that adhere to any of thoſe Hypotheſes, ſhould ſeek for other Cauſes of theſe Effects, unleſs (to uſe the Objector's Argument) *they will multiply Entities without Neceſſity.*

The *third* Thing to be conſidered is, the Condition of the Animadverſor's Conceſſions, which is, That I would explicate my Theories by his Hypotheſis: And if I could comply with him in that Point, there would be little or no Difference between us: For he grants, That, without any reſpect to a different Incidence of Rays, there are different Refractions; but he would have it explicated, not by the different Refrangibility of ſeveral Rays, but by the ſplitting and rarefying Æthereal Pulſes. He grants my third, fourth, and ſixth Propoſitions; the Senſe of which is, That uncompounded Colours are unchangeable, and that compounded Ones are changeable only by reſolving them into the Colours of which they are compounded: and that all the Changes which can be wrought in Colours, are effected only by variouſly mixing or parting them: But he grants them on Condition that I will explicate Colours by the two Sides of a ſplit Pulſe, and ſo make but two Species of them, accounting all other Colours in the World to be but various Degrees and Dilutings of thoſe two. And he further grants, that Whiteneſs is produced by the Convention of all Colours; but then I muſt allow it to be not only by Mixture of thoſe Colours, but by a farther uniting of the Parts of the Ray ſuppoſed to be formerly ſplit.

If I would proceed to examine theſe his Explications, I think it would be no difficult Matter to ſhew, that they are not only inſufficient, but in ſome reſpects (to me at leaſt) unintelligible: For though it be eaſy to conceive, how Motion may be dilated and ſpread, or how parallel Motions may become diverging; yet I underſtand not, by what Artifice any linear Motion can by a refracting Superficies be infinitely dilated and rarefied, ſo as to become ſuperficial: Or, if that be ſuppoſed, yet I underſtand as little, why it ſhould be ſplit at ſo ſmall an Angle only, and not rather ſpread and diſperſe through the whole Angle of Refraction. And further, though I can eaſily imagine, how unlike Motions may croſs one another; yet I cannot well conceive, how they ſhould coaleſce into one uniform Motion, and then part again, and recover the former Unlikeneſs; notwithſtanding that I conjecture the Ways by which the Animadverſor may endeavour to explain it. So, that the direct, uniform, and undiſturb'd Pulſes ſhould be ſplit and diſturbed by Refraction; and yet the oblique and diſturbed Pulſes perſiſt without ſplitting, or further Diſturbance, by following Refractions, is (to me) as unintelligible: and there is as great a Difficulty in the Number of Colours; as you will ſee hereafter.

But whatever be the Advantages or Diſadvantages of this Hypotheſis, I hope I may be excuſed from taking it up, ſince I do not think it needful to explicate my Doctrine by any Hypotheſis at all: For if Light be conſidered abſtractedly without reſpect to any Hypotheſis, I can as eaſily conceive, that the ſeveral Parts of a ſhining Body may emit Rays of different Colours and other Qualities, of all which Light is conſtituted, as that the ſeveral Parts of a falſe or uneven String, or of unevenly agitated Water in a Brook or Cata-

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ract, or the ſeveral Pipes of an Organ inſpir'd all at once, or all the Variety of ſounding Bodies in the World together, ſhould produce Sounds of ſeveral Tones, and propagate them thro' the Air confuſedly intermixed. And if there were any natural Bodies that could reflect Sounds of one Tone, and ſtifle or tranſmit thoſe of another; then, as the Echo of a confuſed Aggregate of all Tones would be that particular Tone, which the echoing Body is diſpoſed to reflect; ſo, ſince (even by the Animadverſor's Conceſſions) there are Bodies apt to reflect Rays of one Colour, and ſtifle or tranſmit thoſe of another; I can as eaſily conceive, that thoſe Bodies, when illuminated by a Mixture of all Colours, muſt appear of that Colour only which they reflect.

But when the Objector would inſinuate a Difficulty in theſe Things, by alluding to Sounds in the String of a muſical Inſtrument before Percuſſion, or in the Air of an Organ-Bellows before its Arrival at the Pipes; I muſt confeſs, I underſtand it as little, as if one had ſpoken of Light in a Piece of Wood before it be ſet on Fire, or in the Oil of a Lamp before it aſcend up the Match to feed the Flame.

You ſee therefore how much it is beſide the Buſineſs in Hand to diſpute about Hypotheſes. For which Reaſon I ſhall now, in the laſt Place, proceed to abſtract the Difficulties in the Animadverſor's Diſcourſe, and without having regard to any Hypotheſis, conſider them in general Terms. And they may be reduced to theſe three Queries:

1. *Whether the unequal Refractions, made without reſpect to any Inequality of Incidence, be cauſed by the different Refrangibility of ſeveral Rays; or by the ſplitting, breaking, or diſſipating the ſame Ray into diverging Parts?*
2. *Whether there be more than two Sorts of Colours?*
3. *Whether Whiteneſs be a Mixture of all Colours?*

The *firſt* of theſe *Queries* you may find determined above, by an Experiment: The Deſign of which was to ſhew, that the Length of the colour'd Image proceeded not from any Unevenneſs in the Glaſs, or any other contingent Irregularity in the Refractions. Amongſt other Irregularities, I know not what is more obvious to ſuſpect, than a fortuitous Dilating and Spreading of Light, after ſome ſuch manner, as *Des Cartes* has deſcribed in his *Æthereal Refractions*, for explicating the Tail of a Comet; or as the Animadverſor now ſuppoſes to be effected by the ſplitting and rarefying of his æthereal Pulſes. And to prevent the Suſpicion of any ſuch Irregularities, I told you, that I refracted the Light contrary ways, with two Priſms ſucceſſively, to deſtroy thereby the regular Effects of the firſt Priſm by the ſecond, and to diſcover the irregular Effects by augmenting them with iterated Refractions. Now, amongſt other Irregularities, if the firſt Priſm had ſpread and diſſipated every Ray into an indefinite Number of diverging Parts, the ſecond ſhould in like manner have ſpread and diſſipated every one of thoſe Parts into a further indefinite Number, whereby the Image would have been ſtill more dilated, contrary to the Event. And this ought to have happened, becauſe thoſe linear diverging Parts depend not on one another for the manner of their Refraction, but are every one of them as truly and compleatly Rays, as the whole was before its Incidence; as may appear by intercepting them ſeverally.

The Reaſonableneſs of this Proceeding will, perhaps, better appear by acquainting you with this further Circumſtance. I ſometimes placed the ſecond Priſm in a Poſition tranſverſe to the firſt, on Deſign to try if it would make the long Image become four-ſquare, by Refractions croſſing thoſe that had drawn the round Image into a long one. For if, amongſt other Irregularities, the Refraction of the firſt Priſm did, by ſplitting, dilate a linear Ray into a ſuperficial; the croſs Refractions of that ſecond Priſm ought, by further ſplitting, to dilate and draw that ſuperficial Ray into a pyramidical Solid. But, upon Trial, I found it otherwiſe; the Image being as regularly oblong as before, and inclined to both the Priſms at an Angle of 45 Degrees.

I tried alſo all other Poſitions of the ſecond Priſm, by turning the Ends about its middle Part; and in no caſe could obſerve any ſuch Irregularity. The Image was ever alike inclined to both Priſms, its Breadth anſwering to the Sun's Diameter, and its Length being greater or leſs, according as the Refractions more or leſs agreed or contradicted one another.

And by theſe Obſervations, ſince the Breadth of the Image was not augmented by the croſs Refraction of the ſecond Priſm, that Refraction muſt have been performed without any ſplitting or dilating of the Ray; and therefore at leaſt the Light incident on that Priſm muſt be granted an Aggregate of Rays *unequally Refrangible* in my Senſe. And ſince the Image was equally inclined to both Priſms, and conſequently the Refractions alike in both, it argues that they were performed according to ſome conſtant Law, without any Irregularity.

To determine the *ſecond Query*, The Animadverſor refers to an Experiment made with two Wedge-like Boxes, recited in the *Micrography* of the ingenious Mr. *Hook*, *Obſerv.* 10. *Pag.* 73. The Deſign of which was to produce all Colours out of a Mixture of two. But there is, I conceive, a double Defect in this Inſtance: For it appears not, that by this Experiment all Colours can be produced out of two; and if they could, yet the Inference would not follow.

That all Colours cannot by that Experiment be produced out of two, will appear by conſidering, that the Tincture of Aloes, which afford one of thoſe Colours, was not all over of one uniform Colour, but appeared Yellow near the Edge of the Box, and Red at other Places where it was thicker; affording all Variety of Colours, from a pale Yellow to a deep Red or Scarlet, according to the various Thickneſs of the Liquor. And ſo the Solution of Copper, which afforded the other Colour, was of various Blues and Indicoes. So that inſtead of two Colours, here is a great Variety made uſe of for the Production of all others. Thus, for Inſtance, to produce all Sorts of Greens, the ſeveral Degrees of Yellow and pale Blue muſt be mix'd; but to compound Purples, the Scarlet and deep Blue are to be the Ingredients.

Now if the Animadverſor contend, that all the Reds and Yellows of the one Liquor, or Blues and Indicoes of the other, are only various Degrees and Dilutings of the ſame Colour, and not divers Colours; that is a begging of

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the Queſtion: And I ſhould as ſoon grant, that the Two Thirds or Sixths in Muſick are but ſeveral Degrees of the ſame Sound, and not divers Sounds. Certainly it is much better to believe our Senſes, informing us, that Red and Yellow are divers Colours; and to make it a philoſophical Query, Why the ſame Liquor doth, according to its various Thickneſs, appear of thoſe divers Colours; than to ſuppoſe them to be the ſame Colour, becauſe exhibited by the ſame Liquors. For if that were a ſufficient Reaſon, then Blue and Yellow muſt alſo be the ſame Colour, ſince they are both exhibited by the ſame Tincture of Nephritic Wood. But that they are divers Colours, you will more fully underſtand by the Reaſon, which in my Judgment is this: The Tincture of Aloes is qualified to tranſmit moſt eaſily the Rays endued with Red, moſt difficultly the Rays endued with Violet, and with intermediate Degrees of Facility, the Rays endued with intermediate Colours. So that where the Liquor is very thin, it may ſuffice to intercept moſt of the Violet, and yet tranſmit moſt of the other Colours; all which together muſt compound a middle Colour, that is, a faint Yellow. And where it is ſo much thicker, as alſo to intercept moſt of the Blue and Green, the remaining Green, Yellow, and Red, muſt compound an Orange. And where the Thickneſs is ſo great, that ſcarce any Rays can paſs through it beſides thoſe endued with Red, it muſt appear of that Colour, and that ſo much the deeper and obſcurer, by how much the Liquor is thicker. And the ſame may be underſtood of the various Degrees of Blue, exhibited by the Solution of Copper, by reaſon of its Diſpoſition to intercept Red moſt eaſily, and tranſmit a deep Blue or Indico Colour moſt freely.

But ſuppoſing that all Colours might, according to this Experiment, be produced out of two by Mixture; yet it follows not, that thoſe two are the only original Colours; and that for a double Reaſon: Firſt, Becauſe thoſe two are not themſelves original Colours, but compounded of others; there being no Liquor, nor any other Body in Nature, whoſe Colour in Day-light is wholly uncompounded. And then, becauſe though thoſe two were original, and all others might be compounded of them, yet it follows not that they cannot be otherwiſe produced. For I ſaid that they had a double Origin, the ſame Colours to Senſe being in ſome Caſes compounded, and in others uncompounded; and ſufficiently declared in my *third* and *fourth Propoſitions*, and in the *Concluſion*, by what Properties the one might be known and diſtinguiſh'd from the other. But becauſe I ſuſpect by ſome Circumſtances, that the Diſtinction might not be rightly apprehended, I ſhall once more declare it, and further explain it by Examples.

That Colour is Primary or Original, which cannot by any Art be changed, and whoſe Rays are alike refrangible: And that Compounded, which is changeable into other Colours, and whoſe Rays are not alike refrangible. For Inſtance: To know whether the Colour of any green Object be compounded or not, view it through a Priſm; and if it appear confuſed, and the Edges tinged with Blue, Yellow, or any Variety of other Colours, then is that Green compounded of ſuch Colours as at its Edges emerge out of it: But if it appear diſtinct, and well defined, and entirely Green to the very Edges,

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without any other Colours emerging, it is of an original and uncompounded Green. In like manner, if a refracted Beam of Light, being caſt on a white Wall, exhibit a green Colour, to know whether that be compounded, refract the Beam with an interpoſed Priſm; and if you find any Difformity in the Refractions, and the Green be transformed into Blue, Yellow, or any Variety of other Colours, you may conclude that it was compounded of thoſe that emerge: But if the Refractions be uniform, and the Green perſiſt without any Change of Colour, then is it original and uncompounded. And the Reaſon why I call it ſo is, becauſe a Green endued with ſuch Properties cannot be produced by any mixing of other Colours.

Now if two green Objects may to the naked Eye appear of the ſame Colour, and yet one of them through a Priſm ſeem confuſed and variegated with other Colours at the Edges, and the other diſtinct and entirely green; or if there may be two Beams of Light, which falling on a white Wall, do to the naked Eye exhibit the ſame green Colour, and yet one of them, when tranſmitted through a Priſm, be uniformly and regularly refracted, and retain its Colour unchanged, and the other be irregularly refracted, and made to divaricate into a Multitude of other Colours: I ſuppoſe theſe two Greens will in both Caſes be granted of a different Origin and Conſtitution. And if by mixing Colours, a Green cannot be compounded with the Properties of the unchangeable Green, I think I may call that an uncompounded Colour, eſpecially ſince its Rays are alike refrangible and uniform in all Reſpects.

The ſame Rule is to be obſerved in examining whether Red, Orange, Yellow, Blue, or any other Colour, be compounded or not. And, by the way, ſince all white Objects through the Priſm appear confuſed and terminated with Colours, Whiteneſs muſt, according to this Diſtinction, be ever compounded, and that the moſt of all Colours, becauſe it is the moſt confuſed and changed by Refractions.

There now remains the *third* Query to be conſidered, which is, Whether Whiteneſs can be an uniform Colour, or a diſſimilar Mixture of all Colours? The Experiment which I brought to decide it, the Animadverſor thinks, may be otherwiſe explained, and ſo concludes nothing. But he might eaſily have ſatisfied himſelf by trying what would be the Reſult of a Mixture of all Colours. And that very Experiment might have ſatisfied him, if he had pleaſed to examine it by the various Circumſtances. One Circumſtance I there declared, of which I ſee no Notice taken; and it is, That if any Colour at the Lens be intercepted, the Whiteneſs will be changed into other Colours: If all the Colours but Red be intercepted, that Red alone in the Concourſe or croſſing of the Rays, will not conſtitute Whiteneſs, but continues as much Red as before; and ſo of the other Colours. So that the Buſineſs is not only to ſhew how Rays, which before the Concourſe exhibit Colours, do in the Concourſe exhibit White; but to ſhew, how, in the ſame Place, where the ſeveral Sorts of Rays apart exhibit ſeveral Colours, a Confuſion of all together makes White. For Inſtance, If Red alone be firſt tranſmitted to the Paper at the Place of Concourſe, and then the other Colours be let fall on that Red, the Queſtion will be, Whether they convert it into White by mixing with it only,

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as Blue falling on a Yellow Light is ſuppoſed to compound Green? Or whether there be ſome further Change wrought in the Colours by their mutual acting on one another, until, like contrary *peripatetic Qualities*, they become aſſimilated? And he that ſhall explicate this laſt Caſe mechanically, muſt conquer a double Impoſſibility. He muſt firſt ſhew, that many unlike Motions in a Fluid can by claſhing ſo act on one another, and change each other, as to become one uniform Motion; and then, that an uniform Motion can of itſelf, without any new unequal Impreſſions, depart into a great Variety of Motions regularly unequal. And after this he muſt further tell me, why all Objects appear not of the ſame Colour; that is, why their Colours in the Air, where the Rays that convey them every Way are confuſedly mix'd, do not aſſimilate one another, and become uniform before they arrive at the Spectator's Eye?

But if there be yet any doubting, 'tis better to put the Event on further Circumſtances of the Experiment, than to acquieſce in the Poſſibility of any hypothetical Explications: As for Inſtance, by trying what will be the Apparition of theſe Colours in a very quick Conſecution of one another. And this may be eaſily performed by the rapid Gyration of a Wheel with many Spokes or Coggs in its Perimeter, whoſe Interſtices and Thickneſſes may be equal, and of ſuch a Largeneſs, that, if the Wheel be interpoſed between the Priſm and the white Concourſe of the Colours, one half of the Colours may be intercepted by a Spoke or Cogg, and the other half paſs through an Interſtice. The Wheel being in this Poſture, you may firſt turn it ſlowly about, to ſee all the Colours fall ſucceſſively on the ſame Place of the Paper, held at their aforeſaid Concourſe; and if you then accelerate its Gyration, until the Conſecution of thoſe Colours be ſo quick, that you cannot diſtinguiſh them ſeverally, the reſulting Colour will be a Whiteneſs perfectly like that, which an unrefracted Beam of Light exhibits, when in like manner ſucceſſively interrupted by the Spokes or Coggs of that circulating Wheel. And that this Whiteneſs is produced by a ſucceſſive Intermixture of the Colours, without their being aſſimilated, or reduced to any Uniformity, is certainly beyond all Doubt, unleſs Things that exiſt not at the ſame Time, may notwithſtanding act on one another.

There are yet other Circumſtances, by which the Truth might have been decided; as by viewing the white Concourſe of the Colours through another Priſm placed cloſe to the Eye, by whoſe Refraction that Whiteneſs may appear again transformed into Colours: And then, to examine their Origin, if an Aſſiſtant intercept any of the Colours at the Lens before their Arrival at the Whiteneſs, the ſame Colours will vaniſh from amongſt thoſe, into which that Whiteneſs is converted by the ſecond Priſm. Now, if the Rays which diſappear be the ſame with thoſe that are intercepted, then it muſt be acknowledged, that the ſecond Priſm makes no new Colours in any Rays, which were not in them before their Concourſe at the Paper. Which is a plain Indication, that the Rays of ſeveral Colours remain diſtinct from one another in the Whiteneſs, and that from their previous Diſpoſitions are derived the Colours of the

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ſecond Priſm. And, by the Way, what is ſaid of their Colours may be applied to their Refrangibility.

The aforeſaid Wheel may alſo here be made uſe of; and, if its Gyration be neither too quick nor too ſlow, the Succeſſion of the Colours may be diſcern'd thro' the Priſm, whilſt to the naked Eye of a By-ſtander they exhibit Whiteneſs.

There is ſomething ſtill remaining to be ſaid of this Experiment. But this, I conceive, is enough to enforce it, and ſo to decide the Controverſy. However, I ſhall now proceed to ſhew ſome other Ways of producing Whiteneſs by Mixtures, ſince I perſuade myſelf, that this Aſſertion above the reſt appears paradoxical, and is with moſt Difficulty admitted. And becauſe the Animadverſor deſires an Inſtance of it in Bodies of divers Colours, I ſhall begin with that. But in order thereto it muſt be conſider'd, that ſuch colour'd Bodies reflect but ſome Part of the Light incident on them; as is evident by the *13th Propoſition:* And therefore the Light reflected from an Aggregate of them will be much weaken'd by the Loſs of many Rays. Whence a perfect and intenſe Whiteneſs is not to be expected, but rather a Colour between thoſe of Light and Shadow, or ſuch a Grey or dirty Colour as may be made by mixing White and Black together.

And that ſuch a Colour will reſult, may be collected from the Colour of Duſt found in every Corner of an Houſe, which hath been obſerv'd to conſiſt of many colour'd Particles. There may alſo be produced the like dirty Colour, by mixing ſeveral Painters Colours together. And the ſame may be effected by painting a Top (ſuch as Boys play with) of divers Colours. For when it is made to circulate by whipping it, it will appear of ſuch a dirty Colour.

Now the compounding of theſe Colours is proper to my Purpoſe, becauſe they differ not from Whiteneſs in the Species of Colour, but only in a Degree of Luminouſneſs: Which (did not the Animadverſor concede it) I might thus evince. A Beam of the Sun's Light being tranſmitted into a darkened Room, if you illuminate a Sheet of white Paper by that Light, reflected from a Body of any Colour, the Paper will always appear of the Colour of that Body, by whoſe reflected Light it is illuminated. If it be a Red Body, the Paper will be Red; if a Green Body, it will be Green; and ſo of the other Colours. The Reaſon is, that the Fibres or Threads, of which the Paper conſiſts, are all tranſparent and ſpecular; and ſuch Subſtances are known to reflect Colours without changing them. To know, therefore, to what Species of Colour a Grey belongs, place any Grey Body (ſuppoſe a Mixture of Painters Colours) in the ſaid Light, and the Paper being illuminated by its Reflection, ſhall appear White. And the ſame Thing will happen, if it be illuminated by Reflection from a Black Subſtance.

Theſe therefore are all of one Species; but yet they ſeem diſtinguiſh'd not only by Degrees of Luminouſneſs, but alſo by ſome other Inequalities, whereby they become more harſh or pleaſant. And the Diſtinction ſeems to be, that Greys, and perhaps Blacks, are made by an uneven Defect of Light, conſiſting as it were of many little Veins or Streams, which differ either in Luminouſneſs, or in the unequal Diſtribution of diverſly colour'd Rays; ſuch as ought to be caufed by Reflection from a Mixture of White and Black, or of diverfly coloured Corpufcles. But when fuch imperfectly mix'd Light is by a fecond Reflection from the Paper more evenly and uniformly blended, it becomes more pleafant, and exhibits a faint or fhadowed Whitenefs. And that fuch little Irregularities as thefe may caufe thefe Differences, is not improbable, if we confider, how much Variety may be caufed in Sounds of the fame Tone, by irregular and uneven Jarrings. And befides, thofe Differences are fo little, that I have fometimes doubted, whether they be any at all, when I have confidered, that a Black and White Body being placed together, the one in a ftrong Light, and the other in a very faint Light, fo proportioned that they might appear equally luminous, it has been difficult to diftinguifh them, when viewed at Diftance, unlefs when the Black feemed more Bluifh, and the White Body in a Light ftill fainter, hath, in Comparifon of the Black Body, itfelf appeared Black.

