hour, Minute and Second be found, and at the same time let the Moon's Altitude be taken, by the help of an ingenious Affistant ; or these may be done before the Latitude is taken, if it be found necessary, always making due Allowance for the Ship's Way in the mean time, as every Artist's own Reason will direct him. When the Sailor by the means used, as is before directed, knows at what Apparent time, and in what Latitude the Moon was in the same Vertical with a Star, whose Right Ascension and Dclination are likewise known, and also what was the Moon's Apparent Altitude at the same time ; by counterballancing the Moon's Parallax with the Refraction, so as will in its due Place be directed, he may find the Moon's true Altitude from the Center of the Earth ; there being no other Parallax to be here considered but that of Altitude, since every Vertical Circle passes through the Earth's Center. Knowing therefore what Minute of the Equinoctial was then upon the Meridian (by knowing the Hour of the Night) and the Stars Right Ascension, he knows the Angle at the Pole; the complement also of the Latitude, and the Stars Declination being given, he may find the Star's Azimuth, and consequently the Moon's being the same, which being known, together with her true Altitude, he may find her Declination and Right Ascension, and by them her true Longitude and Latitude. And if after this he finds by Sir *Isaac*'s Theory, at what Apparent time in the Meridian of *Greenwich* (for the Tables are made for that Meridian) the Moon will have that Longitude and Latitude, by reducing the Difference of those Apparent times into the Degrees and Minutes of the Equinoctial, he will have the true Difference of Longitude between the two Meridians, and consequently the true Longitude of the Place of Observation. *Q. E. D*

This Method of finding the Longitude, it must be confess'd, is more useful within the Tropicks than in the greater Latitudes, because those Stars which are far remov'd from the Equinoctial, will in this latter Case not be visible ; so that two Stars must here be made use of on either Side the Equinoctial, to have them far enough distant, and the change of Azimuth will not be so quick. In this Case the time must be carefully observed when they first come into one Azimuth, as also when they go off, and the middle time must be taken for the true. So likewise, when the Moon is observed with a fixed Star.

Having proceeded thus far, the Sailor is to set to his Calculation, to find at what time in the known Meridian, for which the *Tables* are made, namely, that of *Greenwich*, the Moon will have the Longitude and Latitude before found.

Supposing then his Reckoned Longitude to be true, let him reduce the Difference of Longitude into Hours, Minutes and Seconds of time, allowing for every Hour 15 Degrees, and proportionally for Minutes and Seconds. Having thus found what a Clock it is at *Greenwich*, according to his Reckoning, let him by the *Tables* of Æquation of time, reduce that time to the mean or equal time, because the *Tables* are adapted to that, and let him try by Calculation, the Method whereof will be presently given, whether at that time the Moon will have the same Place in the Ecliptick as was found before: If it have, his Reckoning was kept true, otherwise it must be corrected by the *Table* of the Moon's horary Motion, thus; as the horary Motion is to 60′: so is the Excess or Defect of the Moon's Place by Calculation, above or under that by Observation, to a fourth Number: this subtracted from, or added to the Apparent time at *Greenwich* before taken, gives a Number, which may be called (*b*,) then, as 60′ to 15°, so will the Number called (*b*) be to the true Difference of Longitude.

If this Method do not please, here follows a Second, which cannot be denied, if Mathematical Demonstration may be accepted, and if the Use of a most perfect Quadrant will be allowed. If not; but the Sailor will shut his Eyes against the Light at Noon Day, let him throw his Quadrant over Board, and cease to seek for the Latitude it self, and be content to grope about in that dark Labyrinth the Ocean; but never expect to arrive at the desired Port: But if the Latitude can be found by the Use of a Quadrant, so may the Longitude as truly by the same Instrument.

The Second Method.

LET therefore the Latitude be found (if the former Method will not be allowed) by waiting for a known Star's greatest Altitude which

which the ſaid Method will ſurely direct him when to expect; afterwards let the Height of that, or an other known Star be taken, either to the Eaſtward or Weſtward of the Meridian, and thereby let the Hour of the Night be found; and when the Altitude is taking by one Aſſiſtant, exactly at that time let the Moon's Altitude be carefully taken by another, and put down, that it be not forgotton; this Altitude muſt afterwards be corrected by the *Tables* of Parallax and Refraction. Having the true time of the Night, it may be known, what point of the Equinoctial was then on the Meridian, and by that the point of the Ecliptick culminating, as alſo the Declination of that point and the Angle, which the Ecliptick then makes with the Meridian, may all be eaſily found in the common Right-angled Spherical Triangle ÆAE, (*Fig* 4.) comprehended between the Equinoctial, the Ecliptick, and the Meridian, the Obliquity of the Ecliptic being now agreed to be 23 deg. 29 min. Having proceeded thus far, the Moon's Place in her own Orbit, and conſequently in the Ecliptick may be found, (*1ſt*,) by the Triangle EMF, in which let EF repreſent the diſtance of the point in the Ecliptick culminating from the neareſt Node of the Moon, which will be found, and correctly æquated by the Rules of the Theory, as will alſo the Angle E F M, the Inclination of the Orbit (at the time of Obſervation) to the Ecliptick; the Angle F E M is the Supplement of AEÆ, namely, of the Angle which the Ecliptick at the time of Obſervation, makes with the Meridian; now from theſe it will be eaſy to find the Angle F M E, comprehended between the Meridian and the Moon's Orbit, likewiſe the Side MF the diſtance between the culminating point of the Orbit and the Node, as alſo the ſide ME, which added to, or ſubtracted from the culminating point of the Ecliptick (according as the Moon's Latitude is North or South) and that Sum or Difference added to the Height of the Equator above the Horizon, or to the Complement of the Latitude, will give the Height of the point in the Moon's Orbit then upon the Meridian. (*2dly*,) in the Triangle G M Z there will be given M Z the diſtance in the Meridian between the point M and the Zenith, namely H Z or $90^\circ - H\text{Æ} + \text{Æ}E \pm EM$, likewiſe the Angle ZMG the Supplement of EMF to 180 deg. or a Semicircle, and alſo the ſide G Z the Complement of G R, or of the Moon's corrected and true Altitude; which being given, the ſide M G may be likewiſe found, which ſubtracted from M F leaves the Moon's Place in her Orbit, which will eaſily be reduced by the *Tables* to the Ecliptick, and her Place found by Obſervation, which is all that was here required.

Or it may be done by the Triangle G C F, Right-angled at C, for G C F being a Right-angle, and C F G before found by the Table of the Equation of the Nodes, and G F=M F—M G; the Moon's Latitude will be G C, and the side C F = E F—E C will shew the Longitude, or her true Place in the Ecliptic, and by the said Triangle may both be found, *Q. E. D.*

Yet farther; some Persons may perhaps disapprove of these Methods of taking Observations in the Night: To remove therefore such an Objection, and to satisfye as much as may be, the different Humours and Opinions of various Minds, (though in a Matter of such Difficulty as the Longitude is, they cannot reasonably expect to have all their nice Scruples entirely removed.) Here is added a third way of finding the Moon's true place in the Ecliptick, and consequently the Longitude (still by the help of Sir *Isaac Newton*'s *Theory*) in the Day time, and so without the Assistance of the Stars, by the common Instruments used at Sea, namely a Quadrant and an Azimuth Compass. Thus,

The Third Method.

LET the Latitude be found after the usual Manner, by taking the Sun's greatest Altitude, and by his Declination, and shortly after by taking another Altitude, at the same time observing the Magnetical Azimuth by the Azimuth Compass; by these three, *viz.* the Latitude, Declination and Altitude of the Sun's Center, (making Allowance for Refraction) the true Azimuth may be found: And by that and the Magnetical Azimuth, may also be found the Variation of the Compass in the Place of Observation. This Variation will suffer no Alteration worthy of Regard in a small Distance of Time or Place; therefore exactly at the time of Sun-setting, *viz.* when the lower Limb of the Sun is above the Horizon about 16 min. or half its Diameter, and may better be known at Sea than Land, the Center being then by Reason of Refraction upon the sensible Horizon, which may safely enough be taken for the Rational, since the Earth's Semidiameter bears little or no Proportion to the Sun's Distance. If at that Moment the Magnetical Amplitude be very carefully observed, by adding to it, or subtracting from it, the Variation of the Compass found before, the true Amplitude or the Distance in the Horizon, betwixt the Sun's Azimuth

muth and the West Point will be had: Then in the Rectangle Triangle ☉ P O, in *Figure* the 4*th*, right Angled at O, the Complement of the Amplitude ☉ O being given, and the Complement of the Declination ☉ P, it will be easy to find the side P O the true Latitude of the Place, and also the Angle ☉ P O, the Time to Midnight, and consequently the true time of the Day; always observing to allow for every Hour 15 deg. of the Equinoctial, and moreover such a Part thereof as answers to the Variation of the Sun's Place in the mean Time, and proportionally for Minutes and Seconds. Having the true time of the Day, it may be exactly known, what point of the Equinoctial was upon the Meridian at the time of Sun-setting, and by that Means may be found what part of the Ecliptick was also on the Meridian. Likewise the Arch of the Meridian intercepted between the Æquator and the Ecliptick, as also the Angle between the Ecliptick and the Meridian. And if the Altitude of the Moon's Center were also carefully and exactly taken at the same Instant of the Sun's setting by one Assistant, when the Magnetical Azimuth was observed by another, and that Altitude corrected by the Tables of Parallax and Refraction; by proceeding as in Page 11*th*, the true Place of the Moon in the Ecliptick, both as to Latitude and Longitude, may be exactly demonstrated, which was the thing before proposed. The like may be done at Sun-rising, if the Moon be then past the Full; as in the other Case of Sun setting, it was supposed to be before it.

If this Method still admit of an Objection, as suppose that the time of Sun Rising or Setting cannot be exactly enough determined, let this further way decide the Controversy, and past all Exception shew, how to find the Moon's Place in the Ecliptick, and consequently (by Sir *Isaac*'s *Theory* and the Tables calculated according to it) to find the Longitude of the Place of Observation at any Time, or in any Place, when or where the Sun and Moon are both visible.

The Fourth Method.

HAving before found the Variation of the Compass, as was just before directed, let the Sun's Altitude and Azimuth, and likewise the Altitude of the Moon's Center be taken at one Instant with the best Instruments, that are already, or may be hereafter contrived; and with all

all the Care that can possibly be applied. Having the Variation o the Compass given, and the Sun's Magnetical Azimuth observed, b adding or subtracting the former to, or from the latter, the Sun's tru Azimuth may be found; by which together with his Altitude (co rected by the Table of Refraction) and present Declination, the Lati tude of the Place, and the Hour of the Day may be exactly found, b which two and the true Altitude of the Moon, her Place in the Ecliptic (by *Fig.* the 4*th*, and the Rules aforegoing) may be likewise found which is all that was desired, or can by any reasonabe and unprejud ced Person be required.