This leads me to another Way of compounding Whitenefs; which is, that, if four or five Bodies of the more eminent Colours, or a Paper painted all over in feveral Parts of it with thofe feveral Colours in a due Proportion, be placed in the faid Beam of Light, the Light reflected from thofe Colours to another White Paper, held at a convenient Diftance, fhall make that Paper appear White. If it be held too near the Colours, its Parts will feem of thofe Colours that are neareft them; but by removing it further, that all its Parts may be equally illuminated by all the Colours, they will be more and more diluted, until they become perfectly White. And you may further obferve, that if any of the Colours be intercepted, the Paper will no longer appear White, but of the other Colours which are not intercepted. Now that this Whitenefs is a Mixture of the feverally coloured Rays, falling confufedly on the Paper, I fee no reafon to doubt; becaufe, if the Light became uniform and fimilar before it fell confufedly on the Paper, it muft much more be uniform, when at greater Diftance it falls on the Spectator's Eye; and fo the Rays, which come from feveral Colours, would in no Qualities differ from one another, but all of them exhibit the fame Colour to the Spectator, contrary to what he fees.

Not much unlike this Inftance it is, that if a polifh'd Piece of Metal be fo placed, that the Colours appear in it as in a Looking-Glafs, and then the Metal be made rough, that by a confufed Reflection thofe apparent Colours may be blended together, they fhall difappear, and by their Mixture caufe the Metal to look White.

But further to enforce this Experiment: If inftead of the Paper, any White Froth, confifting of fmall Bubbles, be illuminated by Reflection from the aforefaid Colours, it fhall to the naked Eye feem White, and yet through a good Microfcope the feveral Colours will appear diftinct on the Bubbles, as if feen by Reflection from fo many fpherical Surfaces. With my naked Eye, being very near, I have alfo difcerned the feveral Colours on each Bubble; and yet at a greater Diftance, where I could not diftinguifh them apart, the Froth hath appeared entirely White. And at the fame Diftance, when I look'd intently, I have feen the Colours diftinctly on each Bubble; and yet by ftraining my Eyes, as if I would look at ſomething afar off beyond them, thereby to render the Viſion confuſed, the Froth has appeared without any other Colour than Whiteneſs. And what is here ſaid of Froths, may eaſily be underſtood of the Paper, or Metal, in the foregoing Experiments. For their Parts are ſpecular Bodies, like theſe Bubbles; and perhaps with an excellent Microſcope the Colours may alſo be ſeen intermixedly reflected from them.

In proportioning the ſeveral colour'd Bodies to produce theſe Effects, there may be ſome Niceneſs; and it will be more convenient to make uſe of the Colours of the Priſm, caſt on a Wall, by whoſe Reflection the Paper, Metal, Froth, and other white Subſtances may be illuminated. And I uſually made my Trials this Way, becauſe I could better exclude any ſcattering Light from mixing with the Colours to dilute them.

To this Way of compounding Whiteneſs may be referred that other, by mixing Light after it hath been trajected through tranſparently colour'd Subſtances. For Inſtance, if no Light be admitted into a Room, but only through colour'd Glaſs, whoſe ſeveral Parts are of ſeveral Colours in a pretty equal Proportion; all white Things in the Room ſhall appear White, if they be not held too near the Glaſs: And yet this Light, with which they are illuminated, cannot poſſibly be uniform; becauſe, if the Rays, which at their Entrance are of divers Colours, do in their Progreſs through the Room ſuffer any Alteration to be reduced to an Uniformity, the Glaſs would not in the remoteſt Parts of the Room appear of the very ſame Colour, which it doth when the Spectator's Eye is very near it: Nor would the Rays, when tranſmitted into another dark Room through a little Hole in an oppoſite Door or Partition-Wall, project on a Paper the Species or Repreſentation of the Glaſs in its proper Colours.

And, by the by, this ſeems a very fit and cogent Inſtance of ſome other Parts of my *Theory*, and particularly of the 13th *Propoſition*. For in this Room all natural Bodies whatever appear in their proper Colours. And all the Phænomena of Colours in Nature, made either by Refraction or without it, are here the ſame as in the open Air. Now the Light in this Room being ſuch a diſſimular Mixture, as I have deſcribed in my *Theory*, the Cauſes of all theſe Phænomena muſt be the ſame that I have here aſſigned. And I ſee no reaſon to ſuſpect, that the ſame Phænomena ſhould have other Cauſes in the open Air.

The Succeſs of this Experiment may be eaſily conjectured by the Appearances of Things in a Church or Chapel, whoſe Windows are of colour'd Glaſs; or in the open Air, when it is illuſtrated with Clouds of various Colours.

There are yet other Ways by which I have produced Whiteneſs; as by caſting ſeveral Colours from two or more Priſms upon the ſame Place; by refracting a Beam of Light with two or three Priſms ſucceſſively, to make the diverging Colours converge again; by reflecting one Colour to another, and by looking through a Priſm on an Object of many Colours; and (which is equivalent to the above-mentioned Way of mixing Colours by concave Wedges filled with coloured Liquors) I have obſerved the Shadows of a painted Glaſs-

Window

Window to become White, where thoſe of many Colours have at a great Diſtance interfered. But yet for further Satisfaction, the Animadverſor may try, if he pleaſe, the Effects of four or five ſuch Wedges fill'd with Liquors of as many ſeveral Colours.

Beſides all theſe, the Colours of Water-bubbles, and other thin pellucid Subſtances, afford ſeveral Inſtances of Whiteneſs produced by their Mixture; with one of which I ſhall conclude this Particular. Let ſome Water, in which a convenient Quantity of Soap or Waſhball is diſſolv'd, be agitated into Froth, and after that Froth has ſtood a while without further Agitation, 'till you ſee the Bubbles, of which it conſiſts, begin to break, there will appear a great Variety of Colours all over the Top of every Bubble, if you view them near at hand; but if you view them at ſo great a Diſtance that you cannot diſtinguiſh the Colours one from another, the Froth will appear perfectly White.

Thus much concerning the Deſign and Subſtance of the Animadverſor's Conſiderations. There are yet ſome Particulars to be taken notice of, before I conclude; as the Denial of the *Experimentum Crucis.* On this I choſe to lay the whole Streſs of my Diſcourſe; which therefore was the principal Thing to have been objected againſt. But I cannot be convinced of its Inſufficiency by a bare Denial, without aſſigning a Reaſon for it. I am apt to believe it has been miſunderſtood; for otherwiſe it would have prevented the Diſcourſes about rarefying and ſplitting of Rays; becauſe the Deſign of it is to ſhew, that Rays of divers Colours conſidered apart, do at equal Incidences ſuffer unequal Refractions, without being ſplit, rarefied, or any ways dilated.

Some Conſiderations upon this Doctrine of Colours; from Paris, *by* ------- N. 96. *p.* 6086. July, An. 1673.

VI. 1. Methinks that the moſt important Objection which is made againſt Mr. *Newton* by way of Query, is that, Whether there be more than two ſorts of Colours? For my part, I believe, that an Hypotheſis, that ſhould explain Mechanically, and by the Nature of Motion, the Colours Yellow, Green, and Blue, would be ſufficient for all the reſt, in regard thoſe others, being only more deeply charged, (as appears by the Priſms of Mr. *Hook)* do produce the dark or deep Red and Blue; and that of theſe four all the other Colours may be compounded. Neither do I ſee why Mr. *Newton* doth not content himſelf with the two Colours, Yellow and Blue; for it will be much more eaſy to find any Hypotheſis by Motion, that may explicate theſe two Differences, than for ſo many Diverſities as there are of other Colours. And 'till he hath found this Hypotheſis, he hath not taught us, what it is wherein conſiſts the Nature and Difference of Colours, but only this Accident (which certainly is very conſiderable) of their *different Refrangibility.*

As for the Compoſition of White made by all the Colours together, it may poſſibly be, that Yellow and Blue might alſo be ſufficient for that: Which is worth while to try; and it may be done by the Experiment which Mr. *Newton* propoſeth, by receiving againſt a Wall of a darkened Room the Colours of the Priſm, and to caſt their reflected Light upon white Paper. Here you muſt hinder the Colours of the Extremities, *viz.* the Red and Purple, from ſtriking againſt the Wall, and leave only the intermediate Colours, Yellow, Green, and Blue, to ſee whether the Light of theſe alone would not make the

Paper appear White, as well as when they all gave Light. I even doubt, whether the lighteſt Place of the Yellow Colour may not all alone produce that Effect, and I mean to try it at the firſt Conveniency; for this Thought never came into my Mind but juſt now. Mean time you may ſee, that if theſe Experiments do ſucceed, it can no more be ſaid, that all the Colours are neceſſary to compound White, and that 'tis very probable, that all the reſt are nothing but Degrees of Yellow and Blue, more or leſs charged.

Anſwered by Mr. Newton. N. 97. p. 6108. Aug. An. 1673.

2. It ſeems to me, that *N.* takes an improper Way of examining the Nature of Colours, whilſt he proceeds upon compounding thoſe that are already compounded. Perhaps he would ſooner ſatisfy himſelf by reſolving Light into Colours, as far as may be done by Art, and then by examining the Properties of thoſe Colours apart, and afterwards by trying the Effects of re-conjoining two or more, or all of thoſe; and laſtly, by ſeparating them again, to examine what Changes that Re-conjunction had wrought in them. I have formerly ſhewn, That all Colours cannot practically be deriv'd out of the Yellow and Blue, and conſequently that thoſe Hypotheſes are groundleſs, which imply they may. If you aſk, what Colours cannot be derived out of Yellow and Blue? I anſwer, None of thoſe which I defined to be Original; and if he can ſhew by Experiment how they may, I will acknowledge myſelf in an Error. Nor is it eaſier to frame an Hypotheſis by aſſuming only two original Colours, rather than an indefinite Variety; unleſs it be eaſier to ſuppoſe that there are but two Figures, Sizes, and Degrees of Velocity or Force of the Æthereal Corpuſcles or Pulſes, rather than an indefinite Variety; which certainly would be a harſh Suppoſition. No Man wonders at the indefinite Variety of Waves of the Sea, or of Sands on the Shore; but, were they all but two Sizes, it would be a very puzzling Phænomenon. And I ſhould think it as unaccountable, if the ſeveral Parts or Corpuſcles, of which a ſhining Body conſiſts, which muſt be ſuppoſed of various Figures, Sizes, and Motions, ſhould impreſs but two Sorts of Motion on the adjacent Æthereal Medium, or any other Way beget but two Sorts of Rays. But to examine how Colours may be explain'd hypothetically, is beſide my Purpoſe. I never intended to ſhew wherein conſiſts the Nature and Difference of Colours, but only to ſhew, that *de facto* they are original and immutable Qualities of the Rays which exhibit them; and to leave it to others to explicate by mechanical Hypotheſes, the Nature and Difference of theſe Qualities; which I take to be no difficult Matter. But I would not be underſtood, as if their Difference conſiſted in the *different Refrangibility* of thoſe Rays; for that *different Refrangibility* conduces to their Production no otherwiſe, than by ſeparating the Rays whoſe Qualities they are. Whence it is, That the ſame Rays exhibit the ſame Colours when ſeparated by any other Means; as by their *different Reflexibility*, a Quality not yet diſcourſed of.

In the next Particular, where *N.* would ſhew, that it is not neceſſary to mix all Colours for the Production of White; the Mixture of Yellow, Green and Blue, without Red and Violet, which he propounds for that End, will not produce White, but Green; and the brighteſt Part of the Yellow will afford no other Colour but Yellow, if the Experiment be made in a

Room

Room well darkened, as it ought; becauſe the coloured Light is much weakened by the Reflection, and ſo apt to be diluted by the mixing of any other ſcattering Light. But yet there is an Experiment or two formerly mentioned, by which I have produced White out of two Colours alone, and that variouſly; as out of Orange and a full Blue, and out of Red and a pale Blue, and out of Yellow and Violet, as alſo out of other Pairs of intermediate Colours. The moſt convenient Experiment for performing this, was that of caſting the Colours of one Priſm upon thoſe of another, after a due Manner. But what *N.* can deduce from hence, I ſee not; for the two Colours were compounded of all others, and ſo the reſulting White (to ſpeak properly) was compounded of them all, and only decompounded of thoſe two. For Inſtance, the Orange was compounded of Red, Orange, Yellow, and ſome Green; and the Blue, of Violet, full Blue, light Blue, and ſome Green, with all their intermediate Degrees; and conſequently the Orange and Blue together made an Aggregate of all Colours to conſtitute the White. Thus if one mix Red, Orange, and Yellow Powders to make an Orange; and Green, Blue and Violet Colours to make a Blue; and laſtly, the two Mixtures to make a Grey; that Grey, though decompounded of no more than two Mixtures. is yet compounded of all the ſix Powders, as truly as if the Powders had been all mixed at once.

This is ſo plain, that I conceive there can be no further Scruple; eſpecially to them who know how to examine, whether a Colour be ſimple or compounded, and of what Colours it is compounded; which having explain'd in another Place, I need not now repeat. If therefore *N.* would conclude any Thing, he muſt ſhew how White may be produced out of two uncompounded Colours: Which when he hath done, I will farther tell him, why he can conclude nothing from that. But I believe there cannot be found an Experiment of that Kind; becauſe, as I remember, I once try'd, by gradual Succeſſion, the Mixture of all Pairs of uncompounded Colours; and though ſome of them were paler, and nearer to White than others, yet none could be truly called White. But it being ſome Years ſince this Trial was made, I remember not well the Circumſtances, and therefore recommend it to others to be tried again.

3. Seeing that Mr. *Newton* maintains his Opinion with ſo much Concern, I liſt not to diſpute. But what means it, I pray, that he ſaith, *Though I ſhould ſhew him, that the White could be produced only of two uncompounded Colours, yet I could conclude nothing from that?* And yet he hath affirm'd, that to compoſe the White, all primitive Colours are neceſſary. *A Reply, by Monſieur* N. N. 97. *p.* 6112.

4. In my ſaying, that when Monſieur *N.* hath ſhewn *how White may be produced out of two uncompounded Colours, I will tell him, why he can conclude nothing from that*; my Meaning was, That ſuch a White (were there any ſuch) would have different Properties from the White which I had reſpect to, when I deſcribed my *Theory*, that is, from the White of the Sun's immediate Light, of the ordinary Objects of our Senſes, and of all white Phænomena that have hitherto fallen under my Obſervation. And thoſe different Properties would evince it to be of a different Conſtitution: Inſomuch, that ſuch a Production of *Anſwered; by Mr.* Newton. N. 96. *p.* 6087. July, An. 1673.

of White would be ſo far from contradicting, that it would rather illuſtrate and confirm my Theory; becauſe by the Difference of that from other Whites, it would appear, that other Whites are not compounded of only two Colours like that. And therefore if Monſieur *N.* would prove any Thing, it is requiſite that he do not only produce out of two primitive Colours a White, which to the naked Eye ſhall appear like other Whites, but alſo ſhall agree with them in all other Properties.

But to let you underſtand wherein ſuch a White would differ from other Whites, and why from thence it would follow that other Whites are otherwiſe compounded, I ſhall lay down this Poſition.

That a compounded Colour can be reſolved into no more ſimple Colours than thoſe of which it is compounded.

This ſeems to be ſelf-evident, and I have alſo tried it ſeveral Ways, and
Fig. 76. particularly by this which follows: Let α repreſent an oblong Piece of White Paper about $\frac{1}{3}$ or $\frac{1}{4}$ of an Inch broad, and illuminated in a dark Room, with a Mixture of two Colours caſt upon it from two Priſms, ſuppoſe a deep Blue and Scarlet, which muſt ſeverally be as uncompounded as they can conveniently be made; then, at a convenient Diſtance, ſuppoſe of ſix or eight Yards, view it through a clear Triangular Glaſs or Cryſtal Priſm held parallel to the Paper, and you ſhall ſee the two Colours parted from one another in the Faſhion of two Images of the Paper, as they are repreſented at β and γ; where ſuppoſe β the Scarlet, and γ the Blue, without Green, or any other Colour between them.

Now from the aforeſaid *Poſition* I deduce theſe two *Concluſions*; 1. That if there were found out a Way to compound White of two ſimple Colours only, that White would be again reſolvable into no more than two. 2. That if other Whites, as that of the Sun's Light, *&c.* be reſolvable into more than two ſimple Colours (as I find by Experiment that they are) then they muſt be compounded of more than two.

To make this plainer, ſuppoſe that A repreſents a white Body, illuminated by a direct Beam of the Sun tranſmitted through a ſmall Hole into a dark Room, and α ſuch another Body, illuminated by a Mixture of two ſimple Colours; which, if poſſible, may make it alſo appear of a white Colour exactly like A: Then, at a convenient Diſtance, view theſe two Whites through a Priſm, and A will be changed into a Series of all Colours, Red, Yellow, Green, Blue, Purple, with their intermediate Degrees ſucceeding in Order from B to C. But α, according to the aforeſaid Experiment, will only yield thoſe two Colours of which it was compounded, and thoſe not conterminate like the Colours at B C, but ſeparate from one another, as at β and γ, by means of the different Refrangibility of the Rays to which they belong. And thus by comparing theſe two Whites, they would appear to be of a different Conſtitution, and A to conſiſt of more Colours than α. So that what Monſieur *N.* contends for, would rather advance my Theory by the Acceſs of a new Kind of White, than conclude againſt it. But I ſee no Hopes of compounding ſuch a White.

As

As for Monfieur *N.* his Expreffion, *That I maintain my Doctrine with fome Concern*, I confefs it was a little ungrateful to me, to meet with Objections which had been anfwered before, without having the leaft Reafon given me why thofe Anfwers were infufficient. Thofe Anfwers were to fhew, that there are other fimple Colours befides Blue and Yellow; I inftanced in a fimple or homogeneal Green, fuch as cannot be made by mixing Blue and Yellow, or any other Colours. And I alfo fhew'd why, fuppofing that all Colours might be produced out of two, yet it would not follow that thofe two are the only original Colours. The Reafons I defire you would compare with what hath now been faid of White. And fo the Neceffity of all Colours to produce White, might have appear'd by that Experiment, where I fay, That if any Colour at the Lens be intercepted, the Whitenefs (which is compounded of them all) will be changed into (the Refult of) the other Colours. *Vid.* Suppl. *p.* 149, & feq.

However, fince there feems to have happened fome Mifunderftanding between us, I fhall endeavour to explain myfelf a little further in thefe Things, according to the following Method.

Definitions.] 1. I call that Light homogeneal, fimilar, or uniform, whofe Rays are equally refrangible.

2. And that heterogeneal, whofe Rays are unequally refrangible.

Note, There are but three Affections of Light, in which I have obferved its Rays to differ, *viz. Refrangibility*, *Reflexibility*, and *Colour*; and thofe Rays which agree in Refrangibility, agree alfo in the other two, and therefore may well be defined homogeneal, efpecially fince Men ufually call thofe Things homogeneal, which are fo in all Qualities that come under their Knowledge, tho' in other Qualities, that their Knowledge extends not to, there may poffibly be fome Heterogeneity.

3. Thofe Colours I call fimple, or homogeneal, which are exhibited by homogeneal Light.

4. And thofe compounded or heterogeneal, which are exhibited by heterogeneal Light.

5. Different Colours, I call not only the more eminent Species, Red, Yellow, Green, Blue, Purple, but all other the minuteft Gradations; much after the fame manner that not only the more eminent Degrees in Mufick, but all the leaft Gradations are efteemed different Sounds.

Propofitions.] 1. The Sun's Light confifts of Rays differing by indefinite Degrees of Refrangibility.

2. Rays which differ in Refrangibility, when parted from one another, do proportionally differ in the Colours which they exhibit. Thefe two *Propofitions* are Matter of Fact.

3. There are as many fimple or homogeneal Colours, as Degrees of Refrangibility: For to every Degree of Refrangibility belongs a different Colour, by *Prop.* 2. and that Colour is fimple, by *Def.* 1, and 3.

4. Whitenefs, in all Refpects like that of the Sun's immediate Light, and of all the ufual Objects of our Senfes, cannot be compounded of two fimple

Colours

Colours alone: For ſuch a Compoſition muſt be made by Rays that have only two Degrees of Refrangibility, by *Def.* 1, and 3; and therefore it cannot be like that of the Sun's Light, by *Prop.* 1; nor, for the ſame Reaſon, like that of ordinary white Objects.

5. Whiteneſs, in all Reſpects like that of the Sun's immediate Light, cannot be compounded of Simple Colours, without an indefinite Variety of them: For to ſuch a Compoſition there are requiſite Rays endued with all the indefinite Degrees of Refrangibility, by *Prop.* 1. And thoſe infer as many Simple Colours, by *Def.* 1, and 3. and *Prop.* 2, and 3.

To make theſe a little plainer, I have added alſo the *Propoſitions* that follow.

6. The Rays of Light do not act on one another in paſſing through the ſame *Medium.* This appears by ſeveral former Paſſages, and is capable of further Proof.

7. The Rays of Light ſuffer not any Change of their Qualities from Refraction.

8. Nor afterwards from the adjacent quiet Medium. Theſe two Propoſitions are manifeſt *de facto* in homogeneal Light, whoſe Colour and Refrangibility is not at all changeable, either by Refraction, or by the Contermination of a quiet Medium. And as for heterogeneal Light, it is but an Aggregate of ſeveral Sorts of homogeneal Light; no one Sort of which ſuffers any more Alteration than if it were alone, becauſe the Rays act not on one another, by *Prop.* 6. and therefore the Aggregate can ſuffer none. Theſe two Propoſitions alſo might be further proved apart by Experiments, too long to be here deſcribed.