The Fifth Method.

THE Fifth and last Method (which, if Night Observations ma be allowed is none of the worst, especially for great Ships, whe a sufficient Number of Hands are) is this which follows, (See *Fig.* 5 in which let P represent the Pole of the World, Z the Zenith of t Place, P A the Complement of the Star A's Declination, P B t Complement of B's, the Angle A P B the Difference of their Right A censions, and A B their Distance. Some time before the Observatio be taken, let two known fixed Stars be chosen on each side of the M ridian, whose Right Ascensions and Declinations may be found in m Tables calculated from Mr. *Flamsteed*'s Catalogue, for the Year 172 by his Rules of Variation; then in the Triangle A P B, A P, and B and A P B being given, the side A B may be found, and likewise t Angles B A P and A B P.

Having proceeded thus far, let the Altitude of these Stars and of t Moon be taken exactly all at once, by three careful Observers, whi (having made a due Preparation before hand, so as will shortly shewn) may be done in two or three Seconds of Time, and t Business is over for the present. The Instruments may be laid asid and the Calculations made any time after at Leisure; only it will proper at this time to heave out the Log, and that a careful Estima be taken of the Traverse, (according to the usual Rules of Art) till nother Observation: In the mean time let the Latitude and Longitu the Ship was in at the time of Observation be found thus; in the T angle AZB, the three Sides are given, *viz.* AZ the Complement of t

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Star A's Altitude, and B Z the Complemet of B's, and the Distance A B found before, it will be easy to find the Angles BAZ and ABZ, but either will be sufficient, for BAP—BAZ=ZAP, or ABP—ABZ =Z B P; then P A and Z A, and ZAP being given, or P B and Z B and Z B P being given, PZ may be found, being the Complement of the Latitude, and by the Latitude of the Place, Altitude, Right Ascension and Declination of either Star, may be found the exact time of the Night, and likewise according to the aforegoing Rules, the true Place of the Moon in her Orbit (supposing the Eye in the Earth's Center) by the Tables of Parallax and Refraction. Whilst one Mate is performing this, another may be calculating what a Clock it was at *Greenwich*, at the very same absolute Time, and so this difficult Problem may be truly solved.

By this last Method alone, (much more by altogether) Observations may be taken almost at Pleasure, and the Longitude as well as Latitude found, and the Reckoning corrected as to both, more exactly and more frequently, than even the Latitude it self, by the Methods hitherto practiced.

Having thus proposed to *Your Honours* five new Methods of finding the Moon's Place by Observation, all which are certainly true in *Theory*, and may be easily and very often practiced by the Use of a Quadrant now to be described; not excepting the first, which will be found upon Trial fully as practicable as by the common Quadrant; I proceed now to shew how these Methods may be reduced to Practice.

The best Instrument for this Purpose yet invented, is the *Fluid Quadrant*, (*Fig*. 6.) of the ingenious Capt. *Row*, which (by his Leave) with some Alteration, may be rendered Thirty times more exact than that of Capt. *Davis*, even to 3 or 4 Seconds, and with a great deal more Speed and Satisfaction; since by that both the Object (or the Shadow) and the Horizon must be observed at the same Instant, and so much time is taken up in removing the Vane up and down till it be exactly adjusted, that in the mean while the proper time will be lapsed, and the Object moved from the Meridian; whereas this Quadrant is attended with no such Inconvenience: For the Sight of an Object may speedily be gotten by a *Tube* of not above 6 Inches long, which is to take in exactly the whole Body of the Sun or Moon (when their Apparent Diameters are the greatest) and no more, by which means, when the Observer has their full Body in his View, he is sure the Center of the *Tube* is directed to their Center, and so with cross Hairs to that of a Star, so that if he can but see their Bodies for three or four Seconds

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of time, he may be aſſured of a moſt exact Obſervation to 3 or 4 Se-conds of Altitude ; for in ſo ſhort a Time may an Aſſiſtant remove Sliding Bridge to the End of the Bubble. In order to explain the De-ſign of this Quadrant, ſuppoſe there were a hollow Glaſs Ring of 4 Yards Diameter, half an Inch thick, and of a true circular Curv throughout, and equally wide, filled with Water or Spirits of Win all but till it left a Bubble of Air, about an Inch and a half or tw Inches long ; this Bubble of Air as the Ring were turned about, woul always be uppermoſt ; or in other Words, if a ſtrait Line parallel t the Horizon were applied to the Ring it would always touch it i the middle of the Bubble. And if the Ring were moved, till the a foreſaid Tangent Line ſhould make an Angle of one Degree with th Horizon, or be elevated one Degree above it, the Bubble would b removed one Degree, or the 360th part of the whole Ring more for ward in the *Tube*, and would move equally if the *Tube* were truly made now the Sine of one Deg. to this Radius of 20 Yards, will be found t be one Foot and 571 thouſandth parts of an Inch, and the Verſed ſin one tenth of an Inch. If one Degree of this Ring were laid in a Groov on the Edge of a truly circular piece of Wood of the ſame Radius o 20 Yards, and about 2 Inches broad, and the broad Side diagonall divided into Minutes and Seconds, as this piece of Wood ſhould b advanced one Degree, the Bubble would be moved from one End to th other, and in its Motion the End of it would tell the Minutes an Seconds of that Advancement ; eſpecially, if a Sliding Bridge movin readily, were ſet to the preciſe End of it, and there faſtened with a Screw.

To proceed farther ; a Quadrant muſt be made of the Radius o 12.571 Inches, or ſome little more, for the one Degree Arch ſhoul be an Inch or two longer at both Ends than 12.571. This Quadran may be divided only into ſingle Degrees, beginning at the Right-hand End of the Arch, when the Center is towards you, at 3 quarter of an Inch from the Beginning of the Diviſions on the other one De-gree Arch, (I now ſuppoſe the Bubble $1\frac{1}{2}$ Inch long.) Two little pie-ces of Braſs may be affixed to the Arch on either Side, to project ſo much over the Glaſs *Tube*, as to allow room for two Holes, to receive a ſlender Screw faſtened in the Center of the Quadrant, upon which ſcrew when theſe two pieces are put, another little female Screw wil faſten the one Degree Arch to the Quadrant, and if at the other End it be faſtened to the Limb of the Quadrant by a Claſp and Screw, ſo as it may by taking thoſe off be moved along the Edge of the Quadrant

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at pleaſure, and ſo faſtened again, it will be ready for Uſe, which will be thus; ſome ſmall Time before the Altitude of any Object is to be taken, let the Obſerver view the ſame through the *Tube*, and at the ſame Time let an ingenious faithful Aſſiſtant obſerve where the Bubble is in the Glaſs; if it be at the farther End from the Eye, let him looſe the Screw upon the Center, and quite take off the other at the Limb, and move down the one Degree Arch towards 90 degrees on the Quadrant, 'till the Bubble begin to move, and continue to move the Arch to the next degree of the Quadrant, and at that even Degree of the Quadrant faſten it by the Screws: For Example, ſuppoſe the Sun or Moon were 40 deg. 30 min. high, and the Arch were faſtened at 30 deg. of the Quadrant, if the Obſerver directed the *Tube* to their Center, the Aſſiſtant would find the Bubble at the farther End of the Glaſs, let him looſe the Screws and bring down the Arch, till the Bubble begin to move, which will be at 39 deg. 30 min. let him farther bring down the Arch to 40 deg. and there faſten it; for if the Obſerver look again, and hold his Inſtrument as ſteady as he can, the End of the Bubble will reſt exactly at 30 Minutes, at which the Aſſiſtant may in an Inſtant lay his Thumb, then move the Bridge to it and faſten it, and the Obſervation is over; for he may count the Diviſions afterwards at his Leiſure. Being thus far prepared, the Quadrant may be hung up, and at any Time may be taken down again, and in three or four Seconds an Obſervation truly taken, till the Object be 41 deg. high; for then the Bubble will have tought the End of the Diviſions, namely, to 60 Minutes, then 'tis but removing the Arch to 41 deg. of the Quadrant, and there faſtening it, which will reduce the Bubble to the Beginning of the Diviſions on the Arch, and need not be altered 'till the Object be 42 deg. high, and ſo on.

Now by the Laws of Hydroſtaticks, when the *Tube* is directed ſteadily to the Center of the Object, the Bubble muſt neceſſarily reſt in the true Place of the Glaſs, ſtill ſuppoſing it a true circular Curve, and truly Cylindrical, eſpecially if this one thing be further obſerved, *viz.* ſuppoſe the Center of the Object exactly upon the Horizon, if the Arch be ſet to the Beginning of the Diviſions on the Quadrant, the middle of the Bubble will be at the Center, and the End at the Beginning of the Diviſions on the Arch; but then this being a Curve will fall off a little at the Diſtance of 12.571, from the Beginning of the Diviſions nearer to 90 deg. therefore a little piece of Braſs muſt be affixed to the Arch in that Place, that may reach juſt to the Beginning of the Diviſions, or that may meet the Line, which touches the middle of the Bubble, if continued. This piece of Braſs being thus affixed, ſuppoſe the Cente of the Object exactly 40 degrees high, if the End of this Piece be ſe to 40 degrees on the Quadrant, and there faſtened, when the *Tub* is directed to the ſaid Center, the End of the Bubble will be exactl at the Beginning of the Diviſions on the Arch (*i. e.*) at (0′). Sti ſuppoſing the Bubble an Inch and a half long, which will be difficul to keep to, by Reaſon the Liquid will be waſting, and if mor be reinfuſed, it will probably be too much or too little, and if it be, is not material; for the Length of the Bubble ought always to be mea ſured ſome Time before the Obſervation, and Allowance made. Fo Example, Suppoſe inſtead of $1\frac{1}{2}$ it be 2 Inches long, then inſtead c 3 quarters there will be 1 Inch from the Center. So that it will reac 1 quarter of an Inch too far, and ſo much muſt all the Length be de ducted from the Number which the End of the Bubble points at. A *Tube* of 6 Inches will be long enough, ſince there is no need o magnifying; and the ſhorter it is, the ſooner will the Sight of an Ob ject be gotten. If the further End of the *Tube* have an Aperture of hundredth parts of an Inch, with a plain Glaſs ſmoked, it will juſ take in the Body of the Sun or Moon; but for a Star there muſt b two Convex Glaſſes and croſs Hairs; the End of the Tube next th Eye, ſhould in the former Caſe be pierced with the point of a Pin o Needle. Now if the learned Dr. *Halley* found it practicable (as i his Appendix to the Second Edition of Mr. *Street's Aſtronomia Caro lina*, he ſays he did) to obſerve the Occultation of a Fixed Star, wit a *Tube* of five or ſix Foot, at a neceſſary Inſtant, ſurely it cannot b thought impracticable to obſerve the Sun, or Moon, or Star, with a *Tub* of 6 Inches; whereby the Sight of them may be ſooner obtained, (eſpeci ally, conſidering how difficult it muſt be to hold a *Tube* of that Lengt ſufficiently ſteady) and that not at a neceſſary Inſtant, but at Diſcretion

By what has been hitherto advanced, it will appear very plain t *Your Honours*, that the Moon's Place in her Orbit may be found to ſuffi cient Exactneſs, as often as will be neceſſary, by ſome one or other o the aforeſaid Methods. There will be no Occaſion of reducing tha Place to the Ecliptick, ſince (becauſe the Moon is always in Motio and conſequently never above a Moment of Time in the ſame Place if it can be found to a few Seconds of Motion, at what Time in th Meridian of *Greenwich* the Moon will be in the ſame Place of her Or bit; ſuppoſing the Eye in both Meridians to be in the Center of th Earth, (which by truly counterballancing the Angles of Parallax an Refraction, will be in effect done) if the Difference of theſe two re

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lative Times (for it is the same Absolute Time) be reduced into the Degrees and Minutes, &c. of the Equator, no Person that knows what is meant by the *Longitude*, can deny, but it may by this Means be found to the Exactness required by Act of Parliament, and a great deal less. It remains therefore to demonstrate from Mr. *Flamsteed's* Observations in a sufficient Variety of Cases, that by Sir *Isaac Newton's Theory of the Moon*, as it ought to be, and is here actually freed from the Errors of the Press, the Moon's Place in her Orbit may at any Time be found so exact by Calculation from Tables truly agreeable to that *Theory*, as it is here corrected (which, if this Performance meet with Encouragement, will soon be published) that the *Longitude* may thereby be discovered to a few Miles. Therefore I come now to shew where the *Theory* (as printed in Dr. *Gregory's Astronomy*, and in Mr. *Whiston's Astronomical Lectures Translated)* is, and must necessarily be erroneous, and that it is the true and only Reason, why Dr. *Halley* finds it sometimes to vary five or six Minutes of Motion from Truth; and also to make it appear, how it may, and ought to be altered to its original Exactness, so as to reduce those five or six Minutes to a few Seconds.

In the first place we find it printed in Dr. *Gregory's Astronomy* (Page 332) that in the Year 1680, on the last Day of *December* at Noon, the Mean Motion of the Moon was 6S. 01° 35′ 45″, and that 20 Years after, *viz.* in 1700, at the same Time of the last of *December* the Mean Motion of the Moon was 10S. 15° 19′ 50″, now here is a manifest Error of the Press; for if the former Mean Motion be true, the latter must be false, and if the latter be true, the Error lies in the former; as will plainly appear from what immediately follows, *viz.* that in 20 *Julian* Years or 7305 Days, the Mean Motion of the Moon is 247 Revolutions, 4S. 13° 34′ 05″, this Motion of 20 Years added to 6S. 1° 35′ 45″, will make 10S. 15° 09′ 50″, as it certainly ought to be printed, instead of 10S. 15° 19′ 50″; otherwise, if this last be true, the former instead of 6S. 01° 35′ 45″, should be 6S. 01° 45′ 45″, as it is printed in the Tables annexed to Mr. *Whiston's Astronomical Lectures*, and as I after him (not having then compared the *Theory* with the Observations) have put it in my *Viaticum Nautarum*; but I find this last to be wrong, and that it makes all the Calculations intolerably wide; and therefore I must humbly beg of *Your Honours*, when you order these following Calculations to be examined, that you will be pleased before-hand, to order the aforesaid Book to be corrected in

the foregoing Particulars, namely, that for the Year 1681, the Radica
Number may be restor'd to 6S. 01° 35′ 45″, and for the Year 1701, to
10 S. 15° 09′ 50″, since the Calculations are made from these last
Numbers, which are evidently the true.

This first Error of the Press being thus truly corrected, I proceed to the next main Mistake thereof, which upon due Examination will appear a manifest Inconsistency, and such as could never proceed from the Hands of the wonderful Author; therefore to do Justice to his illustrious Character (which had it been attempted by an abler Hand, would in all Probability have been much more regarded) and in order to set these things in their true Light, the Figure in Dr. *Gregory's Astronomy*, (Page 334.) is to be considered, see *Figure* the 7*th*, where if the Mean Distance of the Moon from the Earth be supposed 1000000, the greatest Excentricity of the Moon's Orbit represented by T B, is 66782, and the least Excentricity by TA, is 43319 of such Parts, as the Mean Distance contains 1 Million. Now if B T S represent the Annual Argument of the Sun, B C F the double thereof; T F the Excentricity and B T F the Equation of the Apogee required to be found. The Rule is this, being the 3*d Axiom* in *Plane Trigonometry*, *viz*. As the Sum of the Sides TC and CF=TB, is to their Difference, equal to TA, or as the greatest Excentricity 66782, is to the least 43319 so is the Tangent of half the Sum of the Angles CTF and CFT or so is the Tangent of half the Angle BCF, or thirdly, so is the Tangent of the Annual Argument, to the Tangent of half the Difference of the Angles CTF and CFT, which half Difference subtracted from the half Sum, or (which is all one) from the Annual Argument, will give the lesser Angle CTF which is required; being the Equation of the Apogee. To find therefore the greatest Equation thereof, which will be found to be, when the Annual Argument is 51 degrees, work thus; As TB 66782, is to TA 43319, so is the Tangent of 51°, to the Tangent of 38° 41′ 45″, which subtracted from 51 deg. there will remain 12° 18′ 15″.

°	′	″
51	00	00
38	41	45
12	18	15

	Co. Ar
As 66782	5.17534
To 43319	4.636672
So is T. of 51°	10.09163
To T. of 38° 41′ 45″	9.90365

So

So then if those Excentricities be true, the greatest Equation of the Apogee must of Necessity (according to Sir *Isaac's Theory*) be 12° 18′ 15″, whereas it is there printed 12° 15′ 04″, and if this last 12° 15′ 04″ be the true greatest Equation of the Apogee, (as upon farther Examination it will be found to be) then the Excentricities must be wrong. This is that manifest Inconsistency before taken Notice of, which cannot be imputed to the great Sir *Isaac Newton*, and which is the only Reason, why this *Theory* is found Erroneous to five or six Minutes, and some times more, and cannot possibly be otherwise; for these Excentricities being too great, it always appears, that if the fourth Equation of the Moon be made by Addition, the Calculation is too much, and exceeds the Observation, by adding too great a Prosthaphæresis to the third Equation; but if it be made by Subtraction, the Calculation will be always too little for the Observation. And this so much the more, as the Excentricity is greater at the Time of Observation, and the Moon's Mean Anomaly nearer to the Quarters, *viz.* to 3 and 9 Signs, when the Prostaphæreses are the greatest.

I make no doubt, *Your Honours* will look upon this to be true Reasoning. Since therefore it is apparent to every one, that the *Theory* is false printed, and for that Reason ought if possible, to be corrected; and since it will appear by all the Calculations, that this Error is solely to be laid upon the Excentricities being too great, and that if they be retained, it cannot be otherwise; surely a Pardon (if it ought to be so called) will be easily granted for making an Alteration, more especially, if by such an Alteration (and by no other) all the Difficulties may be removed, and the Moon's Place in all Cases found to a sufficient Exactness; which in a due Order of proceeding is the next and main thing to be fully proved and demonstrated.

The following Observations all taken out of the Second Volume of that famous Astronomer Mr. *Flamsteed's Historia Cœlestis Britannica* (though many more might have been produced to confirm the same thing, yet) may be thought sufficient, by Reason they are so pick'd out and designedly chosen to serve all the various nice Cases that can happen, (namely of the Earth's Distance from the Sun, of the Sun's Distance from the Moon's Apogee, of the Moon's Distance from the Sun, and from her Apogee, of the Equations of the Earth's Orbit, and of the Moon's Excentricities) that no Observation can be taken but will agree with, or come very near to some or other of them, insomuch that if these Observations be true, for which we must depend upon the Testimony of the Observer, both as to the Moon's Meridian Altitude

and

and the true or apparent Time of the Night, and if the Calculations be exactly agreeable to the *Theory*, as here altered from the Print, if farther, the Moon's Motion be not a Motion at Random, but (though subject to various Anomalies, yet) constant and regular (as we may say) in its Irregularities ; then the Consequence will be, that by any Observation truly taken at Sea, by a sufficient Instrument, such as is before at large described, and by an accurate Calculation made from the Tables, which (if this Scheme be accepted) will soon be published, together with all other Tables serviceable in the Calculation of Eclipses of the Luminaries ; by these two, I say, the Longitude may be found to a sufficient Exactness. And a farther Consequence will be, that (supposing the Sun and Moon, or rather, if you please, the Earth and Moon be providentially determined as to their Motions, so that they are the same, and will so continue, as they formerly have been ; which no one sure will deny, then) when any Observations are taken, and the Calculations truly and exactly made, do not agree very near therewith, those must of Necessity be false Observations. This is an undeniable Consequence from the former Suppositions. So that in order to render this Scheme impracticable, false or invalid, either the following Observations must be proved false, or the Calculations wrong, for no one surely, will be so daring or silly, as to dispute against the settled Laws of Nature. As to the Second, I humbly submit them to the most strict Scrutiny, and am perswaded, I may say without Vanity, that (abating the Errors of the Press,) they are all truly done to a Second, such Accuracy and Faithfulness has been used through the Whole.

To make this the better appear, I think it not improper, as I proceed to shew the Manner of my Calculations, (for in order to serve the Publick, I shall not grudge the Discovery of any *Arcanum* relating to this Subject) that so, if it appear to *Your Honours*, I have taken any false Steps, a speedy Answer (which in that Case I humbly request *You* will order to be drawn up) may prevent any farther Application. Or, if no Answer be given in due Time, I may be justly encouraged. For with all due submission to *Your Honours* better Judgment, I hope I may be permitted to say without boasting, that I cannot think this so petty, trivial, jejune, and insignificant a Performance, that it ought to be thrown a-side unregarded, and buried in Silence, without taking Notice of ; but rather (if the Universal Benefit of Mankind is to be regarded) I hope it may deserve either a fair Answer, or a due Encouragement. *Your Honours* will be pleased to excuse this, (I should hope) not ill

ground

grounded Assurance; but lest I should seem to prescribe to *Your Honours* much riper Judgment, I pass on to shew the Method I have proceeded by in the following Calculations: And to be as brief as possible, shall explain only one, for all the rest are managed after the same Mannner. I shall pitch upon the *4th* Observation, because the Calculation agrees exactly with it.