9. There can no homogeneal Colours be educed out of Light by Refraction, which were not commixt in it before; becauſe by *Prop.* 7. and 8. Refraction changeth not the Qualities of the Rays, but only ſeparates thoſe which have diverſe Qualities, by means of the different Refrangibility.

10. The Sun's Light is an Aggregate of an indefinite Variety of homogeneal Colours; by *Prop.* 1, 3, and 9. And hence it is, that I call homogeneal Colours alſo primitive or original.

Animadverſions on this Theory of Light and Colours; by Mr. Fr. Linus. N. 110. *p.* 217. Jan. An. 1675.

VII. 1. I doubt not of what Mr. *Newton* affirms; and have myſelf ſometimes in like Circumſtances obſerved the like Difference between the Length and Breadth of the coloured *Spectrum*; but never found it ſo when the Sky was clear and free from Clouds, near the Sun: But then only appeared this Difference of Length and Breadth, when the Sun either ſhined thro' a white Cloud, or enlightened ſome ſuch Clouds near unto it. And then indeed it was no marvel, the ſaid *Spectrum* ſhould be longer than broad; ſince the Cloud or Clouds ſo enlightened, were in order to thoſe Colours like to a great Sun, making a far greater Angle of Interſection in the Hole, than the true Rays of the Sun do make; and therefore are able to enlighten the whole Length of the Priſm, and not only ſome ſmall Part thereof, as we ſee enlightened by the true Sun-Beams coming thro' the ſame little Hole. And this we behold alſo in the true Sun-Beams, when they enlighten the whole Priſm; for altho' in a clear Heaven, the Rays of the Sun paſſing thro' the ſaid Hole, never make a

Spectrum

Spectrum longer than broad, because they then can occupy but a *small* Part of the Prism; yet if the Hole be so much bigger as to enlighten the whole Prism, you shall presently see the Length of the Spectrum much exceed its Breadth; which Excess will always be so much the greater, as the Length of the Prism exceeds its Breadth. From whence I conclude, That the Spectrum, this *Learned Author* saw, much longer than broad, was not effected by the true Sun-Beams, but by Rays proceeding from some bright Cloud, as is said; and by Consequence, that the *Theory of Light* grounded upon that *Experiment* cannot subsist.

What I have here said, needs no other Confirmation than meer Experience, which any one may quickly try: neither have I only tried the same upon this Occasion, but near 30 Years ago shew'd the same, together with divers other Experiments of Light, to that worthy Promoter of Experimental Philosophy, Sir *Kenelm Digby*, who coming into these Parts to take the *Spaw*-Waters, resorted oftentimes to my darkned Chamber *, to see the various Phænomena of Light, made by divers Refractions and Reflections, and took Notes upon them; which Industry if they also had us'd, who endeavour to explicate the aforesaid Difference between the Length and Breadth of this colour'd *Spectrum*, by the received Laws of Refraction, would never have taken so impossible a Task in Hand.

* *At* Leige.

2. These Animadversions seem to need no other Answer but this, that you would be pleased to consider the Scheme in Mr. *Newton's* second Answer to *P. Parides*, and rest assured, that the Experiment, as 'tis represented, was tried in clear Days, and the Prism placed close to the Hole in the Window, so that the Light had no room to diverge, and the coloured Image made not parallel (as in that Conjecture) but transverse to the Axis of the Prism. *Answered by* ' ' ' ' ' ' No. 110. p. 219. Jan. An. 1675.

3. *If these Assertions be admitted*, they do indeed directly cut off what I said of Mr. *Newton*'s being deceived by a *bright Cloud*. But if we compare them with Mr. *Newton*'s first Relation of the Experiment, it will evidently appear, they cannot be admitted, as being directly contrary to what is there delivered. For there he tells us, *The Ends of the coloured Image, he saw on the opposite Wall near five times as long as broad, seem to be semicircular. Now* these *semicircular Ends* are never seen in a clear Day, as Experience shews. From whence follows against the *first* Assertion, that the Experiment was not made in a clear Day. Neither are those semicircular Ends ever seen when the Prism is placed close to the Hole; which contradicts the *second* Assertion. Neither are they ever seen when the Image is transverse to the Length or Axis of the Prism; which directly opposes the *third* Assertion. But if in any of these three Cases, the Image be made so much longer than broad (as easily it may, by turning the Prism a little about its Axis, near *five times* as long as broad) then the one End thereof will run out into a sharp Cone or Pyramis like the Flame of a Candle, and the other into a Cone somewhat more blunt; both which are far from seeming semicircular: Whereas, if the Image be made not in a clear Day but with a bright Cloud, and the Prism not placed close to the Hole but in a competent Distance from the same, then these semicircular Ends always appear, with the Sides thereof, streight Lines, just *A Reply by Mr.* Fr. Linus. N. 121. p. 499. Jan. An. 1676.

as Mr. *Newton* deſcribes them. Neither is the Length of the Image tranſverſe, but parallel to the Length of the Priſm. Out of all which it evidently follows, that the Experiment was not made in a clear Day; nor with the Priſm cloſe to the Hole; nor yet with the Image tranſverſe, but by a bright Cloud and a parallel Image (as I conjectured); and I hope you will alſo now ſay, I had good Reaſon ſo to conjecture, ſince it ſo well agrees with the Relation. And Experience will alſo ſhew you, if you pleaſe to make Trial, as it was made in a dark Chamber, and obſerve the Difference between ſuch an Image made by a bright Cloud, and another made by the immediate Rays of the Sun: For the former you ſhall always find parallel, with the Ends ſemicircular; but the latter you ſhall find tranſverſe, with the Ends pyramidical, as aforeſaid, whenſoever it appears ſo much longer than broad.

More might be ſaid out of the ſame Relation, to ſhew that the Image was not tranſverſe. For if it had been tranſverſe, Mr. *Newton*, ſo well skill'd in *Optics*, could not have been ſurprized (as he ſays he was) to ſee the Length thereof ſo much to exceed the Breadth; it being a Thing ſo obvious and eaſy to be explicated by the ordinary Rules of Refraction. That other Place alſo (where he ſays the *Incident* Refractions were made in the Experiment *equal to the Emergent)* proves again, that the ſaid oblong Image was not tranſverſe, but parallel. For it is impoſſible the tranſverſe Image ſhould be ſo much longer than broad, unleſs thoſe two Refractions be made very unequal; as both the Computation according to the common Rules of Refraction and Experience teſtify.

Anſwer'd by Mr. Newton. N. 121. *p.* 501. N. 123. *p.* 556. Mar. An. 1676.

4. What it is that impoſes upon Mr. *Line* I cannot imagine; but I ſuſpect he has not try'd the Experiment ſince he acquainted himſelf with my Theory, but depends upon his old Notions, taken up before he had any Hint given to obſerve the Figure of the coloured Image. I ſhall deſire him therefore, before he returns any Anſwer, to try it once more for his Satisfaction, and according to this Manner.

Let him take any Priſm, and hold it ſo that its Axis may be perpendicular to the Sun's Rays, and in this Poſture let it be placed as cloſe as may be to the Hole through which the Sun ſhines into a dark Room, which Hole may be about the Bigneſs of a Pea. Then let him turn the Priſm ſlowly about its Axis, and he ſhall ſee the Colours move upon the oppoſite Wall, firſt towards that Place to which the Sun's direct Line would paſs, if the Priſm were taken away, and then back again. When they are in the Middle of theſe two contrary Motions, that is, when they are neareſt that Place to which the Sun's direct Ray tends, there let him ſtop; for then are the Rays equally refracted on both Sides the Priſm. In this Poſture of the Priſm let him obſerve the Figure of the Colours, and he ſhall find it not round, as he contends, but oblong, and ſo much the more oblong as the Angle of the Priſm, comprehended by the refracting Planes, is bigger, and the Wall, on which the Colours are caſt, more diſtant from the Priſm; the Colours Red, Yellow, Green, Blue, Purple, ſucceeding in Order, not from one Side of the Figure to the other, as in Mr. *Line*'s Conjecture, but from one End to the other; and the Length of the Figure being not parallel but tranſverſe to the

Axis of the Prifm. After this manner I ufed to try the Experiment; and it will not fucceed well if the Day be not clear, and the Prifm placed clofe to the Hole, or fo near at leaft, that all the Sun's Light that comes from the Hole may pafs through the Prifm alfo, fo as to appear in a round Form, if intercepted by a Paper immediately after it has paffed the Prifm.

When Mr. *Line* has try'd this, I could wifh he would proceed a little further, to try that which I call'd the *Experimentum Crucis*. For when he has try'd them (which by his denying them, I know he has not done yet as they fhould be try'd) I prefume he will reft fatisfied. It may be try'd (tho' not fo perfectly) even without darkning a Room, or the Expence of any more Time than half a Quarter of an Hour.

5. Mr. *Linus* (now deceafed) *try'd the Experiment* again and again, and called divers on purpofe to fee it, nor ever made Difficulty to fhew it to any one, who either by Chance came into his Chamber as he was doing it, or fhewed the leaft Defire to fee the fame, fo that for Point of Experience, Mr. *Newton* cannot be more confident on his Side, than we are here on the other; who are fully perfuaded, that, unlefs the Diverfity of placing the Prifm, or the Bignefs of the Hole, or fome other fuch Circumftance, be the Caufe of the Difference betwixt them, Mr. *Newton*'s Experiment will hardly ftand.

The Experiment of Mr. Line *affirmed by Mr.* Gafcoigne, N. 121. *p.* 503. *marg.* Jan. An. 1676.

6. By Mr. *Gafcoigne*'s Letter one might fufpect, that Mr. *Linus* try'd the Experiment fome other Way than I did; and therefore I fhall expect, till his Friends have try'd it according to my late Directions. In which Trial it may poffibly be a further Guidance to them, to acquaint them that the Prifm cafts from it feveral Images. One is, that oblong One of Colours which I mean; and this is made by two Refractions only. Another there is made by two Refractions and an intervening Reflexion; and this is round and colourlefs, if the Angles of the Prifm be exactly equal; but if the Angles at the reflecting Bafe be not equal, it will be colour'd, and that fo much the more, by how much unequaller the Angles are, but yet much more unround, unlefs the Angles be very unequal. A third Image there is, made by one fingle Reflection, and this is always round and colourlefs. The only Danger is, in miftaking the *Second* for the *Firft*. But they are diftinguifhable not only by the Length and lively Colours of the *Firft*, but by its different Motion too: For, whilft the Prifm is turned continually the fame Way about its Axis, the *Second* and *Third* move fwiftly, and go always on the fame Way, till they difappear; but the *Firft* moves flow, and grows continually flower, till it be Stationary, and then turns back again, and goes back fafter and fafter, till it vanifh in the Place where it began to appear.

Anfwered by Mr. Newton, *Ibid.* N. 123. *p.* 556. Mar. An. 1676.

If, without darkning their Room, they hold the Prifm at their Window in the Sun's open Light, in fuch a Pofture that its Axis be perpendicular to the Sun-Beams, and then turn it about its Axis, they cannot mifs of feeing the firft Image; which having found, they may double up a Paper once or twice, and make a round Hole in the middle of it, about $\frac{1}{2}$ or $\frac{1}{4}$ of an Inch broad, and hold the Paper immediately before the Prifm, that the Sun may fhine on the Prifm through that Hole; and the Prifm being ftayed, and held fteddy in that Pofture which makes the Image ftationary, if the Image then fall directly on an opposite Wall, or on a Sheet of Paper placed at the Wall, suppose 15 or 20 Feet from the Prism, or further off; they will see the Image in such an oblong Figure as I have described, with the Red at one End, the Violet at the other, and the bluish Green in the Middle: And if they obscure their Room as much as they can, by drawing Curtains, or otherwise, it will make the Colours the more conspicuous.

This Direction I have set down, that no Body, into whose Hands a Prism shall happen, may find Difficulty and Trouble in trying it. But when Mr. *Linus*'s Friends have try'd it thus, they may proceed to repeat it in a dark Room with a less Hole made in their Window-shut. And then I shall desire that they will send a full and clear Description how they try'd it. I should be glad too, if they will favour me with a Description of the Experiment as it hath been hitherto try'd by Mr. *Linus*; that I may have an Opportunity to consider what there is in that which makes against me.

Exceptions by Mr. Lucas. N. 128. *p.* 692. Aug. An. 1676.

7. Mr. *Gascoigne* wanting Convenience to make the Experiment, according to the fresh Directions from Mr. *Newton*, requested me to supply this Want. The vertical Angle of my Prism was 60 Degrees; the Distance of the Wall, whereon the coloured *Spectrum* appeared from the Window, about 18 Feet; the Diameter of the Hole in the Window-shuts about $\frac{1}{2}$ Inch, which, upon Occasions, I contracted to half the said Diameter, but still with equal Success as to the main of the Experiment. The Refractions on both Sides the Prism were, as near as I could make them, equal; and consequently about 48 Deg. 40 Min. the refractive Power of Glass being computed according to the Ratio of the Sines 2 to 3. The Distance of the Prism from the Hole in the Shuts was about 2 Inches; the Room darkned to that Degree as to equal the darkest Night, while the Hole in the Shuts was covered.

Now as to the Issue of my Trials; I constantly found the Length of the coloured Image (transverse to the Axis of the Prism) considerably greater than its Breadth, as often as the Experiment was made on a clear Day; but if a bright Cloud were near the Sun, I found it sometimes exactly as Mr. *Line* wrote to you, namely, broader than long, especially while the Prism was placed at a great Distance from the Hole: Which Experiment will not, I conceive, be question'd by Mr. *Newton*, it being so agreeable to the received Laws of Refractions. And indeed the Observations of these two learned Persons, as to this Particular, are easily reconcileable to each other, and both to Truth; Mr. *Newton* contending only for the Length of the Image (transverse to the Axis of the Prism) in a very clear Day; whereas Mr. *Line* only maintained the Excess of Breadth, parallel to the same Axis, while the Sun is in a bright Cloud. Tho' as to what is further deliver'd by Mr. *Newton*, and opposed by Mr. *Line*, namely that the Length of the coloured Image was *five times* the Diameter of its Breadth; I never yet have found the Excess above thrice the Diameter, or at most $3\frac{1}{2}$, while the Refractions on both Sides the Prism were equal. So much as to the Matter of Fact.

Now as to Mr. *Newton*'s *Theory of Light* and *Colours*, I confess his neat Sett of very Ingenious and Natural Inferences was to me, upon the first Perusal, a strong Conjecture in Favour of his new Doctrine; I having formerly

merly obſerved the like Chain of Inferences upon Search into natural Truths. But ſince ſeveral Experiments of Refractions remain ſtill untouched by him, I conceived a further Search into them would be very proper, in order to a further Diſcovery of the Truth of his Aſſertion. For accordingly as they are found, either agreeing with, or diſagreeing from his new Theory, they muſt needs much ſtrengthen, or wholly overthrow the ſame. The Experiments I pitched upon for this Purpoſe are as follow :

1. Having frequently obſerved, that the Form of Objects viewed in the Microſcope (or rather of the Microſcope itſelf) conſiſts almoſt in an indiviſible Point, I concluded two very ſmall Pieces of Silk, the one Scarlet, the other Violet Colour, placed near together, ſhould, according to Mr. *Newton*'s Theory, appear in the Microſcope in a very different Degree of Clarity, in regard their unequal Refrangibility muſt cauſe the Scarlet Rays, or Species, to over-reach the *Retina*, while placed in the due Focus of the Violet ones, and conſequently muſt occaſion a ſenſible Confuſion in the Viſion of the former, one and the ſame Point of the Scarlet Object affecting ſeveral Nerves in the *Retina*. Yet upon frequent Trials I have not been able to perceive any Inequality in this Point.

2. The ſecond Experiment I made in Water. I took a Braſs Ruler, and faſtning thereunto ſeveral Pieces of Silk, Red, Yellow, Green, Blue, and Violet, I placed it at the bottom of a Square Veſſel of Water : Then I retired from the Veſſel ſo far, as not to be able to ſee the aforeſaid Ruler and coloured Silks, otherwiſe than by the Help of the refracted Ray. Now, did Mr. *Newton*'s Doctrine hold, I conceived I ſhould not ſee all the mentioned Colours in a ſtreight Line with the Ruler, in regard the unequal Refrangibility of different Rays muſt needs diſplace ſome more than others. Yet in Effect, upon many Trials, I conſtantly found them in as ſtreight a Line, as the bare Ruler had appeared in.

3. To advance this Experiment, I adjoined a ſecond Refraction to the former of Water, by placing my Priſm ſo, as to receive perpendicularly the refracted Species of the Silk and Ruler ; whereby only the emergent Species ſuffered a ſecond Refraction : but ſtill with equal Succeſs, as to their appearing in a ſtreight Line to the Eye placed behind the Priſm.

4. To theſe two Refractions I further added a third, by receiving the coloured Species obliquely upon the Priſm ; whereby both incident and emergent Species ſuffered their reſpective Refractions : But ſtill with the ſame Succeſs as formerly, as to the ſtreight Line they appeared in.

For further Aſſurance in this Experiment, leſt Prepoſſeſſion, occaſion'd from previous Knowledge of the Silk's Situation in a ſtreight Line, might poſſibly prejudice the Judgment of the Eye (as ſometimes I have obſerv'd to happen to the Judgment the Eye paſſeth upon the Diſtance of Objects) I call'd into the Room ſome unconcern'd Perſons, wholly ignorant of what the Experiment aim'd at ; and demanding whether they ſaw not the coloured Silks and Ruler in a crooked Line, they anſwer'd in the Negative.

5. The next Experiment I made in uncompounded Colours (as Mr. *Newton* terms them, *Prop.* 5. and 13.) as follows. Having caſt two coloured Images upon

upon the Wall, ſo as the Scarlet Colour of the one did fall in a ſtreight Line (parallel to the Horizon) with the Violet of the other; I then looked upon both through another Priſm, and found them ſtill appear in a ſtreight Line parallel to the Horizon, as they had formerly done to the naked Eye. Now according to Mr. *Newton*'s Aſſertion of different Refrangibility in different Rays, I conceive the Violet Rays ſhould ſuffer a greater Refraction in the Priſm at the Eye, than the Scarlet ones; and conſequently both Colours ſhould not appear in a ſtreight Line parallel to the Horizon.

6. Another Experiment I made, in order to ſome further Diſcovery of that ſurprizing Phænomenon of the coloured Image, which occaſioned Mr. *Newton*'s ingenious Theory of Light and Colours, as alſo of his excellent Invention of the reflecting Teleſcope and Microſcope. Having then ſometimes ſuſpected, that not only the direct Sun-Beams, but alſo other extraneous Light, might poſſibly influence the coloured *Spectrum*, I hoped to diſcover the Truth of this Suſpicion by means of the Sun-Spots, made to appear in the coloured Image, by placing a Teleſcope behind the Priſm. But my Endeavours proving ineffectual herein, by reaſon of ſome intervening Difficulties, I thought at length of a more feaſible Method, in order to the deſigned Diſcovery; as in the following Experiment.

Fig. 77. I faſtned a very white Paper-Circle (about an Inch in Diameter) upon my Window ſhuts; and beholding it thro' my Priſm, I found a coloured Image painted thereby upon my *Retina*, anſwerable in almoſt all reſpects to the former of the Sun-Beams upon the Wall, eſpecially when the Paper-Circle was indifferently well illuminated. This Image indeed appeared contrary to the former, as to the Situation of Colours, that is, the Scarlet appearing above, the Violet below, tho' but faint. But this I was not ſurprized at, having obſerved upon diſſecting the Eye, that Objects are painted on the Retina after a contrary Poſture to what they appear to ſight. Having thus rendered the coloured Image much more tractable than formerly it was, I conceived good Hopes of ſome further Diſcovery in the Point mentioned.

In Purſuance then of my former Suſpicion, having fixed my Priſm in a ſteady Poſture, I cauſed the Paper C to be applied cloſe up to the Paper-Circle *a b d*; whereupon the former Violet *d*, and the Scarlet Colour of C, vaniſhed into Whiteneſs. Next I removed the mentioned Circle from the Shuts, and placed it in the open Window, ſupported only by the Edge *d*: whereupon, to my Aſtoniſhment, all the former Colours exchanged Poſtures in the *Retina*; the Scarlet now appearing below, the Violet above, the intermediate Colours ſcarce diſcernible. And here, by the by, 'tis very remarkable, that during this Obſervation I clearly perceived both Blue and Scarlet Light to be tranſparent, I being able to diſcern ſeveral Objects thro' both, namely, Steeples oppoſite to my Window: Whence it follows, that theſe Colours do in great Part ariſe from the neighbouring Light. Laſtly, I placed the Paper-Circle anew, ſo as the one half *b* was faſtned to the Shuts, the other Semicircle *a* being expoſed to the open Air. Whereupon the Semicircle *a* became bordered with Violet above, Scarlet below; but the other Semicircle *b*, quite contrary. Hence I make the following Inferences.

Firſt,

First, That not only the Light reflected from the Paper-Circle, but alſo from the ambient Air, hath great Influence upon the coloured Image, eſpecially as to the Violet and Scarlet Colours. Whence, perchance, it will not hereafter ſeem ſtrange that the coloured Spectrum on the Walls is ſo long, but only that the Breadth is not greater. Secondly, Were there a more luminous Body behind the Sun, we ſhould in all likelihood have the Colours of the Spectrum in a contrary Situation to what they appear in at preſent: Whence, Thirdly, it ſeems to follow, that the preſent Situation and Order of Colours ariſeth not from any intrinſical Property of *Refrangibility*, (as maintained by Mr. *Newton*) but from contingent and extrinſical Circumſtances of neighbouring Objects: For accordingly as the Body behind the Paper-Circle was more or leſs illuminated than the Circle itſelf, all the ſeveral Colours changed their Situation.

8. The next Experiment was made in order to Mr. *Newton*'s Doctrine of primary Colours, as *Prop.* 5. Having covered the Hole in the Window-ſhuts with a thin Slice of Ivory, the tranſmitted Light appeared Yellow; but upon adding three, four, or more Slices, it became Red. Whence it ſeems to follow, that Yellowneſs of Light is not a primary Colour, but a Compound of Red, *&c.*

9. The laſt Experiment was made in reference to Mr. *Newton*'s 12. *Prop.* where from his own Principles he renders a very plauſible Reaſon of a ſurprizing Phænomenon, related by Mr. *Hooke*; namely, of two Liquors, the one Blue, and the other Red, both ſeverally tranſparent; yet both, if placed together, became opake. The Reaſon whereof, ſaith Mr. *Newton*, is, becauſe if one Liquor tranſmitted only Red, the other only Blue, no Rays could paſs thro' both.

In reference then to this Point, I filled two ſmall Glaſſes with flat poliſhed Bottoms, the one with *Aqua fortis* deeply died Blue, the other with Oil of Turpentine died Red, both to that Degree, as to repreſent all Objects thro' them reſpectively Blue or Red: Then placing the one upon the other, I was able to diſcern ſeveral Bodies thro' both. Whereas, according to Mr. *Newton*'s Theory, no Object ſhould appear through both Liquors; becauſe if one tranſmit only Red, the other only Blue, no Rays can paſs thro' both.

P. S. *Juſt upon the cloſe of the adjoined Letter, I received from Mr.* Gaſcoigne *yours of* May *the 4th; wherein you are pleaſed to favour us with an exact Account of the famous Experiment of the coloured Spectrum, lately exhibited before the* Royal Society. *I was much rejoiced to ſee the Trials of that Illuſtrious Company agree ſo exactly with ours here; tho' in ſomewhat ours diſagree from Mr.* Newton.

8. The Things oppoſed by Mr. *Line* being upon Trials found true and granted me, I begin with the new Queſtion about the Proportion of the Length of the Image to its Breadth: And it is no wonder that Mr. *Lucas* found the Image ſhorter than I did, ſeeing he tried the Experiment with a leſs Angle. *Anſwered by Mr.* Newton. *Ibid. p.* 698.

The

The Angle indeed which I uſed was but about 63 Degrees, 12 Min. and his is ſet to 60 Degrees; the Difference of which from mine being but 3 Deg. 12 Min. is too little to reconcile us; but yet it will bring us conſiderably nearer together. And if this Angle was not exactly meaſured, but the round Number of 60 Degrees ſet down by gueſs, or by a leſs accurate Meaſure (as I ſuſpect by the conjectural Meaſure of the Refraction of his Priſm, by the Ratio of the Sines as 2 to 3, ſet down at the ſame Time, inſtead of an Experimental one) then might it be two or three Degrees leſs than 60 Deg. if not ſtill leſs: And all this, if it ſhould be ſo, would take away the greateſt Part of the Difference between us.

But however it be, I am well aſſured my own Obſervation was exact enough. For I have repeated it divers times ſince the Receipt of Mr. *Lucas*'s Letter, and that without any conſiderable Difference of my Obſervations, either from one another, or from what I wrote before: And that it might appear experimentally, how the Increaſe of the Angle increaſes the Length of the Image, and alſo that no body, who has a mind to try the Experiment exactly, might be troubled to procure a Priſm which has an Angle juſt of the Bigneſs aſſigned by me, I tried the Experiment with divers Angles, and have ſet down my Trials in the following Table; where the firſt Column expreſſes the Angles of two Priſms which I uſed, which are meaſured as exactly as I could, by applying them to the Angle of a Sector; and the ſecond Column expreſſes, in Inches, the Length of the Image made by each of thoſe Angles; its Breadth being two Inches, its Diſtance from the Priſm 18 Feet and 4 Inches, and the Breadth of the Hole in the Window-ſhut $\frac{1}{4}$ of an Inch.

	Angles		*Lengths*
The firſt Priſm	56°	10′	$7\frac{1}{4}$
	60	24	$9\frac{1}{2}$
	63	26	$10\frac{1}{3}$
The ſecond Priſm	54°	0′	$7\frac{1}{3}$
	62	12	$10\frac{1}{3}$
	63	48	$10\frac{3}{4}$

You may perceive, that the Length of the Images, in reſpect of the Angles that made them, are ſomething greater in the ſecond Priſm than in the firſt; but that was becauſe the Glaſs, of which the ſecond Priſm was made, had the greater refractive Power.

The Days in which I made theſe Trials were pretty clear, but not ſo clear as I deſired; and therefore, afterwards meeting with a Day as clear as I deſired, I repeated the Experiment with the ſecond Priſm, and found the Lengths of the Image made by its ſeveral Angles, to be about $\frac{1}{4}$ of an Inch greater than before; the Meaſures being thoſe ſet down in the Table.

	Angles		*Lengths*
The ſecond Priſm	54°	0′	$7\frac{1}{3}$
	62	12	$10\frac{1}{2}$
	63	48	11

The

The Reafon of this Difference, I apprehend, was, that in the cleareft Days the Light of the White Skies, which dilutes and renders invifible the fainteft Colours at the Ends of the Image, is a little diminifhed in a clear Day, and fo gives leave to the Colours to appear to a great Length; the Sun's Light at the fame time becoming brifker, and fo ftrengthening the Colours, and making the faint ones at the two Ends more confpicuous: For I have obferved, that in Days fomething cloudy, whilft the Prifm has ftood unmoved at the Window, the Image would grow a little longer or a little fhorter, accordingly as the Sun was more or lefs obfcured by thin Clouds which paffed over it; the Image being fhorteft while the Cloud was brighteft, and the Sun's Light fainteft. Whence it is eafy to apprehend, that if the Light of the Clouds could be quite taken away, fo that the Sun might appear furrounded with Darknefs, or if the Sun's Light were much ftronger than it is, the Colours would ftill appear to a greater Length.

In all thefe Obfervations the Breadth of the Image was juft two Inches. But obferving that the Sides of the two Prifms I ufed were not exactly plain, but a little Convex, (the Convexity being about fo much as that of a double Convex-Glafs of a fixteen or eighteen Foot Telefcope) I took a third Prifm, whofe Sides were as much Concave as thofe of the other were Convex; and this made the Breadth of the Image to be two Inches and a third Part of an Inch; the Angles of this Prifm, and the Lengths of the Image made by each of thofe Angles, being thofe expreffed in this Table.

Angles	*Lengths*
58°.	$8\frac{1}{2}$
$59\frac{1}{2}$	9
$62\frac{1}{2}$	$10\frac{1}{3}$

In this Cafe you fee the Concave Figure of the Sides of the Prifm, by making the Rays diverge a little, caufes the Breadth of the Image to be greater in proportion to its Length than it would be otherwife. And this I thought fit to give you notice of, that Mr. *Lucas* may examine, whether his Prifm hath not this Fault. If a Prifm may be had with Sides exactly plain, it may do well to try the Experiment with that; but 'tis better if the Sides be about fo much Convex as thofe of mine are, becaufe the Image will thereby become much better defined: For this Convexity of the Sides does the fame Effect, as if you fhould ufe a Prifm with Sides exactly plain, and between it and the Hole in the Window-fhut, place an Object-Glafs of an 18 Foot Telefcope, to make the round Image of the Sun appear diftinctly defined on the Wall when the Prifm is taken away, and confequently the long Image made by the Prifm to be much more diftinctly defined (efpecially at its ftreight Sides) than it would be otherwife.

One Thing more I fhall add: That the utmoft Length of the Image, from the fainteft Red at one End, to the fainteft Blue at the other, muft be meafured. For in my firft Letter about Colours, where I fet down the Length to be five Times the Breadth, I called that Length the utmoft Length of

 the

the Image; and I meaſured the utmoſt Length, becauſe I account all that Length to be cauſed by the immediate Light of the Sun, ſeeing the Colours (as I noted above) become viſible to the greateſt Length in the cleareſt Days, that is, when the Light of the Sun tranſcends moſt the Light of the Clouds. Sometimes there will happen to ſhoot out from both Ends of the Image a glaring Light a good way beyond theſe Colours; but this is not to be regarded, as not appertaining to the Image. If the Meaſures be taken right, the whole Length will exceed the Length of the ſtreight Sides by about the Breadth of the Image.

By theſe Things ſet down thus circumſtantially, I preſume Mr. *Lucas* will be enabled to accord his Trials of the Experiment with mine; ſo nearly at leaſt, that there ſhall not remain any very conſiderable Difference between us. For if ſome little Difference ſhould ſtill remain, that need not trouble us any further, ſeeing there may be many various Circumſtances which may conduce to it; ſuch as are not only the different Figures of Priſms, but alſo the different refractive Power of Glaſſes, the different Diameters of the Sun at divers Times of the Year, and the little Errors that may happen in meaſuring Lines and Angles, or in placing the Priſm at the Window; though, for my part, I took Care to do theſe Things as exactly as I could. However, Mr. *Lucas* may make ſure to find the Image as long or longer than I have ſet down, if he take a Priſm whoſe Sides are not hollow ground, but plain, or (which is better) a very little convex, and whoſe refracting Angle is as much greater than that I uſed, as that he hath hitherto tried it with, is leſs; that is, whoſe Angle is about 66 or 67 Degrees, or (if he will) a little greater.

Concerning Mr. *Lucas*'s other Experiments, I am much obliged to him that he would take theſe Things ſo far into Conſideration, and be at ſo much Pains for examining them; and I thank him ſo much the more, becauſe he is the firſt that hath ſent me an experimental Examination of them. But yet it will conduce to his more ſpeedy and full Satisfaction, if he a little change the Method which he has propounded, and, inſtead of a Multitude of Things, try only the *Experimentum Crucis:* For it is not Number of Experiments, but Weight to be regarded; and where one will do, what need many?

The main Thing he goes about to examine is, the *Different Refrangibility of Light*; and this I demonſtrated by the *Experimentum Crucis*. Now if this Demonſtration be good, there needs no further Examination of the Thing; if not good, the Fault of it is to be ſhewn: For the only way to examine a demonſtrated Propoſition is to examine the Demonſtration. Let that Experiment therefore be examined in the firſt Place, and that which it proves be acknowledged; and then, if Mr. *Lucas* wants my Aſſiſtance to unfold the Difficulties which he fancies to be in the Experiments he has propounded, he ſhall freely have it. At preſent I ſhall ſay nothing in Anſwer to his Experimental Diſcourſe, but this in general, That it has proceeded partly from ſome Miſunderſtanding of what he writes againſt, and partly for want of due Caution in trying Experiments; and that amongſt his Experiments, there is one, which, when duly tried, is, next to the *Experimentum Crucis*, the moſt con-

ſpicuous

ſpicuous Experiment, I know, for proving the different Refrangibility of Light, which he brings it to prove againſt.

By the Poſtſcript of Mr. *Lucas*'s Letter, one not acquainted with what has paſſed, might think that he quotes the Obſervation of the *Royal Society* againſt me; whereas the Relation of their Obſervation, which you ſent to *Liege*, contained nothing at all about the juſt Proportion of the Length of the Image to its Breadth according to the Angle of the Priſm, nor any Thing more (ſo far as I can perceive by your laſt) than what was pertinent to the Things then in Diſpute, *viz.* that they found them ſucceed as I had affirmed. And therefore, ſince Mr. *Lucas* has found the ſame Succeſs, I ſuppoſe, that when he expreſſed, That *he much rejoiced to ſee the Trials of the* R. Society *agree ſo exactly with his*, he meant only ſo far as his agreed with mine.

P. S. *I had like to have forgotten to adviſe, that the* Experimentum Crucis, *and ſuch others as ſhall be made for knowing the Nature of Colours, be made with Priſms that refract ſo much, as to make the Length of the Images five Times its Breadth, and rather more than leſs; for otherwiſe, Experiments will not ſucceed ſo plainly with others, as they have done with me.*

VIII. I took a ſtiff Piece of brown Paper, and pricking a ſmall Hole therein, I held it at a little Diſtance from me; then applying a Needle to my Eye, I was ſurprized to ſee the Point of it inverted. The nearer the Needle was to the Hole, it was ſo much the more magnified, but leſs diſtinct; and if it were ſo held, as that its Image was near to the Edge of the Hole, its Point ſeemed crooked. So that, it ſeems, theſe ſmall Holes, or ſomewhat in them, perform the Effects of a Concave Speculum; and ſo I take leave to call them *Aerial Speculums.*

An Optical Experiment; by Mr. Steph. Gray. N. 221. *p.* 286. June, An. 1696.

IX. 1. Having this Opportunity I ſend you a Conſtruction of the Problem of *Alhazen*, which my Colleges here approve of very much. The Problem is this: *A Concave or Convex Speculum being given, alſo the Eye and a Point of the Object, to find the Point of Reflexion.*

A Problem of Alhazen, *ſolved by Mr.* Chr. Huygens. N. 97. *p.* 6119. Oct. An. 1673. *Fig.* 78.

Let the Speculum be a Part of a Sphere whoſe Center is the Point A, let the Eye be at B, and the viſible Point at C, and let the Plain drawn through A, B, C, make a Circle D *d* in the Sphere, in which the Points of Reflexion are to be found. Through the three Points A, B, C, let the Circumference of a Circle be deſcribed, whoſe Center is Z: Let A E produced meet it in R, being perpendicular to B C, and to the two Lines R A, O A, let N A be a third Proportional, and N M parallel to B C will be one of the Aſymptotes. Again, let theſe be Proportionals E A, $\frac{1}{2}$ A O, A I, and the Sum I Y being equal to I N, let Y M be drawn parallel to A Z; which will be the other Aſymptote. Laſtly taking I X, I S, each of which is equal in Power to half the Square A O, together with the Square A I; the Points *x* and *s* will be in the Hyperbola, or the oppoſite Sections D *d* to be deſcribed to the Aſymptotes now found, whoſe Interſections with the Circumference D O will ſhew the Points of Reflexion required. This Conſtruction takes Place in every

Case in which the Problem is solid, except in one, wherein a Parabola and not an Hyperbola is to be described. That is, when the Circumference through the Points A, B, C, touches the Right Line A E.

By Mr. Slusius. *ibid.* 2. When I reduced the Construction of the ingenious Mr. *Huygens* to Calculation, I found he had follow'd the same Analysis as myself. But since two Effections may be derived from it, each of them by the Hyperbola about its Asymptotes, he made Choice of one, and I of the other as being the easier. Now it is plain, that nothing else is required in this Problem, if we reduce it to mere Geometrical Terms, unless that in a given Circle, whose Center is A and Radius A P, some Point as P should be found, from whence drawing Right Lines P E, P B, to the given Points E, B, at an unequal Distance from the Center A, the Right Line A P being produced may bisect the Angle E P B. Now this admits of a Variety of Cases. Either the Perpendicular from A upon the Right Line E B, that is A O, falls between E and B, or beyond B. If beyond, the Rectangle E O B is either equal to the Square of A O, or is greater or less. Concerning the Case of Equality we shall see afterwards; now we shall comprehend the other three Cases nearly *Fig.* 79, 80, 81. in the same Construction. Let a Circle pass through the three Points A, E, B, to the Circumference of which let A O be produced to D. And if the Point O falls between E and B, the Right Line A O is to be produced towards O; but if it falls beyond B, and the Rectangle E O B be greater than the Square of A O, it must be produced towards A; but if that Rectangle be less than the Square, the Circle will cut the Right Line A O in the Point D. Then drawing A X parallel to E B, cutting the given Circle in N, let it be made, as the Rectangle D A O is to the Square of A N, so $\frac{1}{2}$ A X to A H, which must be taken towards X if O falls between E and B, or the Rectangle E O B be less than the Square of O A, or on the contrary Side if it be greater. Now let us suppose O Q to be equal to A H, (directly to E B in the first and second Case, but towards E in the third) then let these be made Proportionals X A, N A, H K, to be taken in all Cases towards X; and A O being divided in V, that K A to A V may have the same Ratio as A D to A X; let K V be joined, and produced till it meet the Right Line Q M, parallel to O A, indefinitely produced in the Point L. Then in every Case K L and Q L will be the Asymptotes of the Hyperbola, which being described through the Point O will answer the Purpose: Yet with this Difference, that in the first and second Case an Hyperbola through O will solve the Problem in the Convex Speculum, but the Section opposite to it in the Concave. But in the third Case on the contrary, the Hyperbola through O will serve for the Concave, and the opposite Hyperbola for the Convex. And thus it will be when the Point V falls between A and O; for if it should fall beyond O, one Hyperbola alone described between the same Q L, K L, would suffice both for the Concave and Convex. But if V should fall upon the Point O, then the Problem would become plane, and the Right Lines L Q, L K, would perform it. Whence it appears, that there are infinite Cases of this Problem, which may be solved by what is called *Locus planus*: So that they seem to deserve to be forgiven, who have thought it may be solved universally by the

the same *Locus*; because thus sometimes the Calculation has been successful. For no Position can be given of the three Points A, E, B, (as to the Case of Equality between the Rectangle E O B and the Square O A, we shall see presently) which does not admit that some Circle may be described from the Center O, at whose Circumference the Problem may be solved by a plane Place. Now the Radius of this Circle, if it be worth while, may thus be found. In the first and second Case of the Construction above, let it be made, as the Square of A X together with the double of the Rectangle O A D, to the double Square of A D, so the Square of A O to the Square of A N; A N will be the Radius required. But in the third Case it must be made, as the Square of A X subtracting the double Rectangle O A D, to the double Square of A D, so is the Square of A O to the Square of A N.

Now there remains another Case to be constructed, that is, when the Rectangle E O B is equal to the Square of A O, or in which the Circle described through the Points A, E, B, touches the Right Line A O. For Mr. *Huygens* has rightly admonished, that in this Case a Parabola must be described. Which yet is not so to be understood, as though it could not be solved by an Hyperbola, since it admits of either an Hyperbola, or an Ellipsis, nay an infinite Number of them, if any one shall proceed by our Method. However it admits of a Solution by a Parabola, which the other Cases refuse. For the same Reason that must be limited when he says, that his Construction takes Place in every Case where the Problem is solid; for he means, that by a small Alteration an Hyperbola may always be found, which will serve the Purpose; which will appear to any one that shall compare the Cases above constructed with his Construction. Now that I may return to the Case of Equality, and that I may not seem to have made a rash Assertion, here you have not one but two Parabola's, and opposite Hyperbola's besides, that will answer the Purpose. Let the given Points be E, B, as before; let a Circle be described with Center A, and another through the three Points A, E, B, whose Tangent is A O, and Center D. Drawing the Diameter N A D X, let there be three Proportionals X A, N A, Z A, the half of which is A L. Again let there be three Proportionals 2 O A, N A, I A, whose half is K A, and let the Rectangle L A O V be compleated; and L V being produced to S, till V S be a third Proportional to A I, O V; with Axis S L and *latus rectum* A I, and Vertex S, let a Parabola be described; for this will cut the Circle in the Points required, P, P. Another will do the same Thing; thus the Rectangle D A K C being compleated, and K C being produced to T, so that C T may be a third Proportional to A Z, D C, it may be described about the Axis T K, with the Vertex T, and the *latus rectum* Z A; for it will meet the Circle in the same Points P, P. The Construction is still easier by the opposite Sections; for making as before the three Proportionals X A, N A, Z A, let fall the Perpendicular Z I, being a third Proportional to the double of A O, and A N. Therefore will Z I be greater than Z A, since the double of A O is less than X A. Then in the Point I let the Right Lines I Q, I M, be inclined to the Right Line I Z on both Sides to half a Right Angle, and be produced indefinitely both Ways.

Fig. 82.

Fig. 83.

Ways. Then about them as Afymptotes let an Hyperbola be defcribed through A, and another oppofite to it; for this will fatisfy the Problem in the Convex Speculum, and the other in the Concave. But fince Z I is always greater than Z A, as we have fhewn, the Right Line I M will never pafs through A. Therefore there will be no Cafe in which by this Conftruction (as in the former) the Problem can be folved by the Afymptotes themfelves. And yet this fometimes may admit a *Locus Planus*, when it happens, that the Right Line X O, drawn to the Center D, may touch the Circle N P P; for then the Point of Contact itfelf will fatisfy the Queftion. And fo much concerning a Problem, which has exercifed the Wits of many, and whofe Solution I compleated fome Years ago.

Otherwife by Mr. Slufius. *ibid. p.* 6123. *Fig.* 84.

I fend you here my fecond Thoughts about the Problem of *Alhazen.*

Let a Circle be given whofe Center is A; and D and d are Points given. Let that which is inquired be fuppofed to be done, and let the incident Ray be D E; the reflected Ray E d, and from the Point of Reflexion E let the Perpendicular E I fall upon the joined Line D A; and upon the fame the Perpendicular d N from d, and let the Tangent E C and the Ray dE meet the fame produced in B. Now make $DA = z$, $AI = a$, $NA = n$, $EI = e$, $dN = b$, $BA = y$, $AE = q$, and $CA = x$. Therefore, fince the Angles D E C and C E B are equal, and C E A is a Right Angle, by the Hypothefis the three Lines D A, C A, B A, will be Harmonically Proportionals, which is eafily fhewn. Therefore it will be as D A to B A fo is D C to C B; or in Analytical Terms; $z . y :: z - x . x - y$, and $2zy - xy = zx$, or $\frac{2zy}{z+y} = x$. Now fince the Rectangle C A I, or xa, is equal to the Square of A E, or qq, it will be $x = \frac{qq}{a}$, and confequently $\frac{2zy}{z+y} = \frac{qq}{a}$, or $\frac{zqq}{2za - qq} = y$. Again, it is as dN to E I, fo is N B to I B; or $b . e :: y - n . y - a$. Therefore $ye - ne = by - ba$, and $y = \frac{ba - ne}{b - e}$. Therefore $\frac{zqq}{2za - qq} = \frac{ba - ne}{b - e}$, or $2zbaa - 2znae - qqba + qqne = bzqq - zqqe$. Which is an Equation to the Hyperbola about its Afymptotes, the Conftruction of which with a given Circle fatisfies the Problem. But becaufe of the Circle, fince it is $qq = aa + ee$, if inftead of $2bzaa$ its Value $2bzqq - 2bzee$ is fubftituted, we fhall have $bzqq - 2bzee - 2znae - qqba + qqne = -zqqe$, which is another Equation to the Hyperbola about the Afymptotes. And by this Method, or by that which we have explained in our Treatife of Analyfis, infinite Equations will come out to Hyperbolas and Ellipfes, which with a given Circle will perform the Problem; except that the Effections will generally become fo intricate, as it may not be worth while to attempt them. Yet they may be conftructed after that Manner which we have made ufe of in the Ellipfis.