In the *350th* Page of the aforesaid Book, we find that in the Year *1698* being the *2d* after Leap-year, on *Thursday, June* 16d. 14h. 46′ 33″ Apparent Time in the Meridian of *Greenwich*, the Latitude whereof, according to Mr. *Flamsteed* is 51° 28′ 30″ the Moon's Center past the Meridian, the higher Limb of it being distant then from the Vertex, 63° 46′ 40″, by the Diagonal Lines on the Instrument, but more correctly (by 1446 Revolutions of the Screw) 20 Seconds more, *viz.* 63° 47′ 00″, from which subtracting 7′ 30″ for the Quantity, that the Meridian Wall had shrunk since it was first erected, which was his Way of computing, as will appear from Page the *117th* of his *Prolegomena*, the Remainder will be 63° 39′ 30″, for the Apparent Vertical Distance of the Moon's higher Limb. By the way it may be noted, that there is a Mistake of the Press, in the just now quoted Page, *viz.* in Line the *5th*, for whereas it is printed Error Div. + 0° 0′ 20″, it ought to be 0° 0′ 28″, as will appear from the *9th* Page of the Appendix to the Second Volume, where 38 hundredth Parts of one Revolution of the Screw, constantly answer to 1 Min. of Altitude. Now if recourse be had to the *85th* Page of Vol. *2d.* it will be found, that on the *12th* of *December*, 1690. at Noon, the Sun's lower Limb was distant from the Vertex 75° 11′ 30″, and 1704,*69* Revolutions of the Screw. Since therefore in the Appendix 1704 Rev. 51 C. P. answer to 75° 11′ by the Rule of Proportion, As 38 Cent. : 60′ : : 18 C. : 28″, therefore 28″ ought to be added to 75° 11′, and the Distance ought to be 75° 11′ 28″, so that either 28″ ought to be added to 75° 11′ 00″, or from 75° 11′ 30″, there should be 2″ subtracted. In this Place I cannot forbear to remark, that it is a Thing much to be lamented by all lovers of *Astronony*, that this otherwise never to be sufficiently valued Book, is so monstrously false printed. But to return from this Digression; having premised thus much, I shall now shew in one Instance the Method of my Calculation fully in all its Parts, by which the rest may be fairly examined.

From

From my *TABLES* in the other Book may be had these Numbers.

	Sun's Mean Mo.	Sun's Apogee.			
	S. ° ' "	S. ° ' "		S. ° ' "	S. ° '
A. D. 1681	09.20.34.46	03.07.23.30	Sun's Mean		3.05.40.1
Years 17	11.29.52.54	17.51	Motion	3.05.40.15	3.07.41.5
June	04.28.49.58	26	Eq. Earth's		
Days 16	15.46.13	3	Center -+	—04.00	11.27.58.2
Hours 14	34.30		Sun's Place	3.05.44.15	Mean Anomaly
Minutes 46	1.53	03.07.41.50	Par. Pro. -+	06	Eq. 1 + 0.1
Seconds 33	1		Sun's Place		Eq. 2 + 2.0
			Correct.	3.05.44.21	
	03 05.40.15				Eq. time + 2.2
					☉'s hor. Motion 2.2
					Parts Propor. +0.0

Thus the Sun's true Place, the Apparent Time being reduced to th Mean, was then 3 S. 05° 44′ 21″. The Moon's Place for the Mea Time is now to be found.

The Moon's *Place is sought for the Mean Time,* June *the Sixteenth,* *14 Hours,* 48 *Minutes, and* 53 *Seconds,* A. D. *1698. in the Meridian of* Greenwich.

A. D.	Moon's Mean Motion.	Motion of the Apogee.	Motion of the Node Retro.
	S. ° ' "	S. ° ' "	S. ° ' "
1681	06 01 35 45	08 04 28 05	05 24 14 35
Years 17.	03 02 14 19	11 01 44 03	10 28 47 56
June.	06 09 38 08	16 49 21	07 59 46
Days 16.	07 00 49 20	01 46 57	50 50
Hours 14.	07 41 10	03 54	01 51
Minutes 48.	26 21	13	06
Seconds 53.	29	00	11 07 40 29
	10 22 25 32	07 24 52 33	06 16 34 06

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Having thus found the Moon's Mean Motion, the Place of the Moon's Apogee, and of the Ascending Node, the next Thing in order according to Sir *Isaac*'s Rules will be to find their first Equations, thus, As 1° 56′ 20″ is to 4′ the Equation of the Earth's Orbit, so is 11′ 49″ to 24″, and so is 20′ to 41″, and so is 9′ 30″ to 20″; and because the Eq. Orbit was +, the second must be —, the third +, and the fourth —; but had the Equation of the Orbit been—, then the other three must have been contrary to what they are. To find the Moon's second Equation, having first subtracted the Place of the Moon's Apogee first equated from the true Place of the Sun, say thus; As Radius is to the Sine of the double Distance of the Sun from the next Syzygia or Quadrature (by Syzygia is meant either the Conjunction with, or Opposition to that Place of the Apogee) so is the natural Number answering to the Logarithm in the last little Table, found by the Sun's Mean Anomaly, to the natural Number required. This must be added, if the Sun be moving to the Syzygia; but if from it, to be subtracted. In this Case the Number 3′ 32″ being subtracted from the first Equation of the Moon, leaves 10 S. 22° 21′ 36″ for the Moon's second Equation; then to find the Moon's third Equation, first subtract the Place of the Node the first time equated, from the true Place of the Sun, and say; As Radius is to the Sine of the Sun's double Distance from the next Syzygia or Quadrature, so is 47 sec. to the Number required; which is here 17 sec. this (contrary to what was in the aforegoing Article) must be — or subtracted, when the Sun moves to the Syzygia, and when from it, to be + or added, the Moon's Place the third time equated will be 10 S. 22° 21′ 53″.

Thus far the Process is the same, whatever be the Excentricities; but if we take the printed Excentricities, they being too great, and the Prosthaphæresis to be — negative or subtracted, because the Moon's Mean Anomaly is less than six Signs, the fourth Equation, and so the whole Calculation will be 6′ 10″ too little for the Observation, as by Computation may be found, whereas by these Excentricities, *viz.* 65633, whereof the Logarithm is 4.817122 for the greatest, and 42655, the Logarithm 4.629965 for the least, they will both exactly agree; and these will also produce the true greatest Equation of the Apogee 12 deg. 15 min. 04 sec. thus by *Axiom* the 3*d* of *Plane Trigonometry*, as in *Page* the 20*th*.

		Co. Ar.
As 65633	Log.	5.18287
To 42655		4.62996
So is the Tangent of 51°		10.09163
To the Tang. of 38° 44′ 56″		9.90447
This subtracted from 51 00 00		
Leaves 12 15 04 the Equa. req		

The next thing to be done, is to find the second Equation of th Moon's Apogee, and the present Excentricity, thus by *Figure* the *6th* As TC+FC = TB is to TC—FC=TA, or as is the greatest Excen tricity 65633 to the least 42655, : : so is the Tangent of half th Sum of the Angles C T F and C F T, or so is the Tangent of hal the Angle B C F, or *3dly*, so is the Tangent of the Annual Argument to the Tangent of half the Difference of the Angles CTF and CFT which half Difference subtracted from the half Sum, or (which is a one) from the Annual Argument, will give the lesser Angle C T F which is required, being the Equation of the Apogee. Therefore having subtracted the Moon's Apogee the first time equated from th true Place of the Sun, the Remainder will be the Annual Argument, o the Sun's Distance from the Apogee, being half the Angle B C F Thus from 3 S. 05° 44′ 21″ subtract 7 S. 24° 53′ 14″, the Re mainder 7 S. 10° 51′ 07″, is the Annual Argument; then as 6563 is to 42655 : : so is the Tangent of 7 S. 10° 51′ 07″, or of 1 S. 10 51′ 07″, to the Tangent of 29° 20′ 10″ this subtracted from 1 S 10° 51′ 07″, leaves 11 30′ 57″, for the second Equation of the A pogee, which if the Annual Argument be under 3 Signs or above 6 as here, and under 9, must be added, otherwise subtracted.

The Operation.

		Co. Ar
As 65633	Log.	5.18287
To 42655		4.62996
So is the Tangent of 40° 51′ 07″		9.93689
To the Tangent of 29.20.10		9.74973

This 11 deg. 30 min. 57 sec. added to 7 S. 24 deg. 53 min. 14 sec gives 08 S. 06 deg. 24 min. 11 sec. for the Place of the Apogee a 2 time equated.

T

To find the Excentricity of the Moon's Orbit at the time of Obſervation; As the Sine of the Angle CTF (in *Figure* the *6th,*) laſt found, *viz.* 11° 30′ 57″, is to the ſide CF equal to the half of TB—TA equal to 11489 : : ſo is the Sine of T C F equal to the Sine of B C F, equal to twice the Annual Argument, equal to the Sine of 2 S. 21° 42′ 14″, to the Side T F the Excentricity required, *viz.* 56947.

The Operation.

	Co Ar.
As the Sine of 11° 30′ 57″	0.699755
Is to 11489	Log. 4.060282
So is the Sine of 81° 42′ 14″	9.995431
To 56947	4.755468

To find the Moon's Mean Anomaly, ſubtract the Place of the Apogee the ſecond time equated, from the Place of the Moon equated the third time, and the Remainder will be the Mean Anomaly. Thus,

	S.	°	′	″
From	10	22	21	53
Subtract	8	06	24	11
Mean An.	2	15	57	42

In the next Place to find the fourth Equation of the Moon, I proceed thus; As the Sum of the Mean Diſtance of the Moon from the Earth, and of the preſent Excentricity, is to their Difference, or as S A (in *Fig.* 8.) equal to 1056947 is to P S equal to 943053 ; ſo (by *Prop.* 6. of *Book* the 3d of *Gregory*'s *Aſtronomy*) is the Tangent of half the Mean Anomaly, to the Tangent of half the true Anomaly. This laſt ſubtracted from the 3*d* in the Proportion gives a Number, which being doubled, is the Proſthaphæreſis required ; to be ſubtracted, when the Mean Anomaly is leſs than 6 Signs, otherwiſe to be added to the 3*d* Equation, and the Remainder or the Sum will give the Place of the Moon equated a fourth time.

The Operation.

		Co. Ar
As 1056947	Log.	3.975947
To 943053		5.97453
So is the Tangent of 37° 58′ 51″		9.89251
To the Tangent of 34° 51′ 41″		9.842993

From	37	58	51		From	10	22	21	53
Subtract	34	51	41		Subtr.	0	06	14	20
Remains	3	07	10		Leaves	10	16	07	33 for the Place of the Moon the 4th Time equated.
Double	6	14	20						

For the *5th* Equation, from this Place of the Moon subtract the true Place of the Sun, and say; as Radius to the Sine of the double Distance of the Moon from the next Syzygia or Quadrature, so is the Number answering to the Logarithm in the Table of the Moon's Variation found by the Sun's Mean Anomaly, to the Number required; which if the Moon's Distance from the Sun be less than three Signs or between Six and Nine, must be added to, otherwise subtracted from the *4th* Equation, and the Sum or Difference will give the Moon's Place equated a *5th* time. For *Example*,

	S.	°	′	″		
From	10	16	07	33	As Radius	10.000000
Subtr.	3	05	44	21		
					To the S. of 80° 46′ 24″ Log	9.994344
Remains	7	10	23	12	So is 33′ 07″	3.298388
					To 32′ 42″	3.292732

If 32′ 42″ be added to the 4th Equation, it will make 10 S. 16° 40′ 15″ for the 5th Equation.

Then from the Moon's Apogee the 2d time equated, subtract the Apogee of the Sun, and note the Remainder; likewise from the Place of the Moon the *5th* time equated, subtract the Place of the Sun, and note the Remainder. Thus,

From

	S.	°	′	″
From	8	06	24	11
Subtr.	3	07	41	50
Rem.	4	28	42	21

	S.	°	′	″
From	10	16	40	15
Subtr.	3	05	44	21
Rem.	7	10	55	54
+	4	28	42	21
	0	09	38	15

Then, as Radius to the Sine of the Sum of these two Remainders : : so is 2 min. 10 sec. to a *4th* Number; which must be subtracted, if that Sum or it's Excess above twelve Signs be less than a Semicircle, otherwise it must be added to the 5th, to make the 6th Equation; thus,

As Radius	10.000000
To the Sine of 9° 38′ 15″	9.223792
So is 02′ 10″	2.113943
To 22″	1.337735

	S.	°	′	″
From the 5th Equation	10	16	40	15
Subtract				22
Remains the 6th Equation	10	16	39	53
From this last subtract ☉'s Place	3	05	44	21
Remains	7	10	51	32

Then as Radius Log.	10.000000
To the Sine of 7 S. 10° 51′ 32″	9.815709
So is 2′ 40′	2.146128
To 1′ 32″	1.961837

This 1 min. 32 sec. must be added to the 6th Equation, because the Moon is past the Full, otherwise subtracted.

To

	S.	°	′	″
To ——— ——— ——— ———	10	16	39	53
Add ——— ——— ——— ———			1	32
The 7th and last Equation ———	10	16	41	25

This is the Moon's Place in her Orbit, which yet is to be reduced to the Ecliptick. In order to which, from the Place of the Sun is to be subtracted the Place of the Node first equated, which was 6 S. 16° 33′ 46″, which subtracted from 3 S. 05° 44′ 21″, there remains 8 S. 19° 10′ 35″, in the Table of the Equation of the Node, the Number answering to this is —33 min. 58 sec. and the Inclination of the Limit 0 min. 38 sec.

	S.	°	′	″
From	6	16	33	46
Subtract			33	58
Remains	6	15	59	48

this last is the true Place of the Node, and this being subtracted from the Place of the Moon in her Orbit, leaves 4 S. 00 deg 41 min. 37 sec. for the Argument of Latitude; then in the Table of Reduction, the Number answering to this last is 5 min. 45 sec. to be added, and the Excess agreeing thereto being 43 sec. As 18 min. 00 sec. the greatest Inclination, is to 43 sec. so is 38 sec. to 0 min. 01 sec. the proper Excess, this added to 5 min. 45 sec. makes 5 min. 46 sec. and this last added to the Moon's true Place in her Orbit

	S.	°	′	″
	10	16	41	25
——— ——— +			5	46
——— ———	10	16	47	11

Gives the Moon's true Place in the Ecliptick, or the true *Longitude* by Calculation.

This being finished, we are to enquire, whether the Observation will agree with it. In order whereunto it has appeared already, that at the time of Observation, the Moon's higher Limb was apparently distant from the Vertex 63 deg. 39 min. 30 sec. In the next Place the Horizontal Parallax must be found, which will be done by *Fig.* the 7*th*, For as the Sine of the Angle SLF, the Prosthaphæresis before found

6 deg.

6 deg. 14 min. 20 sec. is to the side SF, double the Excentricity equal to 113894, so is the Sine of LFS, or the Sine of the mean Anomaly A F L 2 S. 15 deg. 57 min. 42 sec. to the side S L, the Moon's Distance from the Earth.

		Co. Ar.
As the Sine of 6° 14′ 20″	Log.	0.963874
Is to 113894		5.056501
So is the Sine of 75° 57′ 42″		9.986831
To 1016731		6.007206

Then as this Distance is greater than the mean Distance 1000000; so is the Sine of the Horizontal Parallax of the Moon in the Syzygia (according to the *Theory*) 57 min. 30 sec. greater than the Sine of the present Parallax.

		Co. Ar.
As 1016731	Log.	3.992794
To 1000000		6.000000
So is the Sine of 57′ 30″		8.223357
To the Sine of 56° 33′		8.216151

The Parallax then being 56 min. 33 sec. in the Syzygia, the Horizontal Parallax proper for the Moon's present Distance from the Sun will be found to be 56 min. 13 sec. by this small Table framed from the Rules of the *Theory*.

The Use is thus; from the Moon's Place in her Orbit, subtract the Place of the Sun, and the nearest Distance from the Syzygia either forwards or backwards, look for in the Table, in the left Hand Column, or the nearest to it: then as 57′ 30″ to the Number over-against it, so is the Horizontal Parallax before found, to the proper Parallax. Thus,

	S	°	′	″
From	10	16	41	25
Subtract	3	05	44	21
Remains	7	10	57	04

A TABLE *whereby to find the Moon's proper Horizontal Parallax.*

°	′	″
10	57	29
20	57	24
30	57	18
40	57	10
50	57	01
60	56	53
70	56	46
80	56	42
90	56	40

The

The Number in the Table answering nearest to 40° 57′ 04″ is 57′ 09″, therefore as 57′ 30″ to 57′ 09″, so is 56′ 33″ to 56′ 13″, the proper Parallax.

To find the Moon's apparent Diameter (according to the *Theory*) As 57′ 30″ to 31′ 30″, so is 56′ 13″ to 30′ 48″.

	°	′	″
To the Vertical Distance of the Moon's higher Limb ——	63	39	30
Add the Apparent Semidiameter of the Moon ——		15	24
	63	54	54
To this add the Refraction ——		01	40
Vertical Distance of the Moon's Center ——	63	56	34
Subtract the Parallax of Altitude ——		50	30
True Vertical Distance of the Moon's Center ——	63	06	04

As Radius —— Log.	10.00000
To the Sine of the Vertical Distance 63° 56′ 34″ ——	9.95344
So is the Sine of 56′ 13″ ——	8.21356
To the Parallax of Altitude 50′ 30″ ——	8.16700

		°	′	″
Altitude of the Moon's Center ——		26	53	5
Complement of the Latitude of *Greenwich* ——		38	31	3
Subtract the Altitude of the Moon's Center ——		26	53	5
Declination South of the Moon's Center ——		11	37	3
The Sun's true Place *June 16th*, at Noon	3 S.	05	09	0
Right Ascension then ——		95	36	5
The Sun's true Place at Night ——	3 S.	05	44	2
Right Ascension then ——		96	15	1
Difference of Right Ascensions ——			38	2

Rig

	°	′	″
Right Ascension at Noon	95	36	53
For 14 hours add	210	00	00
For 46 Minutes add	11	30	00
For 33 Seconds add	00	08	15
For the Difference of Right Ascensions add	00	38	20
Right Ascension of the Moon's Center	317	53	28
By this and the Declination given South	11	37	34

the Longitude will be found, thus;

	°	′	″			°	′	″	
	101	37	34			101	37	34	
+	23	29	00		−	23	29	00	
	125	06	34	Sum		78	08	34	Difference
	62	33	17	half Sum		39	04	17	half Diff.

	°	′	″	
From	317	53	28	
Subtract	270	00	00	
Remains	47	53	28	the contained Angle
	23	56	44	the Half

Then First,

	Co. Ar.
As the Sine of 62° 33′ 17″ — Log.	0.051855
To the Sine of 39 04 17	9.799539
So is the Co-tangent of 23° 56′ 44″	10.352529
To the Tangent of 57° 58′ 59″	10.203923

Again

Again,	Co. Ar.
As the Co-sine 62° 33′ 17″	Log. 0.336392
To the Co-sine of 39 04 17	9.890064
So is the Co-tang. of 23 56 44	10 352529
To the Tang. of 75 13 50	10.578985

	° ′ ″
To the Tangent of half Z√√	75 13 50
Add the Tangent of half X√√	57 58 59
Subtract	133 12 49
From	180 00 00
Remains	46 47 11
Add	270 00 00
Gives	316 47 11

316° 47′ 11″ divided by 30 quotes 10S. 16° 47′ 11″

Exactly agreeing with the Calculation

Thus (may it please *Your Honours*) I have given *You* in full a Specimen of the Method of my Calculation in one Instance; and the rest upon Examination, will be found to be done with the same Care and Fidelity, which (though they do not agree so exact with the Observations, yet) are all of them near enough, and fall a great deal within the Limits prescribed by the Act, and may so plainly and fully be understood by what has gone before, that the Sailor may thereby be instructed to make the like Calculation upon any Observation, which was the chief thing I had in View, by this so full an Explanation. I am satisfied *Your Honours* will not suffer it to be turned to my Disadvantage. It may be thought by some, that this way of Calculation is too laborious, and will take up too much time; but if the Nature of the thing require it, I cannot help that. Yet if two Persons be employed upon every Occasion, one to manage the Observation, and the other the Calculation, 2 or 3 Hours in a Week, or perhaps in a Fortnight, should not (one would think) be grudged in so useful a Work. And this I know upon Experience to be sufficient, more especially, if the *Table* of *Logistical Logarithms* be added to the Book, as it is designed, that so it alone may serve all the Uses of Calculation where the Motions of the Moon are concerned.

At

At present to draw to a Conclusion, that I may trespass no longer upon *Your Honours* Patience, be pleased to give me leave to make a short Recapitulation.

I have here presented *You* in the first Place, with several Methods of finding the Moon's Place by Observation, all of them Mathematically demonstrable, and all, or most of them easily and very often practicable. As they are all new to me, having never met with any one of them either by Reading or Conversation; but delivered them to the Publick as they occurred to me, upon a close and intense Application, so I hope they will appear to the Learned, especially to *Your Honours*, and therefore will be the more taken Notice of.