We

We have reduced, as you will perceive, the Sum of our Calculation to the Line D A; but you may obſerve, that with the ſame eaſe it might have been referred to d A, which is alſo given, by drawing thoſe Lines which in the Scheme are ſhadowed out by Points. But there is no need of the Labour of a new Calculation. For if you apply to the Right Line d A and to its Parts the ſame Analytical Terms as before, that is, if you make $d\mathrm{A}=z$, $\mathrm{D}n=b$, $n\mathrm{A}=n$, $\mathrm{AI}=a$, $i\mathrm{E}=e$, &c. the ſame Equation will come out as before, and you will obtain infinite other Hyperbola's and Ellipſes, which with the given Circle will ſatisfy the Porblem. I ſhould be tireſome if I was to purſue all the Caſes, ſince their Equations differ only by the Signs $+$ and $-$. I except only one, which is when d A D is a right Angle; for its Equation will be had only by expunging out of the former thoſe Terms which are effected by n, which then vaniſhes into nothing. Which Equation will be this, $2zbaa-qqba=bzqq-zqqe$; or this, $zbqq-qqba=2zbee-zqqe$, inſtead of $2zbaa$ writing its Value.

Yet it is to be obſerved, that although by referring the Analyſis to the right Line D A, two Hyperbola's in the Equation preſently offer themſelves; and others as many different from the former, when the Calculation is referred to the Right Line d A; yet the very ſame Parabola's come forth, when the Analyſis is referred to either of the Right Lines d A or D A. The Reaſon of which you will perceive by a little Conſideration.

Now give me Leave, learned Sir, to apply the foregoing Analyſis to all the Problems which are uſed to be propoſed about the Reflection of Spherical *Specula*, and that by a new Scheme. Therefore let there be a Circle as before, whoſe Center is A, D a point given, and from that an incident Ray D E, whoſe reflected Ray is E Q. Let D A be joined, and to it be drawn the Tangent E C, and perpendicular E I. Let the Right Line Q E B be produced to the ſame, and the Parts be denominated as before; that is, $\mathrm{DA}=z$, $\mathrm{CA}=x$, $\mathrm{AE}=q$, $\mathrm{BA}=y$, $\mathrm{AI}=a$, $\mathrm{IE}=e$. Now becauſe of the three Lines harmonically Proportionals D A, C A, B A, and the three Geometrically Proportionals C A, A E, A I, we ſhall always have the Equation *Fig.* 85.

$y=\frac{zqq}{2za-qq}$, upon whatever point of the Circle the Ray D E may fall. Therefore if the Point E be required, in which if the Ray D E falls, it may be reflected parallel to the Diameter L A V perpendicular to D A, the reflected Ray Q E produced will paſs through I, as is plain; and I and B will coincide. Therefore $a=y=\frac{zqq}{2za-qq}$, or $aa-\frac{1}{2}\times\frac{qqa}{z}=\frac{1}{2}qq$, and the Problem will be ſolved by Plains.

If the Point be required, from whence a Ray may be reflected parallel to any other Line, as A K drawn from the Center A; from the point L draw a Tangent to it $\mathrm{KL}=d$; it is plain the Triangles A K L, E I B, will be ſimilar, ſince all the Sides of one are parallel to the Sides of the other. Therefore A L to L K, as E I to I B, or $q.d::e.a-y$; and $\frac{qa-de}{q}=$

$y=$

$y = \frac{zqq}{2za - qq}$; and $zq^3 = 2qzaa - 2zdae - q^3a + qqde$, or for aa putting $qq - ee$, $zq^3 = 2zq^3 - 2zqee - 2zdae - q^3a + q^2de$. But either of the Equations is to an Hyperbola about the Aſymptotes, which with a given Circle ſolves the Problem.

Let it now be propoſed to cauſe, that the reflected Ray ſhall paſs through a given Point N, as in the Problem of *Alhazen*, or that being produced towards the Point of Reflection E, it may meet the given Point N. From N let $NO = n$ fall perpendicularly upon A L, and make $AO = b$. It is plain it will be, as A O to the difference of O N and A B, ſo is E I to I B; that is, $b \,.\, n - y :: e \,.\, a - y$: Or $b \,.\, y - n :: e \,.\, y - a$. Therefore $\frac{ba - ne}{b - e} = y = \frac{zqq}{2za - qq}$. Whence $2zbaa - 2znae - qqba + qqne = bzqq - zqqe$; which is the very Equation of *Alhazen's* Problem, which we deduced above. Or in the ſecond caſe $\frac{ba + ne}{b + e} = y = \frac{zqq}{2za - qq}$, or $2zbaa + 2znae - qqba - qqne = zbqq + zqqe$.

And theſe are the Problems commonly propoſed about the Point of Reflection, in which hitherto we have ſuppoſed the Diſtance of the point D to be finite. But the Analyſis will be eaſier if we ſuppoſe it infinite. For C A being divided equally in G, it is plain from the Property of the three harmonical Proportionals D A, C A, B A, that the three Lines D G, C G, B G, will be Geometrical Proportionals, whatever the Diſtance of the point D is ſuppoſed to be. Therefore if it is ſuppoſed infinite, B G will become nothing, and the Points B, G, will coincide. Therefore A B will always be equal to B C, and $CA = 2y$, and the Rectangle C A I being equal to the Square of A E, will give in Analytical Terms $2ay = qq$, or $y = \frac{qq}{2a}$. And ſince the Diſtance of the Point D is ſuppoſed infinite, E D will be parallel to A C. Therefore if the reflected Ray parallel to A L is required, becauſe in this Caſe a and y coincide, it will be $a = y = \frac{qq}{2a}$, or $aa = \frac{1}{2}qq$; if it is deſired to be parallel to A K, it will be again $q \,.\, d :: e \,.\, a - y$, and $\frac{qa - de}{q} = y = \frac{qq}{2a}$, or $2qaa - dae = q^3$. If it is required to paſs through N, it will be as above $\frac{ba \pm ne}{b \pm e} = y = \frac{qq}{2a}$, and therefore $2baa \pm 2nae = bqq \pm qqe$. Which Equations are alſo to Hyperbola's about their Aſymptotes, unleſs when the Point N is ſuppoſed to be in A L; for whereas then n becomes nothing, taking away thoſe Terms from the Equation in which n is found, the remaining Terms will give an Equation to a Parabola, as we have taken Notice before.

You

You cannot expect, learned Sir, that as hitherto I have given Examples only in concave Speculum's, so now I should proceed to convex. For you know the Analysis is the same in both, and their Equations differ only in varying the Signs + and —. You know the Parabola or Ellipsis that satisfies one, will satisfy the other also; and if the Hyperbola solves the Problem in the Convex, the opposite Hyperbola will do the same in the Concave. Therefore omitting these I shall only add, that by the same Analysis in concave Speculum's we may find their Focus's, and the Spaces taken up by the Rays in the Axis, at any distance of the lucid Point: But with great Facility when the Rays come parallel, which yet I have seen demonstrated by some in a round-about way. For in the Concave Speculum E E, whose Center is A, if the extreme Ray is supposed to be reflected to the Axis A R in B, *Fig.* 86. drawing the Tangent E C it will be C B = B A. Let the Semiaxis A R be bisected in Q; therefore Q will be the Focus; and Q B will be the Space required. But Q B is half C R, because of the Equals A Q, Q R, A B, B C, that is, half of the Excess of the Arch E R above the whole Sine. Therefore if the Arch E R, for Example, be Nine Degrees, A C will be 101246, and $BQ = \frac{623}{100000}$ of A R.

4. This is the Compendium that I found at the same time, about the first *Otherwise by Mr.* Huygens, N. 98. *p.* 6140. D. An. 1673. Construction communicated to you at first. Drawing the Line A T, parallel to C B, and that being bisected in V, this is that point through which one of the opposite Hyperbola's ought to pass, whose Asymptotes are found to be Y M, *Fig.* 87, 88. M N.

But here is that genuine Construction which is sufficient in all cases. Let the given Circle be E D whose Center is A, and the points given B and C. Drawing the Lines A B, A C; let these be Proportionals, B A, the Radius of the Circle, and F A; and likewise C A, the Radius of the Circle, and G A. Then let F G be joined, and let it be bisected in H. Through this Point let the Lines L H K, M H N, be drawn, intersecting one another at Right Angles, of which let L H K be parallel to the Line which bisects the Angle B A C. These are the two Asymptotes of the Hyperbola's to be described through the Points F and G, one of which will pass also through the Center A; whose Intersections with the Periphery of the Circle will mark out the Points of Reflection required.

5. Here the great *Huygens* has well observed, how the Equilateral Hyperbola may be accommodated to all the cases, which, as I insinuated in my former, immediately offered itself in the case of a Right Angle. Also of those *Farther considered by Mr.* Slusius. *ib. p.* 6141. infinite Ellipses which might be used, one may be chosen of no difficult Construction. But it is tedious to dwell so long upon one Problem. But one thing still remains of no disagreeable Speculation: That is, since the Sections which with the given Circle are made use of for the Solution of the Problem, cut it in four Points, of which only two can serve for the Reflexion; it may be inquired, what Problem is solved by the other two, and how is the Proposition to be expressed so as to include all those four Cases? And again, do

not those four Cases occur, when those Points are equally distant from the Center?

Again ib. The learned *Huygens* makes use of no other than my Analysis, which admits of a Parabola only in one Case. That this may appear more evidently to you, I will here produce the Equation which he has constructed. Recollect (if you please) what I wrote to you, when I sent you my second Thoughts, and you will find, that I assign'd two Equations proper for solving the Problem by an Hyperbola about its Asymptotes. They were these following.

$$2zbaa - 2znae - qqba + qqne = bzqq - zqqe,$$

$$\text{And } bzqq - 2znae - qqba + qqne = 2zbee - zqqe;$$

Then I added, that by a small Alteration (for instance, by substituting for qq its Value $aa + ee$,) infinite Hyperbola's and Ellipses might be found, which with the given Circle would solve the Problem. Now in the former of these Equations for $bzqq$ let its Value be substituted; then

$$zbaa - 2znae - qqba + qqne = bzee - zqqe;$$

$$\text{Or, } aa - \frac{qqa}{z} = ee - \frac{qqe}{b} + \frac{2nae}{b} - \frac{qqne}{zb}.$$

And this is the Equation which that very learned Gentleman has constructed, with great Ingenuity and equal Facility.

Again ib. Fig. 89. I happened lately upon the following Construction, which I could not forbear submitting to your Judgment and Censure, believing that a shorter can hardly be given. Let the given Points be E, B, the Circle with Center A. Joining EA, BA, cutting the Circle in F and C; let EA, FA, VA, be three Proportionals, and three others BA, CA, XA. Then VX being joined and produced at Pleasure, with Vertex X, *latus transversum* VX, and *latus rectum* equal to it, let the Hyperbola XP be described, whose Ordinates to the Diameter VXG are parallel to the Right Line AB. For this satisfies the Proposition in the Case of a Convex Speculum, and its opposite in the Case of a Concave. If you desire to have the Asymptotes they will easily be found, by producing VX till it meets EB produced in L. Then bisecting VX in I, and taking LD equal to LI; for DI being joined will be one of the Asymptotes, upon which the other falls perpendicularly at I.

But perhaps it will not be unacceptable to you to know how I arrived at this Construction. Know then that I deduced it thus from my former Analysis.

Fig. 90. The same things being given as before, let fall the Perpendicular AO upon EB, and let the Point desired be P, from which let PR fall perpendicularly upon AO. Make $AO = b$, $EO = z$, $OB = d$, $AP = q$, $PR = e$, $AR = a$. Then this Equation is easily derived.

$$\frac{2zdae + 2bbae - 2bqqe}{zb - bd} + ee = aa - \frac{qqa}{b}, \text{ which may be changed}$$

into these,

$$\frac{zdae + bbae - bqqe}{zb - bd} = aa - \tfrac{1}{2}qq - \frac{\tfrac{1}{2}qqa}{b},$$

$$\text{And } \frac{zdae + bbae - bqqe}{zb - bd} + ee = \tfrac{1}{2}qq - \frac{\tfrac{1}{2}qa}{b}.$$

The

The Conſtruction of this laſt I have ſent to you already, and Mr. *Huygens* has ſent you the Conſtruction of the other. But as to the firſt, tho' it preſently came into my View, yet I almoſt neglected it, becauſe its Conſtruction ſeemed to be difficult. But I find myſelf to have been deceived by a needleſs Fear, ſince I have lately found it to bring me to this Conſtruction which I now ſend you. For the ſake of abbreviating the Calculation, make $z - d = k$, $zd + bb = bm$; it will be $ee + \frac{2mac - 2qqe}{k} = aa - \frac{qqa}{b}$. And adding $\frac{q^4 + m^2a^2 - 2q^2ma}{kk}$ on both Sides, it will be $ee + \frac{mae - 2qqe}{k} + \frac{q^4 + mmaa - 2qqma}{kk}$ (that is, the Square of $e - \frac{qq + ma}{k}$) $= aa - \frac{qqa}{b} + \frac{q^4 + m^2a^2 - 2q^2ma}{kk}$. Therefore there will be this Analogy, $kk . kk + mm :: aa - \frac{kkqqa}{bkk + bmm} - \frac{2qqma + q^4}{kk + mm}$. And the Square of $e - \frac{qq + ma}{k}$. Which may be reduced to an eaſier Equation, if making $kk + mm = pp$, it ſhall be $\frac{ky}{p} = a$. At length it is, the Square of $e - \frac{qq}{k} + \frac{my}{p} = yy - \frac{qqky}{bp} - \frac{2qqmy}{kp} + \frac{q^4}{kk}$, which Equation you will find to anſwer the former Conſtruction, if you undertake the Calculation. And at the ſame time you will obſerve, to which ever of the Lines E A, A B, B E, the Analyſis is refer'd, the ſame Sections will always ariſe, though by a longer Proceſs and very different Equations.

From this Equation by Analogy we may deduce an Effection of the other Problem, that is, when a Point is ſought from whence the Reflected Ray ſhall be parallel to any given Line. Thus if the luminous Point B being given, and the Circle with Center A, the reflected Ray parallel to the Right Line A E were ſought. For it is the ſame thing as if in the other Problem the Diſtance of the Points A and E were ſuppoſed infinite. In which Caſe the third Proportional to E A and F A would vaniſh into nothing, and the Points A and V would coincide. Therefore V X would be equal to A X, and A E parallel to P E. Therefore apply the foregoing Conſtruction and you will ſolve the Problem. That is, with Vertex X, and *latus tranſverſum* V X or A X, and *latus rectum* equal to it, deſcribe the Hyperbola X E, whoſe Ordinates to the Diameter A X are parallel to the Right Line A E. *Fig.* 91.

6. It is true, and likewiſe wonderful, that the Conſtruction I ſent you formerly, may alſo be found by Mr. *Sluſius's* Calculation, after the Change of qq into $aa + ee$. But this ſeems to be done by chance, nor does the Simplicity of the Conſtruction appear there, till after we have apply'd ourſelves to it. *By Mr.* Huygens. *ibid. p.* 6143. *Fig.* 92.

The Problem of Alhazen] *A Circle being given whoſe Center is A, Radius A D, and two Points B, C; to find a Point H in the Circumference of the given Circle*

Circle, whence drawing the Lines H B, H C, they ſhall make equal Angles at the Circumference.

Suppoſe it found, and drawing the Right Line A M which ſhall biſect the Angle B A C, draw H F perpendicular to it, as alſo B M, C L. Then join A H, to which let H E be perpendicular, and let H M meet the Lines B H, H C, in the Points K, G.

Now let it be $AM = a$, $MB = b$, $AL = c$, $LC = n$, Radius $AD = d$, $AF = x$, and $FH = y$. Now becauſe the Angles K H E and C H Z are equal, as alſo E H G; and E H A is a Right Angle; it will be as K E to E G, ſo K A to A G. And becauſe B M to M D, ſo H F to F K, it will be as $BM + HF$ to H E, ſo is M F to F K. That is, $b + y . y :: a - x . \frac{ay - xy}{b + y}$. Add $FA = x$, then $KA = \frac{ay + bx}{b + y}$.

Again, becauſe C L to L G, as H F to F G, it will be *permutando & dividendo*, $CL - HF$ to H F, ſo is L F to F G. That is, $n - y . y :: c - x . \frac{cy - xy}{n - y}$. Which being taken away from $AF = x$, tis $GA = \frac{nx - cy}{n - y}$.

But it is $EA = \frac{dd}{x}$, becauſe F A, A H, A E, are Proportionals. Therefore $EA - GA = EG = \frac{dd}{x} - \frac{nx + cy}{n - y}$. And $KA - EA = KE = \frac{ay + bx}{b + y} - \frac{dd}{x}$.

But we have ſaid it is K E to E G, ſo is K A to A G. That is, $\frac{ay + bx}{b + y} - \frac{dd}{x} . \frac{dd}{x} - \frac{nx + cy}{n - y} :: \frac{ay + bx}{b + y} . \frac{nx - cy}{n - y}$. Whence is found

$$2anxxy + 2bnx^3 - ddbnx - ddnxy = naddy + nbddx - 2acxyy - 2bcxxy + ddbcy + ddcyy - addyy - bddxy.$$

And becauſe $n = \frac{bc}{a}$, it becomes $\frac{2bbc}{a}x^3 - \frac{bbddcx}{a} - \frac{2bbcyyx}{a}$, becauſe $xx = dd - yy$. But it is $\frac{2bbc}{a}x^3 = \frac{2bbcddx}{a} - \frac{2bbcyyx}{a}$, becauſe $xx = dd - yy$. Therefore $-\frac{2bbcxyy}{a} - \frac{ddbcxy}{a} - 2acxyy + ddcyy = -addyy - bddxy$. And dividing all by y, and multiplying by a,

$$-2bbcxy - ddbcx - 2aacxy + ddcay = -aaddy - bddax$$

$$abddx - cbddx + acddy + aaddy = 2aacxy + 2bbcxy$$

$$\frac{abddx - cbddx + acddy + aaddy}{2aac + 2bbc} = xy,$$ which is an Equation to an Hyperbola.

Or

Or becaufe $bc = na$, $\frac{abddx - anddx + acddy + aaddy}{2aac + 2bbc} = xy$.

Let $\frac{add}{aa + bb} = p$; therefore $\frac{pbx - pnx + pcy + pay}{2c} = xy$.

Now from hence the following Conftruction was not difficult to find. Let BA, AC, be joined, and the Square of the Radius AD being feparately applied to each, let AP and AQ be produced by that Application. Then joining PQ let it be bifected in R, and through the Point R let RD, RN, be drawn cutting each other at Right Angles, of which let RD be parallel to AD, which bifects the Angle BAC. Now RD, RN, will be the Afymptotes of the oppofite Hyperbolas, one of which muft pafs through the Center A, and which will cut the Circumference in H the Points required. Alfo the Hyperbolas will pafs through the Points P, Q. Fig. 93.

The Reafon of the Conftruction appears, when $P\gamma$, $Q\zeta$, are drawn, perpendicular to AM. For it is $A\gamma = \frac{add}{aa + bb} = p$, and $A\zeta = \frac{ap}{c}$. Alfo $P\gamma = \frac{pn}{c}$ and $Q\zeta = \frac{pb}{c}$. Therefore $AO = \frac{pc + pa}{2c}$, and $OR = \frac{pb - pn}{2c}$. Whence the reft wlll be eafy.

7. You will ceafe to wonder, learned Sir, that in the Problem of *Alhazen* the fame Conftruction fhould be derived from different Equations, when you confider that all we have hitherto made ufe of, are contained in one and the fame general Analyfis. Now to fhew this, let a Circle be given whofe Center is A, the Points H and I; and let the Point required be K, to which from the Points I and H let be drawn the Right Lines HK, IK, and the Tangent KD. Then from A let any Line AG be drawn, meeting HK in E, IK in B, the Tangent KD in D; the Lines if needful being produced. Thefe Things fuppofed it is plain, becaufe of equal Angles EKD and DKB, and the Right Angle AKD, that the three Lines AE, BE, DE, will be Harmonically Proportional. Therefore drawing KC, IF, HG, perpendicular to AE, and calling $AK = q$, $AC = a$, $CK = e$, $HG = b$, $AG = d$, $FA = z$, $FI = n$, by the Method I formerly ufed in my fecond Analyfis of this Problem, we fhall have this general Equation, $ndaa - bzaa - nqqa + bqqa = ndee - zbee + 2bnae + 2zdae - dqqe - zqqe$. *By Mr. Slufius. ib. p. 6145. Fig. 94.*

Now fuppofe AG to be perpendicular to HI; there will be no Variety in the Equation, except that AF and AG (that is d and z) will be equal. Writing therefore d for z, the Equation will become $ndaa - bdaa - nqqa + bqqa = ndee - dbee + 2bnae + 2ddae - 2dqqe$. Or applying all to $nd - db$, the Equation is $aa - \frac{qqa}{d} = ee + \frac{2bnae + 2ddae - 2dqqe}{nd - db}$.

Which

Which is the ſame that I deduced from my firſt Analyſis, though another Way, and which I lately ſent you conſtructed after an eaſy Manner.