I hope likewise, the Instrument here described, if truly made, and carefully applied, will easily and exactly answer the Ends of Observation, that is, by taking the true Altitude of the Luminaries, and making due Allowances for Parallax and Refraction, to find the Latitude and Hour to few Seconds, and thereby the exact Place of the Moon in her Orbit, which will be sufficient on the Observer's Part. And whilst he is Calculating the observed Place, another Assistant or Mate by consulting the *Tables*, and proceeding according to Sir *Isaac*'s Method before given, will find at what time in the Meridian of *Greenwich* the Moon will be exactly or sufficiently near in the same Place; for in all the various Observations now to be exhibited, at the most different Seasons of the Year, and in all other Cases sufficiently different, the Moon's Place by the *Tables* agrees with the Observation within 10″ or 5 Geographical Miles, excepting one, which exceeds ten; but that perhaps (as those two eminent Astronomers Dr. *Gregory* and Mr *Whiston* justly suppose) may rather be imputed to the Uncertainty of Observation, than any Imperfection in the *Theory*. Now since the Moon's Mean Motion in 24 Hours is 13° 10′ 35″ or 47435″, that is in one Hour 1976″, and 33″ in one Minute of time, which answers to 15 Geographical Miles of the Earth's Equator, every two Seconds of the Moon's Motion will be but about one Mile in Longitude, even in the Earth's Equator, and as the Latitude encreases still less and less, so that it may be said by this Method the Longitude may be found, sufficiently near; whereas by the Excentricities in the printed *Theory, viz.* 66782 and 43319 the Moon's Place would in the *4th* Observation (where it is now exact) be 6′ 10″ or 185 Miles too little, and in the *6th* Observation 8′ 46″ or 263 Miles, by Reason those Excentricities are too great, and therefore in the *4th* Equation too much is subtracted. Likewise in the *3d* Observation (which is here but 1 Second, or half a Mile wide) it would be 4′ 04″, or 122 Miles too much ; for the like Reason, because too much is added, and in none of these Observations would the *Longitude* be determined within 90 Miles.

I have only one thing more to add, which (though it be a new Notion, and for that Reason may perhaps not be so well relished, but rather be a Disadvantage to what has been before offer'd, yet) is proved to be undoubtedly true, by many of Mr. *Flamsteed*'s Observations purposely examined, whereof the two last here produced, being taken so near together, do confirm the truth of one another, *viz.* that about the 19*th* or 20*th* of *December*, when the Earth is in the Perihelion and nearest to the Sun, and for about 6 Weeks before and after, the Moon's Orbit is not so much Excentrical, as when it is in the Aphelion or farthest off, but comes nearer to a Circle, and therefore the Excentricities are then still less than in the Summer, and this may be the Reason why the Moon's Periodical Motion is longer in the Winter than in the Summer ; Since all Astronomers after *Kepler* agree, that in Elliptica Orbits equal Areas are made in equal times, and therefore the neare the whole Area comes to a Circle, the greater will it be, and require a longer time ; and accordingly in the Summer, when the Area is more Oblong and less, it's Period is shorter ; which agrees to truth, being one of the constantly observed *Phœnomena* of the Moon's Motion. Whether this be true or no, (the truth of this is confirmed by *Prop.* 17*th* *Book* the 4*th*, of *Gregory*'s *Astronomy*,) yet, since the Observations necessarily require it, the Excentricities are still less, *viz.* for the greatest 65057 Log. 4.813294, and for the least 42280, Log. 4.626137, these will answer the greatest Equation of the Moon's Apogee, *viz.* 12° 15′ 04″, and bring the Calculations to agree exactly in one Example with the Observation : Whereas by the printed Excentricities, and for the same Reason the Calculation will be too little by 8′ 46″ or 263 Miles.

I shall conclude all with a short Argumentation.

If by some one or other of the aforegoing Methods, being carefully practiced by a sufficient Instrument, the Moon's Place may be found by Observation, as often as will be necessary.

If Mr. *Flamsteed*'s Observations now to be produced, are truly taken, as to the Moon's Meridian Altititude, and the apparent or true time of the Night.

If the Calculations following be found upon Examination, to be truly and faithfully performed according to the Rules of the *Theory*, as now freed from the Errors of the Press,

An-

And lastly, if by this necessary Correction, and no other, the Moon's Place may be found by *Tables* made exactly agreeable to the *Theory*, (as so altered and corrected) within five, or very few Miles of Truth.

Then one should be inclined to think this Consequence would justly follow ; that by the late incomparable and admirable Sir *Isaac Newton*'s *Theory* of the Moon, assisted by *Tables* exactly agreeable thereunto, may sufficiently be found the *Longitude* at Sea.

But the Antecedents 'tis presumed will appear to be all true.

And therefore —— I leave it to *Your Honours* to infer the Conclusion ; in Confidence of whose most exact Judgment and impartial Determination, I beg leave with the utmost Submission and Respect, to subscribe my self

YOUR HONOURS

most obedient,

and most humble Servant,

Robert Wright.

From *Winwick* in *Lancashire*, the 21*st* of *August*, *A. D.* 1727.

A. D. 1692, *March* 18 day 08h. 54m. 48s. ☉s Apogee 3S. 7d. 35m 16s. ☉s Mean Anomaly 8S. 29d 34m 54s. Eq. Orbit + 1d. 56m 20s. Eq. of time + 4m. 41s. ☉'s true Place 0S. 09d. 06m. 42s.

A. D 1692, *March* 18 day 08h. 59m. 29s. *Mean Time*.

☽'s Equ.	☽'s Mean Motion				☽'s Apogee				☊ Ascend. Node			
	S.	°	'	''	S.	°	'	''	S.	°	'	''
	4	23	52	26	11	10	43	36	10	17	22	18
			—11	49		+	20	00		—	09	30
1*st* Equa.	4	23	40	37	11	11	03	36	10	17	12	48
		—	03	06	+	08	57	01	—	01	27	37
2*d* Equa.	4	23	37	31	11	20	00	37	10	15	45	11
			+	46	Excent. 61297				Inc. Limit 6 51			
3*d* Equa	4	23	38	17	☽s mean Anamoly				Vert. Dist Moons			
	—	03	18	02	5 03 37 40				higher Limb.			
									° ' ''			
4*th* Equ.	4	20	20	15	*Mar.* 18day Noon				37.00 55			
			— 35	15	S. ° ' ''				Error div. + 0.02			
					☉ pla. 0.08.44 44				Error Wall — 2.50			
5*th* Equ	4	19	45	00	R. Asc. 08.01.52				Semid. ☽ + 16.30			
			—	51	At Night ☉s pla.				Refract. + 0.36			
					0.09 06.42				Vert. dist. ☽ Cent.			
6*th* Equ.	4	19	44	09	R. Asc. 08.22 05				37.15.13			
			— 01	46	Diff. R. As. 20.13				Par. Alt.— 36.29			
					R.A. Moons Cent.				True Vert. Dist.			
7*th* Equ.	4	19	42	23	° ' ''				Moon's Center			
	Reduct		—	57	142 04.05				36.38 44			
					Hor.Par.Syz.60.48				Al. ☽ Cen.53.21.16			
Long. Cal.	4	19	41	26	Pro.Ho.Par. 60.16				Com. Lat *Greenw.*			
Lon. Obs.	4	19	40	59	Appar. Diam. of				—38.31.30			
Diff. Long.			0	27	the Moon 33'01''				Dec. No. ☽ Cent.			
13½ Miles.									14.49.46			

A. D. 1714

A. D. 1714, *September* 10 day 10h. 17m. 33s. ☉'s Apogee 3S. 7d. 58m. 53s. ☉'s Mean Anomaly 2 S. 22d. 23m. 32s. Eq. Orbit — 1d. 54m. 52s. Eq. Time —7m. 03s. ☉ true Place 5S. 28d. 27m 16s.

A. D. 1714, *September* 10 day 10h. 10m. 30s. Mean Time

☽'s Eq.	☽'s Mean Motion	☽'s Apogee	☊ Ascend. Node
	S. ° ' ''	S ° ' ''	S ° ' ''
	11 05 54 10 + 11 40	05 25 30 21 — 19 44	08 02 33 17 + 09 22
1 Equa.	11 06 05 50 — 25	05 25 10 37 + 01 08 48	08 02 42 39 + 01 11 19
2 Equa.	11 06 05 25 — 37	05 26 19 25 Excent. 65540	08 03 53 58 Incl. Limit 3 24
3 Equa.	11 06 04 48 — 02 46 06	☽'s Mean Anom. 05 09 45 23	Ver. dist. ☽ lower Limb 58° 31' 10''
4 Equa.	11 03 18 42 — 27 12		
5 Equa.	11 02 51 30 + 01 4[illegible]		
6 Equa.	11 02 53 13 — 01 08		
7 Equa.	11 02 52 05 Reduct — 14		

Long. Cal. 11 02 51 51
Long. Obs. 11 02 51 42
Diff. Long. 09
or 4½ Miles

Sept. 10 day Noon
☉ pla. 5.28.02.02
R. Asc 178.11.48
At Night
☉ pla. 5.28.27.16
R. Asc 178.34.57
Dif. R. As .23.09
R Asc ☽ Center
—— 332.58.12
Hor. Par Syz 61.14
Pro Hor Par 61.04
Ap Dia ☽ 33.27
Par. Altitude
51.49

Error Div. ∓0 42
Er. Wall —14 10
Semid. ☽ —16 43
Refract. + 1 17
Vertical dist. ☽'s Center 58 02 16
Par. Alt.—51 49
True Ver. dis. ☽'s Center 57 10 27
Altit of ☽'s Cent.
32 49 33
Comp. Latitude *Greenwich.*
38 31 30
Decl. S ☽'s Cent.
5 41 57

A. D. 1691, *September* 20 day 07h. 21m. 26s. ☉'s Apogee 3 S. 7d 34m. 45s. ☉'s Mean Anomaly 3S. 2d. 6m. 37s. Eq. Orbit — 1d 56m. 20s. Eq. time —10′ 12″ ☉'s true Place 6 S. 07° 44′ 37″.

A. D. 1691, *September* 20 day 07h. 11′ 14″ Mean Time

☽'s Eq.	☽'s Mean Motion	Moon's Apogee	☊ Ascend. Node
	S ° ′ ″	S. ° ′ ″	S. ° ′ ″
	9 21 07 44	10 20 39 53	10 26 54 28
	+ 11 49	— 20 00	+ 9 30
1 Equa.	9 21 19 33	10 20 19 53	10 27 03 58
	— 3 43	+ 12 08 59	— 1 28 15
2 Equa.	9 21 15 50	11 02 28 52	10 25 35 43
	+ 46	Excent. 54395	Incl. Lim. 10 20
3 Equa.	9 21 16 36	☽'s Mean Anom.	Ver. dist. ☽'s low.
	+ 3 56 36	10 18 47 44	Limb 76° 33′ 15″
			Er Div — 00 04
4 Equa.	9 25 13 12	*Sept.* 20 day Noon	Er. Wall — 02 20
	— 20 23	☉'s Place 6 S. 07°	Semid. ☽ — 14 51
		26′ 29″	Refract. + 03 17
5 Equa.	9 24 52 49	R. Asc. 186.49.52	Vertical dist. ☽'s
	+ 40	☉'s Pla. at Night	Center 76 19 17
		6 07 44 37	Par. Alt. — 52 41
6 Equa.	9 24 53 29	R. A. 187 06 33	True Vert. Dist.
	— 2 14	Diff. R. A. 16 41	☽ Cen 75 26 36
		R. A. ☽'s Center	Altit. ☽'s Center
7 Equa.	9 24 51 15	297 28 03	14 33 24
	Reduct + 6 20	Hor. Par. Syz. 54 56	Compl. Latitude
		Pro. Ho. Par. 54.13	*Greenwich*
Lon. Cal.	9 24 57 35	Ap. Dia. ☽ 29 42	38 31 30
Lon. Obs.	9 24 57 36	Par. Altit. 52 41	— 14 33 24
Diff. Long	01		Decl. S. ☽'s Cent.
	or half a Mile		23 58 06

A. D. 169

A. D. 1698, *June* 16*th* day 14h. 46m. 33ſ. ☉'s Apogee 3 S. 7d. 41m. 50ſ. ☉'s Mean Anomaly 11S. 27d. 58m. 25ſ. Eq. Orbit + 4m. 00ſ. Eq. time +02′ 20″ ☉'s true Place 3 S. 05° 44′ 21″.