Then ſuppoſe A G to coincide with A H; therefore H G or b vaniſhes into nothing. Therefore the Terms being expunged in which b is found, there will remain $ndaa - nqqa = ndee + 2zdae - dqqe - qqze$. This as you may remember I gave you as my ſecond Thoughts, and another like to it, in the Caſe wherein the Right Line A G paſſes through I.

Then let us ſuppoſe the Right Line A G to biſect the Angle H A I; then becauſe of the Similitude of the Triangles H A G, I A F, it will be as H G to G A, ſo is I F to F A; or $b . d :: n . z$, or $nd = bz$. Therefore taking away Equals, 'tis $bqqa - nqqa = 2bnae + 2zdae - dqqe - qqze$. The ſame which, as I underſtand by your Letters, Mr. *Huygens* has conſtructed.

Laſtly, let it be ſuppoſed that the Right Line H G biſects the Right Line H I; therefore H G = I G, or $b = n$. Then it will be by taking away Equals, $bdaa - bzaa = bdee - bzee + 2bbae + 2zdae - dqqe - qqze$. This though no difficult one, none of us have yet conſtructed. But theſe, and the general Equation itſelf, may be divided into two others, by ſubſtituting (as you know) for aa or ee their Values $qq - ee$ or $qq - aa$.

You ſee therefore that whatever has been done yet may be reſolved into the ſame Analyſis, which comprehends alſo infinite other Conſtructions by the given Circle and an Hyperbola. But to inveſtigate them is of no great Conſequence, ſince in this Problem, though formerly Solutions were wanting, yet now we have Plenty enough. I will only add a Conſtruction by the Parabola, and that two Ways; which though it may ſeem more operoſe than thoſe by the Hyperbola, yet it makes amends by the Simplicity of the Curve, in which the Parabola has the Advantage of the other Conic Sections.

Fig. 95. The ſame Things then being given, let A I be joined and produced to S, 'till A S become equal to A H, and H S be joined, biſect I S in M, and through M let R M Q be drawn perpendicular to H S, upon which let fall the Perpendicular A Q, parallel to M Q let the Ray A C be drawn. Then making three Proportionals I A, A C, A E, let it be as S A to A E, ſo is M Q to A D, and R S to A P, in the Right Line A Q towards Q. And in the ſame on the other Side take D O equal to D C. Then biſect P D in X, and let the Right Line V X L be inclined through X in half a Right Angle to A X, meeting the Perpendicular erected at D, in the Point V, and upon which from O let fall the Perpendicular O B. I ſay, if it be V X to X B, ſo is X B to B L, the Point L will be the Vertex, L V the Axis, and X V the *latus rectum* of the Parabola, which will ſatisfy the Problem in every Caſe. For it will cut the given Circle in the Points K, of which the higheſt and laſt will belong to the Problem of *Alhazen*, and the reſt to ſome other Problem.

Another Parabola may alſo be given, as I have hinted already, which will do the ſame as this, and whoſe Deſcription may eaſily be deduced from this, ſo that there is no Occaſion for any other. For let A δ be taken directly to D A, and equal to it; and A ω directly to O A, and alſo equal to it. Then

biſect

bisect P δ in ξ, and through ξ let the Right Line $\aleph\,\xi\,\beta$ be drawn perpendicular to X B, meeting with $\delta\,\aleph$, perpendicular to O A, in $\aleph$, and upon which let the Perpendicular $\omega\,\beta$ fall. Then let it be as $\aleph\,\xi$ to $\xi\,\beta$, so is $\xi\,\beta$ to $\beta\,\lambda$. Then λ will be the Vertex, $\lambda\,\xi$ the Axis, and $\aleph\,\xi$ the *latus rectum* of the Parabola, which will cut the given Circle in the same Points with the former.

X. Let B E β be a double Convex Lens, C the Center of the Segment E B, and K the Center of the Segment E β; B β the Thickness of the Lens, D a Point in the Axis of the Lens; and it is required to find the Point F, at which the Beams proceeding from the Point D are collected therein, the Ratio of Refraction being as m to n. Let the Distance of the Object D B $= \text{D A} = d$, (the Point A being supposed the same with B, but taken at a Distance therefrom, to prevent the Coincidenee of so many Lines) the Radius of the Segment towards the Object C B, or C A $= r$, and the Radius of the Segment from the Object K β, or K $\alpha = \rho$, and let B β, the Thickness of the Lens, be $= t$, and then let the Sine of the Angle of Incidence D A G, be to the Sine of the Refracted Angle H A G, or C A ϕ, as m to n; and in very small Angles the Angles themselves will be in the same Proportion; whence it will follow, that, as d to r, so the Angle at C to the Angle at D, and $d + r$ will be as the Angle of Incidence G A D; and again, as m to n, so $d + r$ to $\frac{dn + rn}{m}$, which will be as the Angle G A H = C A ϕ. This being taken from A C D, which is as d, will leave $\frac{\overline{m - n}\,d - nr}{m}$ analogous to the Angle A ϕ D; and the Sides being in this Case proportional to the Angles they subtend, it will follow, that as the Angle A ϕ D is to the Angle A D ϕ, so is the Side A D or B D, to A ϕ or B ϕ: that is, B ϕ will be $= \frac{mdr}{\overline{m - n}\,d - nr}$, which shews in what Point the Beams proceeding from D would be collected by means of the first Refraction: but if nr cannot be subtracted from $\overline{m - n}\,d$, it follows, that the Beams after Refraction do still pass on diverging, and the Point ϕ is on the same Side of the Lens beyond D. But if nr be equal to $\overline{m - n}\,d$, then they proceed parallel to the Axis, and the Point ϕ is infinitely distant.

To find the principal Focus of Optick Glasses universally; by Mr. Edm. Halley. N. 205. p. 960.

Fig. 96.

The Point ϕ being found as before, and B ϕ — B β being given, which we will call δ, it follows by a Process like the former, that β F, or the Focal Distance sought, is equal to $\frac{\delta \rho n}{\overline{m - n}\,\delta + m\rho} = f$. And in the room of δ substituting B ϕ — B $\beta = \frac{mdr}{\overline{m - n}\,d - nr} - t$, putting p for $\frac{n}{m - n}$, after due Reduction this Equation will arise, $\frac{mpdr\rho - nd\rho t + npr\rho t}{mdr + md\rho - mpr\rho - \overline{m - n}\,dt + nrt} = f$.

Which *Theorem*, however it may seem operose, is not so, considering the great Number of Data that enter the Question, and that one half of the Terms

Terms ariſe from our taking in the Thickneſs of the Lens, which in moſt Caſes can produce no great Effect; however, it was neceſſary to conſider it, to make our Rule perfect. If therefore the Lens conſiſt of Glaſs, whoſe Refraction is as 3 to 2, 'twill be $\frac{6dr\rho - 2d\rho t + 4r\rho t}{3dr + 3d\rho - 6r\rho - dt + 2rt} = f$. If of Water, whoſe Refraction is as 4 to 3, the *Theorem* will ſtand thus: $\frac{12dr\rho - 3d\rho t + 9r\rho t}{4dr + 4d\rho - 12r\rho - dt + 3rt} = f$. If it could be made of Diamant, whoſe Refraction is as 5 to 2, it would be

$$\frac{\frac{10}{3}dr\rho - 2d\rho t + \frac{4}{3}r\rho t}{5dr + 5d\rho - \frac{10}{3}r\rho - 3dt + 2rt} = f.$$

And this is the univerſal Rule for the Foci of double Convex Glaſſes expoſed to diverging Rays. But if the Thickneſs of the Lens be rejected as not ſenſible, the Rule will be much ſhorter, *viz.* $\frac{pdr\rho}{dr + d\rho - pr\rho} = f$; or in Glaſs, $\frac{2dr\rho}{dr + d\rho - 2r\rho} = f$. All the Terms wherein t is found being omitted, as equal to nothing. In this Caſe, if d be ſo ſmall, as that $2r\rho$ exceed $dr + d\rho$, then will it be $-f$, or the Focus will be Negative, which ſhew that the Beams after both Refractions ſtill proceed diverging.

To bring this to the other Caſes, as of Converging Beams, or of Concave Glaſſes, the Rule is ever compoſed of the ſame Terms, only changing the Signs of + and —; for the Diſtance of the Point of Concourſe of Converging Beams from the Point B, or the firſt Surface of the Lens, I call a Negative Radius, or $-r$ if it be the firſt Surface, and $-\rho$, if it be the ſecond Surface. Let then converging Beams fall on a double Convex of Glaſs, and the *Theorem* will ſtand thus $\frac{-2dr\rho}{-dr - d\rho - 2r\rho} = +f$, which ſhews, that in this Caſe the Focus is always Affirmative.

If the Lens were a *Meniſcus* of Glaſs, expoſed to diverging Beams, the Rule is $\frac{-2dr\rho}{-dr + d\rho + 2r\rho} = f$: Which is Affirmative, when $2r\rho$ is leſs than $dr - d\rho$, otherwiſe Negative: But in the Caſe of converging Beams falling on the ſame *Meniſcus*, 'twill be $\frac{+2dr\rho}{+dr - d\rho + 2r\rho} = f$. And it will be $+f$, whilſt $d\rho - dr$ is leſs than $2r\rho$; but if it be greater than $2r\rho$, it will always be found Negative or $-f$. If the Lens be double Concave, the Focus of converging Beams is Negative, where it was Affirmative in the Caſe of diverging Beams on a double Convex, *viz.* $\frac{-2dr\rho}{+da + dr - 2r\rho} = f$: which is Affirmative only when $2r\rho$ exceeds $dr + d\rho$: But diverging

Beams

Beams paſſing a double Concave, have always a Negative Focus, *viz.* $\frac{2dr\varrho}{+dr+d\varrho+2r\varrho}=-f$.

The *Theorems* for converging Beams are principally of uſe to determine the Focus reſulting from any ſort of Lens placed in a Teleſcope, between the Focus of the Object-Glaſs and the Glaſs itſelf; the Diſtance between the ſaid Focus of the Object-Glaſs and the interpoſed Lens being made $=-d$.

In caſe the Beams are parallel, as coming from an infinite Diſtance (which is ſuppoſed in the caſe of Teleſcopes) then will d be ſuppoſed infinite, and in the Theorem $\frac{pdr\varrho}{dr+d\varrho-pr\varrho}$ — the Term $pr\varrho$ vaniſhes, as being finite, which is no Part of the other infinite Terms; and dividing the Remainder by the infinite Part d, the *Theorem* will ſtand thus $\frac{p\varrho r}{r+\varrho}=f$, or in Glaſs $\frac{2r\varrho}{r+\varrho}=f$.

In caſe the Lens were plano-convex expoſed to diverging Beams, inſtead of $\frac{pdr\varrho}{dr+d\varrho-pr\varrho}$, r being infinite, it will be $\frac{pd\varrho}{d-p\varrho}=f$, or $\frac{2dr}{d-2\varrho}=f$, if the Lens be Glaſs.

If the Lens be double-convex, and r be equal to ϱ, as being formed of Segments of equal Spheres, then will $\frac{pd\varrho r}{dr+d\varrho-pr\varrho}$ be reduced to $\frac{pdr}{2d-pr}=f$; and in caſe d be infinite, then it will be yet farther contracted to $\frac{1}{2}pr$, and p being $=\frac{n}{m-n}$, the Focal Diſtance in Glaſs will be $=r$, in Water $1\frac{1}{2}r$, but in Diameter $\frac{4}{3}r$.

This is not only uſeful to diſcover the Focus from the other propoſed Data; but from the Focus given, we may thereby determine the Diſtance of the Object, or from the Focus and Diſtance given we may find of what Sphere it is requiſite to take another Segment, to make any given Segments of another Sphere caſt the Beams from the Diſtance d to the Focus f: As likewiſe from the Lens, Focus, and Diſtance given, to find the Ratio of Refraction, or of m to n, requiſite to anſwer theſe Data. All which, it is obvious, are fully determined from the Equation we have hitherto uſed, viz. $pd\varrho r=drf+d\varrho f-+pr\varrho f$. For to find d, the *Theorem* is $\frac{pr\varrho f}{rf+\varrho f-p\varrho r}=d$, the Diſtance of the Object; for ϱ, the Rule is $\frac{drf}{pdr+df+prf}=\varrho$; but for p, it will be $\frac{drf+d\varrho f}{d\varrho r+f\varrho r}=p$; which latter determines the Ratio of Refraction, m being to n as $1+p$ to p.

I ſhall not expatiate on theſe Particulars, but leave them for the Exerciſe of thoſe that are deſirous to be informed in Optical Matters, which I am bold to ſay are comprehended in theſe three Rules, as fully as the moſt Inquiſitive can deſire them, and in all poſſible Caſes, Regard being had to the Signs $+$ and $-$, as in the former Caſes of finding the Focus. I ſhall only ſhew two conſiderable Uſes of them; the one to find the Diſtance whereat an Object being placed, ſhall by a given Lens be repreſented in a Species as large as the Object itſelf, which may be of ſingular Uſe in drawing Faces, and other Things in their true Magnitude, by tranſmitting the Species by a Glaſs into a dark Room, which will not only give the true Figure and Shades, but even the Colours themſelves, almoſt as vivid as the Life. In this Caſe d is equal to f; and ſubſtituting d for f in the Equation, we ſhall have $p\,d\,r\,\varrho = d\,d\,r + d\,d\,\varrho - d\,p\,\varrho\,r$; and dividing all by d, $p\,r\,\varrho = d\,r + d\,\varrho - p\,r\,\varrho$, that is, $\frac{2\,p\,r\,\varrho}{r+\varrho} = d$; but if the two Convexities be of the ſame Sphere, ſo as $r = \varrho$, then will the Diſtance be $= p\,r$, that is, if the Lens be Glaſs $= 2\,r$; ſo that if an Object be placed at the Diameter of a Sphere diſtant, in this Caſe the Focus will be as far within as the Object is without, and the Species repreſented thereby will be as big as the Life; but if it were a Plano-Convex, the ſame Diſtance will be $= 2\,p\,r$, or, in Glaſs, to four Times the Radius of the Convexity.

A ſecond Uſe is to find what Convexity or Concavity is required to make a vaſtly diſtant Object be repreſented at a given Focus, after the one Surface of the Lens is formed; which is but a *Corollary* to our *Theorem* for finding ϱ, having p, d, r, and f, given; for d being infinite, the Rule becomes $\frac{r\,f}{p\,r - f} = \rho$, that is, in Glaſs, $\frac{rf}{2\,r - f} = \rho$; whence, if f be greater than $2\,r$, ρ becomes Negative, and $\frac{rf}{f - 2\,r}$ is the Radius for the Concave ſought.

But to return to their firſt *Theorem*, which, accounting for the Thickneſs of the Lens, we will here again reſume, *viz.*

$$\frac{m\,p\,d\,r\,\rho - n\,d\,\varrho\,t - n\,p\,r\,\varrho\,t}{m\,d\,r + m\,d\,\varrho - m\,p\,\rho\,r - m - n\,d\,t - n\,r\,t} = f.$$

And let it be required to find the Focus, where a whole Sphere will collect the Beams proceeding from an Object at the Diſtance d. Here t is equal to $2\,r$, and $r = \varrho$; and after due Reduction, the *Theorem* will ſtand thus, $\frac{m\,p\,d\,r - 2\,n\,d\,r + 2\,n\,p\,r\,r}{2\,n\,d + 2\,n\,r - m\,p\,r} = f$: But if d be infinite, it is contracted to $\frac{m\,p\,r}{2\,n} - r = \frac{2\,n - m}{2\,m - 2\,n}\,r = f$; wherefore a Sphere of Glaſs collects the Sun's Beams at half the Semidiameter of the Sphere without it, and a Sphere of of Water at a whole Semidiameter. But if the Ratio of Refraction m to n be as 2 to 1, the Focus fails on the oppofite Surface of the Sphere; but if it be of greater Inequality, it falls within.

Another Example fhall be, when a Hemifphere is expofed to parallel Rays, that is, d and ρ being infinite, and $t = r$, and, after due Reduction, the *Theorem* refults $\frac{nn}{mm - mn} r = f$; that is, in Glafs it is at $\frac{4}{3} r$, in Water at $\frac{9}{4} r$; but if the Hemifphere were Diamond, it would collect the Beams at $\frac{4}{15}$ of the Radius beyond the Center.

Laftly, As to the Effect of turning the two Sides of a Lens towards an Object; it is evident, that if the Thicknefs of the Lens be very fmall, fo as that you neglect it, or account $t = 0$, then in all Cafes the Focus of the fame Lens, to whatfoever Beams, will be the fame, without any Difference upon the turning the Lens: But if you are fo curious to confider the Thicknefs, (which is feldom worth accounting for) in the cafe of parallel Rays falling on a Plano-Convex of Glafs, if the plane-fide be towards the Object, t does occafion no Difference, but the Focal Diftance $f = 2r$. But when the Convex Side is towards the Object, it is contracted to $2r - \frac{2}{3} t$; fo that the Focus is nearer by $\frac{2}{3} t$. If the Lens be Double Convex, the Difference is lefs; if a *Menifcus*, greater. If the Convexity on both Sides be equal, the Focal Length is about $\frac{1}{6} t$ fhorter than when $t = \bullet$. In a *Menifcus*, the Concave Side towards the Object increafes the Focal Length, but the Convex towards the Object diminifhes it. A general Rule for the Difference arifing on turning the Lens, where the Focus is Affirmative, is this $\frac{2at - 2\rho t}{3r - 3 - t}$ for double Convexes of different Spheres. But for *Menifci* the fame Difference becomes $\frac{2rt + 2\rho t}{3r - 3\rho + t}$; of which I need give no other Demonftration, but that by a due Reduction it will follow from what is premifed, as will the *Theorems* for all forts of Problems relating to the Foci of Optick Glaffes.

The Generation of an Hyperbolical Cylindroid; by Sir Christ. Wren. N. 48. p. 961. Jan. An. 1669. Fig. 97.

XI. 1. Let D B and E C be oppofite Hyperbola's, whofe tranfverfe Axis is B C, Center A, and one of the Afymptotes G P; alfo let O M be drawn through the Center at Right Angles to B C. Wherefore if the Hyperbola's are converted about the Axis O M, it is plain, by fuch a Revolution an Hyperbolical Cylindroidal Body will be generated, whofe Bafes and Sections parallel to the Bafe will be Circles. I fay moreover, if the fame Body be cut through the Afymptote G P, the Section will be a Parallelogram.

Let it be cut through the tranfverfe Axis by a Circular Section B N C, alfo through O and M into equal Circles equally diftant from the Center; alfo through the Axis into a generating Figure, whofe half is B D E C, in the

 Plain

Plain of which will be the Aſymptote G P, through which at Right Angles let the Plain B D E be cut in the Plain F H P; laſtly let H O be joined.

Becauſe of the Right-angled Triangle O G H, the Square of O H or O D, ſubtracting the Square of O G, is equal to the Square of G H. And becauſe D O is parallel to B A, and cuts the Aſymptote in G, it will be (by the Properties of the Hyperbola demonſtrated in the Conics) the Square of O G together with the Square of B A, equal to the Square of O D. That is, the Square of O D leſſened by the Square of O G is equal to the Square of A B, or the Square of A N. Therefore the Square of G H is equal to the Square of A N, and thence G H is equal to A N, and they are at Right Angles to G A: And the like may be demonſtrated of all other Sections parallel to the Baſe. Wherefore the Hyperbolic Cylindroid is truly cut through the Aſymptote into a Parallelogram. *Q. E. D.*

Coroll. Hence it appears that in the Superficies of the Cylindroid, though it conſiſts of a double Flexure, innumerable Right Lines may nevertheleſs be drawn. It appears alſo, that there is another Way of generating this Body, that is, by the Revolution of a Parallelogram about the Axis at reſt, in an Angle to the Axis equal to G A O; or laſtly, the generating Line H R remaining immoveable, and forming or cutting the Maſs as it turns about.

And if the very ſharp and ſtreight Edge of the Chiſſel be diſpoſed in reſpect of the Axis after the manner of the generating Line, while the Mandrel turns about; it is plain, that by the Lathe as true Hyperbolas as Circles may be deſcribed, ſince nothing more is required for forming a Cylindroid than a Cylinder; unleſs that in the Cylinder the Edge of the Chiſſel muſt be parallel to the Axis, whereas it muſt be inclined to it to form a Cylindroid.

Therefore we muſt obſerve, that the Species of the Hyperbola will be varied, according to the different Inclination or Magnitude of the Angle G A O; ſo that it is more eaſily accommodated to a given Hyperbola, than to need any Demonſtration. But if the ſame Angle remaining, the generating Line approaches nearer to the Center, thence will ariſe a leſſer Hyperbola, but of the ſame Species as before.

The Application thereof to the Grinding of Hyperbolical Optick Glaſſes; by Sir Chriſt. Wren. N. 53. p. 1059. Nov. An. 1669. *Fig.* 98.

2. Let there be three Bodies fit for Grinding, P, Q, R; of which let P and Q be equal, and formed in the Shape of a Pillar, but let the Body R be in the Shape of a Lens. Let P have a Rotation about the Axis A B, Q about C D, and R about E G. But let A B and C D be in different Plains, yet ſo that E G produced may be at Right Angles to both A B and C D. Laſtly, let the Bodies approach to one another, as much as neceſſary, yet ſo as that the ſame Inclination of the Axes may be ſtill preſerved.

I ſay, that by the Revolution and mutual Attrition of the Bodies before ſuppoſed, new Geometrical Bodies will ariſe, of which P and Q will be equal Hyperbolical Cylindroids, and R an Hyperbolical Conoid, of a given Species and Magnitude.

We have the Demonſtration at hand, as alſo a Model of the Machine itſelf, which is intended for the grinding of Hyperbolical Lenſes. To deſcribe which by the laborious Apparatus of a Picture, and a tedious Explication,

tion, would be more troublesome to me and the Engraver, than it would be to any ingenious Man to find the like. For after the Geometrical Principles are now explained, it is easy to guess what sort of an Instrument it is. The Parts are three oblong Boards, plain, strong, moveable, and placed upon one another. The lowest and middlemost support the unequal Puppets (or Handles that sustain the Mandrel) placed alternately. This is required by the Obliquity and as it were Decussation of each of the Mandrels. The Puppets of the uppermost Board are equal, and disposed according to the Length of the Board; and the Mandrel is let through the nearest Puppet, being perforated for that End. I shall not mention the Wheels, Rollers, Thongs, Weights, Skrews, and other Things necessary for the expeditious Motion and Strength of the Machine. P belongs to the lowest Board, Q to the middlemost, R to the uppermost. R is a Lens of Glass; Q is the Model grinding the Lens; P is the Pattern that corrects the Model; which as it is carried by an oblique Motion, and different from the Motion both of the Lens and the Model, continually grinds and wears away whatever Imperfection is communicated to the Model by the Attrition of the Lens and the Matter.

Wherefore since the Generation of the Hyperbolical Conoid is so simple and natural, being produced only by Circular Motions; and since the Motion is double and various; it is probable that Hyperbolical Lenses may be formed upon these Principles, if upon any at all.

Why four Convex Glasses in a Telescope shew Objects Erect; by Mr. William Molineux. N. 183. *p.* 169. Jul. An. 1686.

XII. This Phænomenon appears very easily explicable, from the Consideration of placing Glasses in a Tube; which is thus: After the Object-Glass, the first Eye-Glass is placed so much distant (towards the Eye) from the Focus of the Object-Glass, as is the Focus of the Eye-Glass; then the middle Eye-Glass is placed so much distant from the Focus of the first Eye-Glass, as is the Focus of the middle Eye-Glass: Lastly, the nearest Eye-Glass is placed so much distant from the Focus of the middle Eye-Glass, as is the Focus of this nearest Eye-Glass; and the Eye looking through them all, is placed in the Focus of the nearest Eye-Glass.

I say therefore, 1. That one single Convex-Glass cannot properly be said by itself to shew Objects Erect or Reverse, but in respect of the placing of the Eye that looks through it: For if the Eye, that looks through a single Convex-Glass, be placed nigher thereto than the Glass's Focus, the Objects are Erect; if the Eye be placed just in the Focus, the Objects are neither Erect nor Reversed, but all in Confusion between both; and if the Eye be placed further from the Glass than the Focus, the Objects are Reversed. I mean here distant Objects, the Rays flowing from any Point whereof may be counted to come Parallel towards the Object-Glass.

2. The Object-Glass of a Telescope reverses the Object, both to the Eye-Glass and the Eye that looks through it: For the Eye-Glass is placed farther from the Object-Glass than is the Focus of the Object-Glass: But the Eye-Glass does nothing towards the Rectification, or Reversion; the Eye being placed just in its Focus.

2. The

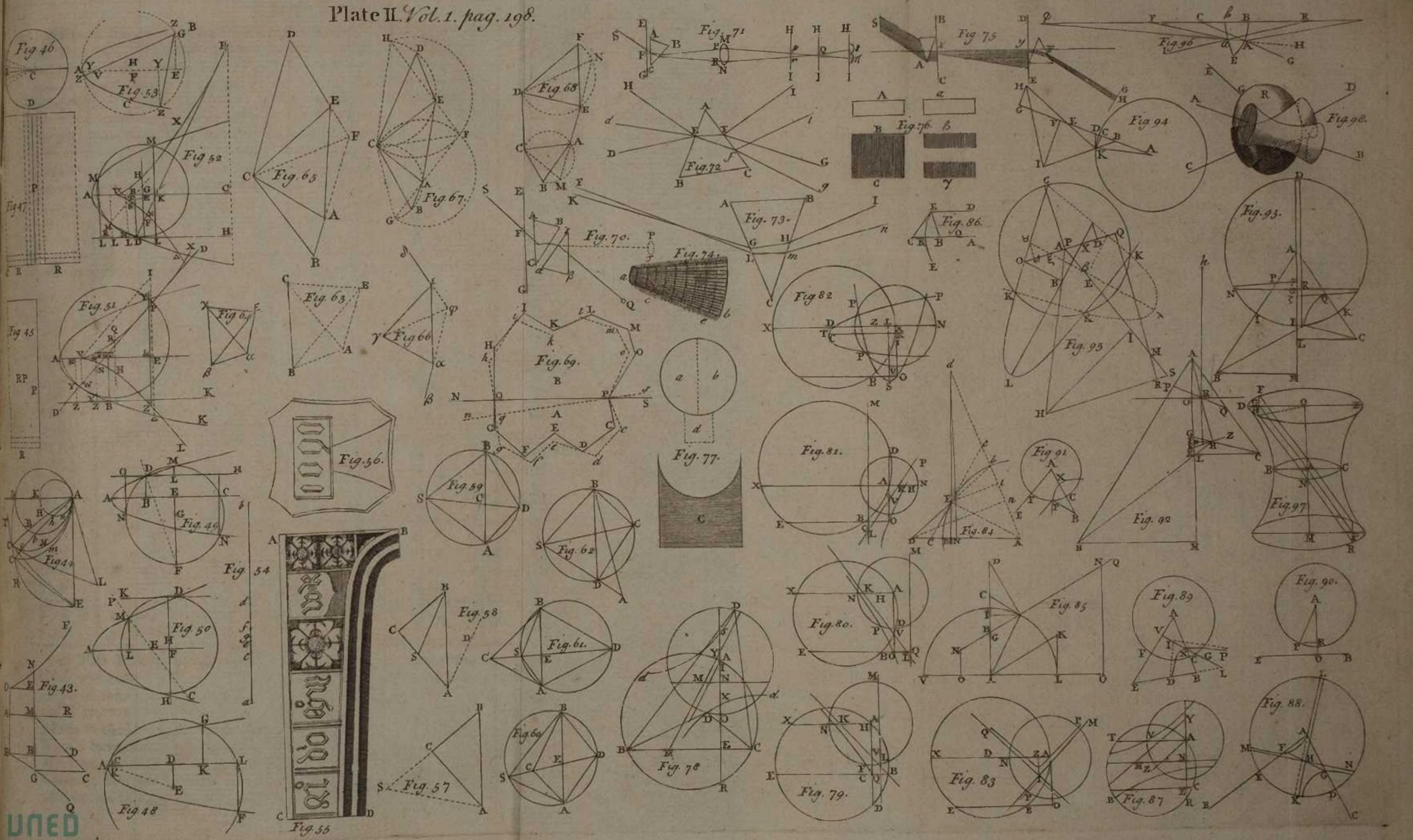
3. If the ſecond Eye-Glaſs (the firſt being that next the Object-Glaſs) be placed, as it ought, in a Teleſcope, place the Eye nearer in this middle Eye-Glaſs than its Focus, and it ſees the Object inverted and confuſed: Place the Eye in the Focus, and it ſees the Object all in Confuſion, neither Erect nor Reverſed; for here again there is a diſtinct Repreſentation of the Objects to be received on a Piece of Paper, as in the Focus of an Object-Glaſs; and the Eye being placed at any Time at this Place (which is uſually call'd the Diſtinct Baſe) ſees all in Confuſion: But then let the Eye be placed farther from this middle Glaſs than its Focus, and it perceives the Objects erect and confuſed.

Laſtly, The third, or immediate Eye-Glaſs, does nothing towards the E-recting or Reverſing the Species, which it receives Erect from the middle Eye-Glaſs; no more than in a Teleſcope of two Convex-Glaſſes, the Eye-Glaſs does to the Species it receives from the Object-Glaſs; as we have ſhewn before. The Reaſon that this laſt or immediate Eye-Glaſs has nothing to do in the Erecting or Reverſing the Species, is the ſame as in the Teleſcope of two Convex-Glaſſes, *viz.* The Eye placed in its Focus, and therefore ſees the Species as 'tis repreſented in the Diſtinct Baſe; that is, the Species is inverted in the Diſtinct Baſe of the Object-Glaſs, and therefore a ſingle Convex Eye-Glaſs brings it to the Eye Inverted; but in the Diſtinct Baſe of the middle or ſecond Eye-Glaſs the Species is Erect, and therefore the third or immediate Eye-Glaſs brings it to the Eye Erect.

Wherefore we are to conſider the Teleſcope conſiſting of an Object-Glaſs and three Eye-Glaſſes, as two Teleſcopes, each conſiſting of two Convex Glaſſes. The firſt conſiſts of the Object-Glaſs and firſt Eye-Glaſs, and this inverts the Species; that is, the Species is inverted in the Diſtinct Baſe of the Object-Glaſs, and ſo brought into the Eye. The ſecond Teleſcope conſiſts of two immediate Eye-Glaſſes, and this Erects what the former Inverted; that is, the Species in the Diſtinct Baſe of the middle Eye-Glaſs is Erect, and is ſo brought into the Eye by the Eye-Glaſs; the Eye-Glaſſes themſelves in neither Caſe having any thing to do with the Erecting or Inverting, but merely in repreſenting in the ſame Poſture the Species immediately before them. So that one Convex-Glaſs, as poſited in a Teleſcope, Inverts; the ſecond (that is, the firſt Eye-Glaſs) does nothing towards the Erecting or Reverſing, but repreſents the Image as it is in the Diſtinct Baſe of the Object-Glaſs before it, that is Inverted; the third Glaſs Erects, or rather Reſtores, what was before Inverted; the fourth repreſents the Image as it receives it from the Diſtinct Baſe of the third, that is, Erect.

XIII.

Plate II. Vol. 1. pag. 198.



XIII. 1. Mr. *Auzout* has found that the Apertures, which Optic-Glasses can bear with Distinctness, are in about a subduplicate Proportion to their Lengths: And, accordingly, he hath made the following *Table*. *The Apertures of Telescopes; by M.* Auzout. N. 4. p. 55. Jun. An. 1665.

Lengths of Glasses. Feet.	In.	*Apertures for* Excellent In.	Lin.	Good In.	Lin.	Ordinary In.	Lin.
	4		4		4		3
	6		5		5		4
	9		7		6		5
1	0		8		7		6
1	6		9		8		7
2	0		11		10		8
2	6	1	0		11		9
3	0	1	1	1	0		10
3	6	1	2	1	1		11
4	0	1	4	1	2	1	0
4	6	1	5	1	3	1	1
5	0	1	6	1	4	1	1
6		1	7	1	5	1	2
7		1	9	1	6	1	3
8		1	10	1	8	1	4
9		1	11	1	9	1	5
10		2	1	1	10	1	6
12		2	4	2	0	1	8
14		2	6	2	2	1	9
16		2	8	2	4	1	11
18		2	10	2	6	2	1
20		3	0	2	7	2	2

Lengths of Glasses. Feet.	In.	*Apertures for* Excellent In.	Lin.	Good In.	Lin.	Ordinary In.	Lin.
25		3	4	2	10	2	4
30		3	8	3	2	2	7
35		4	0	3	4	2	10
40		4	3	3	7	3	1
45		4	6	3	10	3	2
50		4	9	4	0	3	4
55		5	0	4	3	3	6
60		5	2	4	6	3	8
65		5	4	4	8	3	20
70		5	7	4	10	4	0
75		5	9	5	0	4	2
80		5	11	5	2	4	5
90		6	4	5	6	4	7
100		6	8	5	9	4	10
120		7	5	6	5	5	3
150		8	0	7	0	5	11
200		9	6	8	0	6	9
250		10	6	9	2	7	8
300		11	6	10	0	8	5
350		12	6	10	9	9	0
400		13	4	11	5	9	8

2. This Theory of Apertures seems to me not very clear: For the same Glass will endure greater or lesser Apertures, according to the lesser or greater Light of the Object; if it be for looking on the Sun and *Venus*, or for seeing the Diameters of the fixed Stars, then smaller Apertures do better; if for the Moon in the Day-light, or on *Saturn*, or *Jupiter*, or *Mars*, then the largest. Thus I have often made use of a 12 Foot Glass to look on *Saturn* with an Aperture of almost 3 Inches, and with a single Eye-Glass of 2 Inches double Convex; but when, with the same Glass, I looked on the *Sun* or *Venus*, I used both a smaller Aperture, and shallower Charge. *Considered by* Dr. Hook. *ibid. p.* 67.

XIV.

To measure Distances at one Station; by M. Auzout. N. 7. p. 125. Dec. An. 1665.

XIV. I have found long since a Way to measure, with a great Telescope, the Distance of Objects upon the Earth from one Station. The Practice indeed does not altogether answer the Theory, because that the Length of the Telescopes admits of some Latitude; yet one comes near enough, and perhaps as just as by most of the Ways ordinarily used with Instruments. That which I am proposing, I doubt not but Mr. *Hook* will soon understand, and see the Determination of all Cases possible. I shall only say, That if we look upon the sole Theory, we may make use of an ordinary Telescope, whereof the Eye-Glass is to be Convex: For by putting the Glasses at a little greater Distance than they are, proportionably to the Distance for which it is to serve, and, by adding to it a new Eye-Glass, the Object will be seen distinct, tho' obscure; and if the Eye-Glass be Convex, the Object will appear Erect. They may be done two manner of Ways; either by leaving the Telescope in its ordinary Situation, the Object-Glass before the Eye-Glass; or by inverting it, and putting this before that. But if any will make use of two Object-Glasses, whereof the Focus's are known, the Distances of them will be known. If it be supposed, that the Focus of the first be B, and that of the second C, and the Distance given, $B + 2D$, and that $D - C$ be equal to F; for this Distance will be equal to $B + C + F - r F^2 C^2$. And if you have the Focus of the first Object-Glass equal to B, the Distance where you will put the second Glass, equal to $B + C + D$, the Focus of the second Glass will be found equal to $\frac{CD}{C + D}$. And if you will that the Object shall be magnified as much with these two Glasses as it would be with a single one, whereof the Focus should be of the Distance given, having the Focus of the Object-Glass given equal to B, and the Distance given to $B + D$; the Distance between the first and second Glass will be equal to $\frac{2B^2 + 2BD}{2B + D}$; whence, subducting B (the Focus of the Object given) there remains $\frac{BD}{2B + D}$: And if this Sum be composed equal to C, we shall easily know by the precedent Rule, the Focus of the second Glass.

To make a Plano-convex Glass of a small Sphere, collect the Rays at a great Distance; by Dr. Hook. N. 4. p. 66. N. 12. p. 192. June, An. 1665. May, An. 1666.

XV. Prepare two Glasses, the one exactly flat on both Sides, the other flat on the one Side, and convex on the other, of what Sphere you please. Let the flat Glass be a little broader than the other. Then let there be made a Cell or Ring of Brass, very exactly turned, into which these two Glasses may be so fastened with Cement, that the plain Surfaces of them may lie exactly parallel, and that the Convex Side of the Plano-convex Glass may lie inward; but so, as not to touch the Flat of the other Glass. These being cemented into the Ring very closely about the Edges, by a small Hole in the Side of the Brass Ring or Cell; fill the interposed Space between these two with Water, Oil of Turpentine, Spirit of Wine, Saline Liquors, *&c.* then stop the Hole with a Screw: And according to the differing Refraction of the interposed Liquors, so shall the Focus of this Compound Glass be longer or shorter.

But this I would have only look'd upon as one Inſtance of many (for there may be others) of the Poſſibility of making a Glaſs, ground in a ſmaller Sphere, to conſtitute a Teleſcope of a much greater Length: Though (not to raiſe too great Expectation) I muſt add, That, of Spherical Object-Glaſſes, thoſe are the beſt which are made of the greateſt Sphere, and whoſe Subſtance hath the greateſt Refraction.

XVI. 1. *S. Campani* pretends to have found a Way to work great *Optic-Glaſſes* with a Turn-tool, without any Mould: And that he uſeth three Eye-Glaſſes for his great Teleſcopes, without finding any Rainbow Colours. *Teleſcopes and other Optic-Glaſſes; by* Campani *and* Divini. N. 1. *p.* 2. Mar. An. 1665. N. 8. *p.* 131. Jan. An. 1666.

The Great Duke of *Tuſcany*, and Prince *Leopold* his Brother, upon Trial made of the Glaſſes of *Campani* and *Divini*, have found that thoſe of *Campani* excel the other; and with them they have been eaſily able to diſtinguiſh People at 4 Leagues Diſtance.

But *Euſtachio Divini* pretends, that in all the Trials made with them, his great Glaſſes have performed better than thoſe of *Campani*; and that *Campani* was not willing to do what was neceſſary for well comparing one with the other, *viz.* to put equal Eye-Glaſſes in them, or to exchange the ſame Glaſſes. N. 12. *p.* 209.

2. 'Tis now above ten Years ſince I invented a peculiar Way of grinding Optic-Glaſſes, and reduced it alſo into Practice; by which 'tis eaſy, without any conſiderable Danger of failing, to make and poliſh Optic-Glaſſes of any *Conic Section*, and that (which is moſt notable) in any Diſh of any Section of a Sphere. I have already made ſeveral Glaſſes by it, which many learned Men have ſeen and tried. *By M.* Hevelius. N. 6. *p.* 98. Nov. An. 1665.

Mr. *Huygens* alſo intends very ſhortly to try ſomething in that kind. *By M.* Huygens. *Ibid.*

3. M. *du Sons* doth at preſent employ himſelf in *London*, to bring Teleſcopes to Perfection, by grinding Glaſſes of a *Parabolical* Figure. I have ſeen two Eye-Glaſſes of that Shape, about one Inch and a half deep, and one Inch and a quarter broad, wrought by this *eminent Artiſt* with a rare Steel Inſtrument of his own Contrivance and Workmanſhip, and by himſelf alſo poliſh'd to Admiration. And certainly it will be wondered at by thoſe, who ſhall ſee theſe Glaſſes, how they could be truly wrought to ſuch a Figure, with ſuch a Cavity; and yet more, when they ſhall hear the Author undertake to excavate other ſuch Eye-Glaſſes to above 2 Inches, and Object-Glaſſes of 5 Inches Diameter. He hath likewiſe already begun his Object-Glaſſes for the mentioned two ocular ones, of the ſame Figure of about 2 Inches Diameter, which are to be left all open, yet without cauſing any Colours. *By M.* du Sons. *Ibid p.* 99. N. 7. *p.* 119. Dec. An. 1665.

4. The Optic-Glaſſes of M. *Burattini* in *Poland*, are perfectly well wrought and poliſh'd. He hath ſent two to *Paris*, but they are only the one of 10, the other of 8 Foot. They bear a great Aperture in reſpect of their Length. *By M.* Burattini. N. 19. *p.* 348. N. 21. *p.* 374.

5. Mr. *Fr. Smethwick* having found a Way of grinding Glaſſes *not Spherical*, produced before the Royal Society (*Feb.* 27. 166$\frac{7}{8}$.) certain *Specimina* of that Invention; which were, a Teleſcope, a Reading, and two Burning-Glaſſes. *By Mr.* Francis Smethwick. N. 33. *p.* 631.

The Teleſcope was about 4 Foot long, furniſhed with four Glaſſes, whereof the three ocular ones, Plano-convex, were of this newly invented *not-Spherical* Figure, and the fourth a Spherical Object-Glaſs. This being compared with a common, yet very good Teleſcope, longer than it by about 4 Inches, and turn'd to ſeveral Objects, was found by thoſe of the ſaid Society that look'd through them both, to exceed the other in Goodneſs, by taking in a greater Angle, and repreſenting the Objects more exactly in their reſpective Proportions, and enduring a greater Aperture free from Colours.

The Reading-Glaſs of the ſame Figure being compared with a common Spherical Glaſs did far excel it, by magnifying the Letters to which it was applied up to the very Edges, and by ſhewing them diſtinctly from one Brim through the Center to the other; which the Spherical Glaſs came far ſhort of.

Laſtly, The two burning Concaves of this new-invented Figure, were the one of 6 Inches Diameter, its Focus 3 Inches diſtant from the Center thereof; the other of the ſame Diameter, but leſs Concave, and its Focus 10 Inches diſtant. Theſe, when approached to a large Candle lighted, did ſomewhat warm the Faces of thoſe that were 4 or 5 Foot diſtant at leaſt; and when held to the Fire, burned Gloves and Garments at the Diſtance of about 3 Foot from the Fire.

The Biſhop of *Salisbury*, Dr. *Seth Ward*, was by at another Time, when the deeper of the two Concaves turned a Piece of Wood into Flame in the Space of 10 Sec. of Time, and the ſhallower in 5 Sec. at moſt, in the Seaſon of *Autumn*, about Nine of the Clock in the Morning, the Weather gloomy. The Inventor adds, That the deeper Concave, when held to a lucid Body, would caſt a Light ſtrong enough to read by at a conſiderable Diſtance; and that expoſing the ſame to a Northern Window, on which the Sun ſhined not at all, or very little, he had perceived that it would warm one's Hand ſenſibly, by collecting the warmed Air in the Day-time, which it would not do after Sun-ſet.

By an Artiſt at Paris. N. 40. *p.* 795. Oct. An. 1668.

6. We have an Artiſt at *Paris* that poliſhes Optic-Glaſſes on a Turn. I have ſeen a Glaſs of his Workmanſhip, which is very good. He turns thoſe Glaſſes as he does Wood, that is, with the ſame Facility.

By M. Borelli. N. 128. *p.* 691. Aug. An. 1676.

7. M. *Borelli* hath found out a ſure and very eaſy Method to work all ſorts of great Glaſſes. He hath already made one of them very good of 200 Foot, wrought on both Sides on the ſame Rule. His Deſire of advancing Aſtronomical Diſcoveries hath induced him to make Preſents of them to ſeveral Perſons capable to make uſe of them. He hath entruſted the Secret to one of the *Royal Academy* of *Sciences*.