A. D. 1698, *June* 16 day, 14h. 48′ 53″ Mean Time

☽'s Eq.	☽'s Mean Motion	Moon's Apogee	☊ Aſcend. Node
	S ° ′ ″	S. ° ′ ″	S. ° ″
	10 22 25 32	7 24 52 33	6 16 34 06
	—24	+ 41	— 20
1 Equa.	10 22 25 08	7 24 53 14	6 16 33 46
	— 3 32	+ 11 30 57	— 33 58
2 Equa.	10 22 21 36	8 06 24 11	6 15 59 48
	+ 17	Excent. 56947	Incl. Lim. 0 38
3 Equa.	10 22 21 53	☽'s Mean Anom.	Ver. diſt. ☽'s high.
	— 6 14 20	2 15 57 42	Limb 63° 46′ 40″
			Er Div. + 00 20
4 Equa.	10 16 07 33	*June* 16dayNoon	Er. Wall + 07 30
	+ 32 42	☉'sPla 3·05.09.08	Semid. ☽ + 15 24
		R. Aſc. 95.36.53	Refract. + 01 40
5 Equa.	10 16 40 15	☉'s Pla. at Night	Vertical diſt. ☽'s
	— 22	3 05 44 21	Center 63 56 34
		R. A. 96 15 13	Par. Alt. — 50 30
6 Equa.	10 16 39 53	Diff. R.A. 38 20	True Vert. Diſt.
	+ 1 32	R. A. ☽'s Center	☽ Cen 63 06 04
		317 53 28	Compl. Latitude
7 Equa.	10 16 41 25	Hor.Par.Syz 56 33	*Greenwich*
	Reduct + 5 46	Pro.Ho.Par 56.13	38 31 30
		Ap. Dia. ☽ 30 48	—26 53 56
Lon. Cal	10 16 47 11	Par. Altit. 50 30	Decl. S. ☽'s Cent.
Lon. Ob.	10 16 47 11		11 37 34
Diff. Long.	00		

A. D. 1691, *December* 18 day 06h. 27m. 00s. ☉'s Apogee 3S. 7d. 35m. 01s. ☉'s Mean Anomaly 5 S. 29d. 47m. 28s. Eq. Orbit —26s. Eq. Time +2m. 36s. ☉ true Place 9S. 07d. 22m. 10s.

A. D. 1691, *December* 18 day 06h. 29m. 36s. Mean Time.

☽'s Eq.	☽'s Mean Motion	☽'s Apogee	☊ Ascend Node
	S. ° ' "	S ° ' "	S ° ' "
	0 23 26 50 + 3	11 00 34 36 — 4	10 22 11 46 + 2
1 Equa.	0 23 26 53 — + 3 46	11 00 34 32 -- 12 13 05	10 22 11 48 + 1 29 38
2 Equa.	0 23 30 39 — 47	10 18 21 27 Excent. 51618	10 23 41 26 Incl. Limit 9 03
3 Equa.	0 23 29 52 — 05 14 58	☽'s Mean Anom. 2 05 08 26	Ver. dist. ☽ lower Limb 41° 17' 10" Error Div. + 20
4 Equa.	0 18 14 54 — 13 52	*Dec.* 18day Noon ☉ pla. 9.07 05.42 R. Asc 277.43.42	Er. Wall — 2 30 Semid. ☽ — 15 10 Refract. + 42
5 Equa.	0 18 01 02 + 01 21	☉ pla. at Night 9 07 22 10 R. As 278 02 39	Vertical dist. ☽'s Center 41 00 32 Par. Alt. —36 20
6 Equa.	0 18 02 23 — 02 17	Dif. R. As. 18 57 R. Asc ☽ Center 14 47 39	True Ver. dis. ☽'s Center 40 24 12 Altit of ☽'s Cent. 49 35 48
7 Equa.	0 18 00 06 Reduct — 6 36	Hor Par. Syz. 56.09 Pro Hor Par 55.22 Ap Dia ☽ 30.20	Comp. Latitude *Greenwich.* — 38 31 30
Long. Cal. 0 17 53 30 Long. Obs. 0 17 53 38 Diff. Long. 08 or 4 Miles		Par. Altitude 36.20	Decl. N ☽'s Cent. 11 04 18 Long. 17 53 38

A. D. 1691, *Decem.* 19 day 7h. 10m. 36s. ☉s Apogee 3S. 7d. 35m 01s. ☉'s Mean Anomaly 6S. 00 d 48m. 23s. Eq. Orbit + 1m. 40s Eq. of time + 3m. 06s. ☉'s true Place 9S. 08d. 25m. 12s.

A. D. 1691, *Decem.* 19 day 07h. 13m. 42s. *Mean Time.*

☽'s Equ.	☽'s Mean Motion				☽'s Apogee				☊ Ascend. Node			
	S.	°	′	″	S.	°	′	″	S.	°	′	″
	1	07	01	37	11	00	41	30	10	22	08	29
			—	10			+	17			—	08
1*st* Equa	1	07	01	27	11	00	41	47	10	22	08	21
		+	03	48	—	12	14	28	+	01	29	26
2*d* Equa.	1	07	05	15	10	18	27	19	10	23	37	47
			—	47	Excent. 51987				Inc. Limit 9 23			
3*d* Equa.	1	07	04	28	☽s mean Anomaly				Vert. Dist. Moons lower Limb.			
	—	05	46	34	2	18	37	09				
4*th* Equ.	1	01	17	54	*Dec.* 19 day Noon				° ′ ″ 35.58.40			
		—	26	47	S. ° ′ ″				Error div. + 0.15			
					☉ pla. 9.08.06 54				Error Wall. — 2 30			
5*th* Equ.	1	00	51	07	R. Asc. 278.50.12				Semid. ☽ — 15.21			
			+	58	☉s pla. At Night				Refract. + 35			
					9.08.25.12				Vert. dist. ☽ Cent.			
6*th* Equ.	1	00	52	05	R. Asc. 279.11.25				35.41.39			
		—	02	09	Diff. R. As. 21.13				Par. Alt. — 32.41			
					R. A. Moons Cent.				True Vert. Dist.			
7*th* Equ	1	00	49	56	26.50.25				Moon's Center			
	Reduct		— 5	00	Hor. Par. Syz. 56.42				35.08.58			
					Pro. Ho. Par. 56 02				Altit. 54 51.02			
Long. Cal.	1	00	44	56	Appar. Diam. of				— 38.31.30			
Lon. Obs.	1	00	44	56	the Moon 30′42″				Dec. No. ☽ Cent.			
Diff. Long.			0	00					16.19.32			
									Long. 1.00 44 56			

A CATALOGUE *of those* Stars *whose Right Ascension is nearly the same.*

Stars Names	Right Asc	Dist. from the North Pole	Varia. of R. As.	Variation of the Polar Dist.	Magnit.
	d m s	d m s	m s	d m	
Northern in the Fins of the Whale's Tail marked (ι) in *Bayer's* Uranometria	01 21 30	100 21 03	54 59	—23 54	03
— In the middle of *Toucan's* Wing	01 13 39	23 31 39	53 27	23 54	03
Former before *Whales Tail* (η)	13 42 27	101 38 56	53 54	—23 18	03
South. in *Andromeda's Girdle* (β)	13 34 15	55 51 00	58 30	—23 20	02
In *Perseus's Scymitar* (φ)	21 41 02	40 41 59	64 43	—22 22	04
— In *Eridanus, Achernar* (α)	21 45 08	31 21 50	40 28	22 09	01
In the Knot of the two lines of *Pisces* (α)	26 58 22	88 34 35	55 14	—21 30	03
Above *Andromeda's* Left Foot (ν)	26 49 29	49 00 18	68 (63) 57	—21 33	2.3
In the *Whales Jaw, Mencar* (α)	41 59 43	87 00 35	55 46	—18 00	02
Before *Medusa's Head* (ρ)	41 54 59	52 14 37	66 58	—18 06	04
In the tip of the *Bull's* So Horn, (ζ)	80 19 10	69 03 26	64 00	—04 28	03
Middle of the *Hares* Body (α)	80 11 11	108 02 33	47 21	—04 24	03
Orions Right Shoulder (α)	85 04 32	82 40 32	58 05	—02 25	01
— Latter of the Bright Stars in the *Dove*	85 20 05	54 07 16	37 48	01 47	2.3
Pollux (β)	112 07 40	61 20 23	67 19	08 36	02
— Middle of *Argo's Scutum*	111 55 16	63 49 51	44 08	—09 05	03

Stars Names	Right Asc.	Distance from the Nort. Pole	Variat. of R. Asc.	Vari. of Polar Distan.	Magnitude.
	d m s	d m s	m s	m s	
Hydra's Heart	138 31 21	97 29 15	52 57	17 40	2
+ North part of the Section of *Argo*'s Keel	138 22 22	36 11 39	33 22	—17 57	3 2
Hydra's Heart	138 31 21	97 29 15	52 57	17 40	2
Great Bear's left Knee (φ)	138 37 21	37 05 27	76 41	17 34	3.4
In the *Great Bears Ribs* (α)	161 38 05	26 46 06	71 10	22 32	1.2
Bottom of the Bowl (α)	161 38 20	106 50 36	52 40	22 31	4
-|- Northern in the *Centaur*'s Right Thigh (β)	178 35 38	40 49 54	54 33	—23 54	3
Ravens Bill (α)	178 34 50	113 12 07	54 39	23 54	4
Raven's Right Wing (γ)	180 26 50	106 01 07	54 56	23 53	3
-|- First in the *Crosiers* (γ)	180 15 33	32 47 49	55 30	—23 54	3
Virgins Spike	197 42 04	99 43 27	56 08	22 53	1
Mid. of *Great Bears Tail* (ζ)	197 44 03	33 37 44	44 05	22 47	3
+ Star after the left Knee of the *Centaur*	215 12 28	26 16 12	83 37	—19 22	3
Bootes's Left Shoulder (γ)	215 14 53	50 29 15	43 45	19 40	3
In the *Serpents* Neck (δ)	230 26 07	78 32 06	51 44	15 32	3
In the *Little Bear* (γ)	230 21 17	17 11 57	—05 26	15 13	3
Serpens (α)	232 41 32	82 41 43	52 33	14 46	2
+Nor. Basis of Sou. Triangle	232 53 11	27 28 47	92 16	—14 10	3
Scorpio's *Heart, Antares* (α)	243 10 04	115 47 31	65 08	11 10	1
Next after *Hercules*'s *Right Knee*	243 08 06	57 00 22	41 11	11 04	5
Scorpio (ε)	248 07 20	123 45 26	69 39	09 22	3
Hercules (η)	248 20 52	50 32 12	36 44	09 04	3

Above

Stars Names	Right Asc.			Distance from the Nort. Pole			Variat. of R. Asc.		Vari. of Polar Distan.		Magni-tude.
	d	m	ſ	d	m	ſ	m	ſ	m	ſ	
Above Dragon's Eye (β)	261	08	06	37	28	46	24	11	03	52	2 3
In the Head of *Serpentar* (α)	260	52	36	77	13	24	49	41	04	17	2
Draco (γ)	267	35	29	38	27	45	24	57	01	10	2
Sagittar. (γ)	257	02	31	120	23	27	59	02	01	43	3
Hercules (A)	270	22	14	58	38	25	40	28	—00	09	4.5
Sagittar. (δ)	270	50	39	119	54	18	68	48	—00	03	3
In the Serpent's Tail (η)	271	47	48	92	55	28	56	16	—00	24	3
In the South part of Sagittary's Bow (ε)	271	29	59	124	28	40	71	28	—00	10	3
Cygnus (δ)	294	04	48	45	30	59	33	35	—09	32	3.4
Aquila (α)	294	19	56	81	50	10	51	52	—09	30	1.2
Cepheus (ι)	339	56	12	25	14	04	37	23	—22	22	4
Aquar. (δ)	340	02	22	107	16	25	57	44	—22	19	3
Cassiopeia's Chair (β)	358	40	47	32	21	24	53	33	—23	52	3.2
Head of Andromeda (α)	358	33	21	62	25	49	54	42	—23	52	2

A *CATALOGUE* of ſome other Stars of the Firſt and Second Magnitude not mentioned before, with their *Right Aſcenſions*, &c. which may be of Uſe in finding the *Latitude* and Hour of the Night.

Stars Names.	Right Aſc.	Diſt. N. P.	Va R. A	Var. P. d	M
	d. m. ſ.	d. m. ſ.	m. ſ	d. m	
+ Bright Star in the Head of the Phœnix	3 06 17	46 12 37	53 38	23 53	02
Pole Star	9 38 14	02 09 33	161 28	−23 35	02
Bright Star *Aries*	27 56 11	67 51 05	59 22	−21 20	02
New * in the *Whales* Breaſt (*o*)	31 22 31	94 14 17	54 02	−20 36	02
Meduſa's-head, *Argol* (β)	42 36 18	50 07 52	68 06	−[illegible] 56	02
Perſeus Right ſide *Algenib* (α)	46 14 06	41 08 28	74 11	−16 54	02
In Eridanus (*ν*)	56 18 57	104 18 19	49 54	−13 32	02
Bull's Eye, *Aldebaran* (α)	65 02 54	74 04 26	61 07	−10 28	01
Capella (α)	74 07 10	44 18 31	78 20	−07 07	01
Bright Star in Orion's left Foot, *Rigel* (β)	75 20 45	98 32 48	51 31	−06 25	01
Firſt in Orion's Girdle (δ)	79 29 54	90 32 02	54 48	−04 45	02
Great Dog's Fore Foot (β)	92 40 10	107 49 34	47 15	00 47	02
+ Canobus, or the Ship's Stern (α)	94 30 44	37 28 04	23 58	−01 58	01
Pollux Left Foot (ι)	95 27 45	73 24 10	62 10	01 50	02
Great Dogs Mouth *Syrius*, (α)	98 16 33	106 20 48	48 07	03 07	01
Caſtor (α)	109 15 46	57 32 38	69 31	07 26	01
Procyon (α)	111 14 03	84 05 24	57 25	08 17	01.
+ Root of the Royal Oak	137 25 57	21 27 07	13 39	−17 38	02
Lyon's Heart *Regulus* (α)	148 26 04	76 42 49	58 08	20 08	01
Lyon's Tail, *Deneb* (β)	173 46 06	73 54 17	55 51	23 43	01
+ Southern in the Croſiers (ζ)	182 57 34	28 27 04	57 40	−23 52	02
+ The Northern (ε)	184 05 54	34 27 11	57 52	−23 49	02
Great Bears Rump, *Eliot* (ε)	190 30 49	32 21 56	48 38	23 33	02
Arcturus	210 47 43	69 21 21	50 26	20 43	01
+ Right Foot of Centaur (α)	215 25 35	30 20 07	79 14	−19 18	01
The South Ballance	218 57 36	104 53 00	58 52	18 51	02

The

Stars Names.	Right Asc.	Dist. N. P.	Va. R. A	Var. P. d.	Mag.
	d. m. s.	d. m. s.	m. s.	m s.	
The North Ballance	225 55 12	98 21 16	57 24	17 02	02
The Northern Crown (*α*)	230 46 41	62 20 59	45 21	15 18	02
Northern of the 3 in the *Scorpion's Forehead*, (*β*)	237 24 25	109 01 46	61 49	13 12	02
+ The Vertex of the Southern Triangle	244 56 20	21 33 48	110 28	—09 47	02
Lyra (*α*)	276 54 04	51 27 06	36 08	—02 37	01
-|- Peacock's Eye	300 57 03	32 27 47	86 55	12 29	02
Swan's Tail (*α*)	307 58 50	45 40 45	36 39	—14 30	02
-|- Crane's Tail	336 26 23	41 41 25	65 26	22 00	02
Fomalhaut	340 35 04	121 03 33	60 07	—22 24	01
In Pegasus Scheat (*β*)	342 37 06	63 24 18	51 22	—22 43	02
Marchab (*α*)	342 46 03	76 16 23	53 16	—22 43	02
End of Pegasus's Wing	359 46 58	76 20 58	54 56	—23 54	02

These

Theſe two Catalogues I ſhould hope would be much valued, ſince they are no where elſe to be met with, but in the Original, *viz.* By *Flamſteed's Hiſtoria Cœleſtis Britannica*, from whence they are taken, and calculated to the Beginning of the Year 1726, according to his Rules of Variation, which it will be very proper and neceſſary here to ſet down, otherwiſe even theſe Catalogues will be of Uſe but for a ſhort time.

The Reaſon of this Variation is, that the Equinoctial Points are found to recede $50''$ in a Year, and that thereby the *Longitude* of a Star, or its Diſtance from thoſe points will be encreaſed 1 Degree in 72 Years; and the *Longitude* being encreaſed, the Right Aſcenſion will be ſo too, and the Polar Diſtance alſo changed. Therefore if you would know the true Right Aſcenſion and Declination of a Star any time to come, work thus, As 72 to the Interval of Years, ſo is the Number in the *Table*, to the Proportional Parts, to be added in the Right Aſcenſion, (except in ſome few Stars near the North Pole, as the Star in the *Little Bear* (γ) whoſe Variation muſt be ſubtracted) and in the Polar Diſtance too, if the Stars *Longitude* be in any of the Signs from the Beginning of *Cancer*, to the Beginning of *Capricorn*; but if the contrary, to be ſubtracted from the North Polar Diſtance found in the *Table*.

For Inſtance, if you would know the Right Aſcenſion and Declination of *Achernar*, the Firſt of *July* in the Year 1740. From the Beginning of 1726 to that of 1740 are 14 Years, therefore by the Rule of Proportion, As 72 : $14\frac{1}{2}$: : 40m. 28ſ. : 8m. 09ſ. the Right Aſcenſion of *Achernar* will then be 21 deg. 53 min. 17 ſec. ſo for the Declination, As 72 : $14\frac{1}{2}$: : 22m. 09ſ. : 4m. 27ſ. which $4'$ $27''$ ought to be ſubtracted from the Polar Diſtance, becauſe the Star is in *Piſces*, but here the Diſtance being from the South Pole it muſt be added, therefore to 31 deg. 21 min 50 ſec. add 4 min. 27 ſec. the Sum 31 deg. 26 min. 17 ſec. will be the South Polar Diſtance of *Achernar* at that time, and its Complement 58 deg. 33 min. 43 ſec. will be it's Declination South, and thus of the reſt.

After this Manner, by a very eaſy Computation muſt the true Right Aſcenſion and Declination of every Star be found, whenever an Obſervation is taken, otherwiſe the Calculation will not be exactly true. To know when the Proportional Parts are to be added and when ſubtracted, this Mark (—) prefixed to the Polar Diſtance, ſhews they muſt be ſubtracted, when there is no Mark they muſt be added; this Mark (+) ſet before a Star's Name, means that it's Diſtance is taken from the South Pole; if no Mark, it is taken from the North, and ſo much may ſuffice for a full Explanation of the Catalogue.

I have now but one Obſervation or two to make, before I conclude. The learned Mr. *Whiſton* in his *Aſtronomical Lectures*, is pleaſed to baniſh the Motion of the Sun's Apogee, or the Earth's Aphelion out of the Heaven's; but ſince Sir *Iſaac* allows it a ſlow Motion, *viz*. 4′ 20″ in 20 Years, and ſince Dr. *Gregory* is of the ſame Judgment, as appears from *Propoſition* the *15th* of his *3d Book*, and likewiſe from *Schol. Propoſition* the *20th*, *Book* the *4th*, therefore he will pleaſe to excuſe me, if in my *Tables* I differ from him in this Particular. Laſtly, as to the Advantage of the aforegoing Methods above others, it may be obſerved, that whereas the Eclipſes of the Sun and Moon happen too ſeldom to be of much Uſe, and the Eclipſes of *Jupiter*'s Satellites cannot be diſcovered without long Teleſcopes; and whereas the Method by the Occultation of the Fixed Stars is very difficult and uncertain, by Reaſon of the Moon's Parallax, though made eaſier by Mr. *Flamſteed*'s *Geometrical Conſtruction*; this of the Moon her ſelf is a conſtant and never failing Phænomenon, only for two or three Days before and after the Change, ſo that all the reſt of the Month, there is never wanting (in proper Weather) either Night or Day a fit Opportunity of diſcovering the *Longitude*, therefore 'tis to be hoped, it will be accepted by the learned World, eſpecially by the Honourable and Learned *Commiſſioners*.

FINIS.

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