N. 140. *p.* 1005. July, An. 1678.

Campani and *Divini* have commonly ſold their Glaſſes at a Piſtole the Foot. Sometimes they have far exceeded that Price. One of *Divini*'s, of 12 Foot, was ſold for 400 Livres; and another of *Campani*'s, of 34 Foot, for 2000 Livres. Notwithſtanding which, *S. Borelli* is willing to part with the beſt of his own Glaſſes, of 50, 60, or 65 Foot, for 500 *(French)* Crowns; and the ſmall Glaſſes, from 6 to 12 Foot, at a *(French)* Crown a Foot; from 12 to 18, at half a Piſtole; and from 18 to 26, at a Piſtole.

8. Though it be commonly believed, that *Rock Cryſtal* is not fit for Optic-Glaſſes, becauſe there are many Veins in it; yet *Euſtachio Divini* made one of it, which he ſaid proved an excellent one, though full of Veins: But perhaps they were only ſuperficial Strictures and ſlight Scratches, not Veins. *Optic Lens of Rock Cryſtal*; by Euſt. Divini. N. 23. p. 362. Dec. An. 1666.

9. Drops of fair Water being let fall on a Piece of plain Glaſs, form themſelves into Plano-convexes, having a Convexity proportionable to the Heights from which they deſcend; from a greater Height a leſs, from a leſs a greater Degree of Convexity. I applied ſome of theſe as Reading-Glaſſes for ſingle Words of ſmall Letters, as on the Globes and Maps, and found no other Inconveniency, than that the Fluidity of the Water obliges one to keep the Glaſs Horizontal, which I after deviſed a Way to remedy. I took a ſufficient Quantity of Iſing-Glaſs, and diſſolved it in Water over the Fire, and whilſt it was warm I dipt a Stick into the Solution, and let ſome Drops of it fall on the Glaſs as before; and in a quarter of an Hour they acquire a Conſiſtency, that permits them to be held in any Poſition; and though they are not altogether ſo tranſparent, yet this is little or no Impediment to their Uſe. The Drops of this Solution are more exactly defined than thoſe of common Water, having their Edges exactly circular; and one may make them of a much longer Focus than thoſe. *Of Water*; by *Mr.* Stephen Gray. N. 228. p. 539. May, An. 1697.

A thin flat Ring of Braſs, not exceeding 4 Tenths of an Inch Diameter in its interior Circle, being cemented to a plain Piece of Glaſs, and filled with Water, or the Solution now mentioned; then by preſſing the Finger into it, 'till what is ſuperfluous be taken off, there will be formed a Plano-concave, which may ſerve as an Eye-Glaſs to a Perſpective, or to any other optical Uſe Concave Glaſſes are applicable to.

I have tried what would be the Succeſs of combining Portions of Water by the help of Braſs Rings, and plain Pieces of Glaſs, to give them their true Figure and requiſite Apertures, and inſerted them at the Ends of Tubes of ſeveral Lengths; and find, that though theſe *Natural Lentes* may ſerve as Eye-Glaſſes, yet when uſed as Object ones, either to Teleſcopes, or double Microſcopes, the Effects will not compenſate the Trouble there is in uſing them.

XVII. 1. When I had found, that *Light conſiſts of Rays differently refrangible*, I left off my Glaſs-works; for I ſaw, that the Perfection of Teleſcopes was hitherto limited, not ſo much for want of Glaſſes truly figured according to the Preſcriptions of Optic Authors, (which all Men have hitherto imagined) as becauſe that *Light* itſelf is an heterogeneous Mixture of *differently Refrangible Rays*: So that were a Glaſs ſo exactly figured as to collect any one ſort of Rays into one Point, it could not collect thoſe alſo into the ſame Point, which having the ſame Incidence upon the ſame Medium, are apt to ſuffer a different Refraction. Nay, I wondered, that ſeeing the Difference of Refrangibility was ſo great as I found it, Teleſcopes ſhould arrive to that Perfection they are now at: For, meaſuring the Refractions in one of my Priſms, I found, that ſuppoſing the common Sine of Incidence upon one *The Advantages of Reflection to Optic Inſtruments*; by *Mr.* Newton. N. 80. p. 3079. Feb. An. 1672.

 of

of its Planes was 44 Parts, the Sine of Refraction of the utmoſt Rays on the red End of the Colours, made out of the Glaſs into the Air, would be 68 Parts, and the Sine of Refraction of the utmoſt Rays on the other End 69 Parts; ſo that the Difference is about a 24th or 25th Part of the whole Refraction. And conſequently, the Object-Glaſs of any Teleſcope cannot collect all the Rays which come from one Point of an Object, ſo as to make them convene at its Focus in leſs room than in a circular Space, whoſe Diameter is the 50th Part of the Diameter of its Aperture; which is an Irregularity, ſome hundreds of times greater, than a circularly figured *Lens*, of ſo ſmall a Section as the Object-Glaſſes of long Teleſcopes are, would cauſe, by the Unfitneſs of its Figure, were Light uniform.

This made me take Reflections into Conſideration; and finding them regular, ſo that the Angle of Reflection of all ſort of Rays was equal to their Angle of Incidence, I underſtood that by their Mediation Optic Inſtruments might be brought to any Degree of Perfection imaginable, provided a reflecting Subſtance could be found, which would poliſh as finely as Glaſs, and reflect as much Light as Glaſs tranſmits, and the Art of communicating to it a parabolic Figure be alſo attained. But theſe ſeemed very great Difficulties, and I have almoſt thought them inſuperable, when I farther conſider'd that every Irregularity in a reflecting Superficies makes the Rays ſtray five or ſix times more out of their due Courſe, than the like Irregularities in a refracting one: So that a much greater Curioſity would be here requiſite, than in figuring Glaſſes for Refraction.

Amidſt theſe Thoughts I was forced from *Cambridge*, *Anno* 1666, by the intervening Plague, and it was more than two Years before I proceeded further. But then having thought on a tender way of poliſhing, proper for Metal, whereby, as I imagined, the Figure would be corrected to the laſt, I began to try what might be effected in this kind, and by degrees ſo far perfected an Inſtrument (in the eſſential Parts of it like that I ſent to *London*) by which I could diſcern *Jupiter*'s four Concomitants, and ſhewed them divers times to two others of my Acquaintance. I could alſo diſcern the Moon-like *Phaſe* of *Venus*, but not very diſtinctly, nor without ſome Niceneſs in diſpoſing the Inſtrument.

From that time I was interrupted till this laſt *Autumn*, when I made another. And as that was ſenſibly better than the firſt (eſpecially for Day-Objects) ſo I doubt not, but they will be ſtill brought to a much greater Perfection by their Endeavours, who, as you inform me, are taking Care about it at *London*.

A new Catadioptrical Teleſcope invented by Mr. Newton. N. 82. p. 4004. Mar. An. 1672. *Fig.* 99.

2. This new Inſtrument is compoſed of two Metalline Speculums, the one Concave (inſtead of an Object-Glaſs) the other Plain: and alſo of a ſmall Plano-convex Eye-Glaſs; as in the Figure, where A B is a Concave Speculum, of which the Radius or Semidiameter is $12\frac{2}{3}$ or 13 Inches.

C D, another Metalline Speculum, whoſe Surface is flat, and the Circumference oval.

G D, an Iron Wire, holding a Ring of Braſs, in which the Speculum C D is fixed.

F, a

F, a ſmall Eye-Glaſs, flat above, and convex below, of the 12th Part of an Inch Radius, if not leſs.

GGG, the fore Part of the Tube (which is open) faſtened to a Braſs Ring HI. to keep it immoveable.

PQKL, the hinder Part of the Tube, faſtened to another Braſs Ring PQ.

O, an Iron Hook faſtened to the Ring Ring PQ, and furniſhed with a Screw N, thereby to advance or draw back the hinder Part of the Tube, and ſo by that means to put the Specula in their due Diſtance.

MQGI, a crooked Iron ſuſtaining the Tube, and faſtened by the Nail R to the Ball and Socket S, whereby the Tube may be turned every Way.

The Center of the flat Speculum CD, muſt be placed in the ſame Point of the Tube's Axe, where falls the Perpendicular to this Axe, drawn to the ſame from the Center of the little Eye-Glaſs; which Point is here marked at T.

And to give the Reader ſome Satisfaction to underſtand in what Degree it repreſents Things diſtinct, and free from Colours, and to know the Aperture by which it admits Light, he may compare the Diſtances of the Focus E from the Vertexes of the little Eye-Glaſs and the Concave Speculum; that is, EF, $\frac{1}{6}$ of an Inch, and ETV, 6 $\frac{1}{3}$ Inches; and the Ratio will be found as 1 to 38; whereby it appears, that the Objects will magnified about 38 times; and be repreſented bigger by 2 $\frac{1}{2}$ times in Diameter, when ſeen thro' this, than thro' an ordinary Teleſcope of about two Foot long.

Thus far as to the Structure of this Teleſcope. Concerning the metalline Matter, fit for theſe Reflecting Speculums, the Inventor hath alſo conſidered the ſame, and gives this Caution, that whilſt Men ſeek for a white, hard, and durable metalline Compoſition, they reſolve not upon ſuch an one as is full of ſmall Pores, only diſcoverable by a Microſcope: For tho' ſuch an one may, to Appearance, take a good Poliſh, yet the Edges of thoſe ſmall Pores will wear away faſter in the poliſhing, than the other Parts of the Metal; and ſo, however the Metal ſeem polite, yet it ſhall not reflect with ſuch an accurate Regularity as it ought to do. Thus Tin-Glaſs mixt with ordinary Bell-Metal makes it more white, and apt to reflect a greater Quantity of Light; but withal, its Fumes raiſed in the Fuſion, like ſo many aërial Bubbles, fill the Metal full of the microſcopical Pores. But white Arſenick both blanches the Metal, and leaves it ſolid, without any ſuch Pores, eſpecially if the Fuſion hath not been too violent. What the Stellate-Regulus of *Mars* (which I have ſometimes uſed) or rather ſuch like Subſtance, will do, deſerves particular Examination.

To this he adds this further Intimation, that Putty, or other ſuch like Powder, with which it is poliſhed, by the ſharp Angles of its Particles, fretteth the Metal, if it be not very fine, and fills it full of ſuch ſmall Holes as he ſpeaketh of. Wherefore Care muſt be taken of that, before Judgment be given, whether the Metal be throughout the Body of it porous or not.

But not having tried, as he ſaith, many Proportions of the Arſenick and Metal, he does not affirm which is abſolutely beſt, but thinks there may conveniently

veniently be uſed any Quantity of Arſenick equalling in Weight between a ſixth and an eighth Part of the Copper; a greater Proportion making the Metal brittle.

The Way which he uſed was this: He firſt melted the Copper alone, then put in the Arſenick, which being melted, he ſtirred them a little together, bewaring, in the mean time, not to draw in Breath near the pernicious Fumes. After this he put in Tin; and again, ſo ſoon as that was melted (which was very ſuddenly) he ſtirred them well together, and immediately poured them off.

He ſaith, he knows not, whether by letting them ſtand longer on the Fire after the Tin was melted, a higher Degree of Fuſion would have made the Metal porous; but he thought that Way he proceeded to be the ſafeſt.

He adds, that in the Metal, which he ſent to *London*, there was no Arſenick, but a ſmall Proportion of Silver; as he remembers, one Shilling in three Ounces of Metal. But he thought withal, that the Silver did as much harm in making the Metal ſoft, and ſo leſs fit to be poliſhed, as good in rendering it white and luminous.

At another time he mixed Arſenick one Ounce, Copper ſix Ounces, and Tin two Ounces; and this an Acquaintance of his hath, as he intimates, poliſhed better than he did the other.

As to the Objection, that with this kind of Perſpectives, Objects are difficultly found; he anſwers, That that is the Inconvenience of all Tubes that magnify much; and that after a little Uſe, the Inconvenience will grow leſs, ſeeing that himſelf could readily enough find any Day Objects, by knowing which way they were poſited, from other Objects that he accidentally ſaw in it. But in the Night, to find Stars he acknowledges it to be more troubleſome; which yet may, in his Opinion, be eaſily remedied by two Sights affixed to the Iron Rod, by which the Tube is ſuſtained, or by an ordinary Perſpective-Glaſs faſtened to the ſame Frame with the Tube, and directed towards the ſame Object; as *Des Cartes* in his *Dioptrics* hath deſcribed, for remedying the ſame Inconvenience of his beſt Teleſcopes.

Approved by M. Hugens de Zulichem. *Ibid. p.* 4008.

3. I ſee by the Deſcription you have ſent me of Mr. *Newton's* admirable Teleſcope, that he hath well conſidered the Advantage which a Concave Speculum hath above Convex-Glaſſes in collecting the parallel Rays; which certainly, according to the Calculation I have made thereof, is very great. Hence it is, that he can give a far greater Aperture to that Speculum, than to an Object-Glaſs of the ſame Diſtance of the Focus; and conſequently, that he can much more magnify Objects this Way, than by an ordinary Teleſcope. Beſides, by it he avoids an Inconvenience, which is inſeparable from Convex Object-Glaſſes, which is the Obliquity of both their Surfaces, which vitiateth the Refraction of the Rays that paſs towards the Sides of the Glaſs, and does more hurt than Men are aware of. Again, by the mere Reflection of the metalline Speculum there are not ſo many Rays loſt as in Glaſſes, which reflect a conſiderable Quantity by each of their Surfaces, and beſides intercept many of them by the Obſcurity of their Matter.

Mean time the main Buſineſs will be, to find a Matter for this Speculum that will bear ſo good and even a Poliſh as Glaſſes, and a Way of giving this

Poliſh

Poliſh without vitiating the Spherical Figure. Hitherto I have found no Specula that had near ſo good a Poliſh as Glaſs: And if Mr. *Newton* hath not already found a way to make it better than ordinarily, I apprehend his Teleſcope will not ſo well diſtinguiſh Objects as thoſe with Glaſſes. But 'tis worth while to ſearch for a Remedy to this Inconveniency, and I deſpair not of finding one. I believe that Mr. *Newton* hath not been without conſidering the Advantage, which a Parabolical Speculum would have above a Spherical one in this Conſtruction; but that he deſpairs, as well as I do, of working other Surfaces than Spherical ones with due Exactneſs; tho' elſe it be more eaſy to make a Parabolical, than Elliptical or Hyperbolical ones, by reaſon of a certain Propriety of the Parabolic Conoid, which is, that all the Sections parallel to the Axis make the ſame Parabola.

But though Mr. *Newton* (with M. *Hugens*) deſpairs of performing that Work by Geometrical Rules, yet he doubts not but that the thing may in ſome meaſure be accompliſhed by mechanical Devices. *Ibid. p.* 4009.

4. In my laſt Letter I gave you occaſion to ſuſpect that the Inſtrument which I ſent you is in ſome reſpect or other indiſpoſed, or that the Metals are tarniſhed; and by yours I am fully confirmed in that Opinion: For, whilſt I had it, it repreſented the Moon in ſome Parts of it as diſtinctly as other Teleſcopes uſually do which magnify as much as that. Yet I very well know, that that Inſtrument hath its Imperfections both in the Compoſition of the Metal, and in its being badly caſt, as you may perceive by a ſcabrous Place near the Middle of the Metal of it on the poliſhed Side, and alſo in the Figure of that Metal near that ſcabrous Place: And in all thoſe Reſpects that Inſtrument is capable of further Improvement. *A further Account of this Inſtrument; by Mr.* Newton. *Ibid.*

You ſeem to intimate, that the Proportion of 38 to 1, holds only for its magnifying Objects at ſmall Diſtances. But if for ſuch Diſtances, ſuppoſe 500 Feet, it magnify at that Rate, by the Rules of Optics it muſt for the greater Diſtance imaginable magnify more than $37\frac{3}{4}$ to 1, which is ſo inconſiderable a Diminiſhing, that it may be even then as 38 to 1.

Here is made another Inſtrument like the former, which does very well. Yeſterday I compared it with a ſix Foot Teleſcope, and found it not only to magnify more, but alſo more diſtinctly: And to Day I found, that I could read in one of the Philoſophical Tranſactions, placed in the Sun's Light, at 100 Foot Diſtance, and that at 120 Foot Diſtance I could diſcern ſome of the Words. When I made this Trial, its Aperture (defined next the Eye) was equivalent to more than an Inch and a third Part of the Object-Metal. This may be of ſome Uſe to thoſe that ſhall endeavour any thing in Reflections; for hereby they will in ſome meaſure be enabled to judge of the Goodneſs of their Inſtruments.

5. I know that the Aperture was $1\frac{1}{3}$ of an Inch, by trying that an Obſtacle of that Breadth was requiſite to intercept all the Light which came from one Point of the Object. *The Apertures and Charges of theſe Inſtruments; by Mr.* Newton. N. 82. *p.* 4032. April, An. 1672.

I ſhould tell you alſo, that the little plain Piece of Metal next the Eye-Glaſs is not truly figured: Whereby it happens, that Objects are not ſo diſtinct at the Middle as at the Edges. And I hope that by correcting its Figure (in which

which I find more Difficulty than one would expect) they will appear all over distinct, and distincter in the middle than at the Edges. And I doubt not but that the Performances will then be greater.

But yet I find, that there is more Light lost by Reflection of the Metal which I have hitherto used, than by Transmission through Glasses: For which Reason a shallower Charge would probably do better for obscure Objects; suppose such a one as would magnify 34 or 32 times. But for bright Objects at any Distance, it seems capable of magnifying 38 or 40 times, with sufficient Distinctness. And for all Objects, the same Charge, I believe, may with Advantage be allowed, if the steely Matter, employed at *London*, be more strongly reflective than this which I have used.

The Performances of one of these Instruments of any Length being known, it will appear by this following Table, what may be expected from those of other Lengths by this Way, if Art can accomplish what is promised by the Theory. In the first Column is expressed the Length of the Telescope in Feet; which doubled, gives the Semidiameter of the Sphere on which the Concave Metal is to be ground. In the second Column are the Proportions of the Apertures for those several Lengths. And in the third Column are the Proportions of the Charges, or Diameter of the Spheres, on which the Convex Superficies of the Eye-Glasses are to be ground.

Lengths.	*Apertures.*	*Charges.*	*Lengths.*	*Apertures.*	*Charges.*
$\frac{1}{2}$	100	100	8	800	200
1	168	119	10	946	211
2	283	141	12	1084	221
3	383	157	16	1345	238
4	476	168	20	1591	251
5	562	178	24	1824	263
6	645	186			

The Use of this Table will best appear by Example: Suppose therefore a half Foot Telescope may distinctly magnify 30 times with an Inch Aperture, and it being required to know, what ought to be the analogous Constitution and Performance of a four Foot Telescope: By the second Column, as 100 to 476; so are the Apertures, as also the Number of Times which they magnify. And consequently since the half Foot Tube hath an Inch Aperture and magnifieth 30 times, a four Foot Tube proportionally should have $4\frac{76}{100}$ Inches Aperture, and magnify 143 times. And by the third Column, as 100 to 168; so have their Charges. And therefore if the Diameter of the Convexity of the Eye-Glass for a half Foot Telescope be $\frac{1}{5}$ of an Inch; that for a four Foot should be $\frac{168}{500}$, that is about $\frac{1}{3}$ of an Inch; and so of other Lengths. But what the Event will really be, we must wait to see determined by Experience. Only this I thought fit to insinuate, that they which intend to make Trial in other Lengths, may more readily know how to design their Instruments. Thus for a four Foot Tube, since the Aperture should be 5 or 6 Inches,

Inches, there will be required a Piece of Metal 7 or 8 Inches broad at leaſt, becauſe the Figure will ſcarcely be true to the Edges. And the Thickneſs of the Metal muſt be proportional to the Breadth, leſt it bend in the Grinding. The Metals being poliſhed, there may be Trials made with ſeveral Eye-Glaſſes, to find what Charge may with beſt Advantage be made uſe of.

Some Objections of Mr. —— Anſwered, by Mr. Newton. *ib. p.* 4034.

XVIII. 1. I doubt not but *M. A.* will allow the Advantage of Reflection in the Theory to be very great, when he ſhall have informed himſelf of the *different Refrangibility* of the ſeveral Rays of Light. And for the practick Part, it is in ſome Meaſure manifeſt by the Inſtruments already made, to what Degree of Vivacity and Brightneſs a metalline Subſtance may be poliſhed. Nor is it improbable but that there may be new Ways of poliſhing found out for Metal, which will far excell thoſe that are yet in Uſe. And when a Metal is once well poliſhed, it will be a long while preſerved from tarniſhing, if Diligence be uſed to keep it dry and cloſe ſhut up from Air: For the principal Cauſe of Tarniſhing ſeems to be the condenſing of Moiſture on its poliſhed Surface, which, by an acid Spirit, wherewith the Atmoſphere is impregnated, corrodes and ruſts it; or at leaſt at its exhaling leaves it covered over with a thin Skin, conſiſting partly of an earthly Sediment of that Moiſture, and partly of the Duſt, which, flying to and fro in the Air, had ſettled and adhered to it.

Where there is not occaſion to make frequent Uſe of the Inſtrument, there may be other Ways to preſerve the Metal for a long time; as perhaps by immerging it in Spirit of Wine, or ſome other convenient Liquor. And if they chance to tarniſh, yet their Poliſh may be recovered by rubbing them with a ſoft Piece of Leather, or other tender Subſtance, without the Aſſiſtance of any fretting Powders, unleſs they happen to be ruſty; for then they muſt be new poliſhed.

I am very ſenſible, that Metal reflects leſs Light than Glaſs tranſmits; and for that Inconvenience, I gave you a Remedy in my laſt Letter, by aſſigning a ſhallower Charge in Proportion to the Aperture, than is uſed in other Teleſcopes. But as I have found ſome metalline Subſtances to be more ſtrongly reflective, and to poliſh better, and be freer from tarniſhing than others; ſo I hope there may in time be found out ſome Subſtance much freer from theſe Inconveniencies than any yet known.

The Conſiderations of —— Anſwered by Mr. Newton. N. 88. *p.* 5084. Nov. An. 1672.

2. The *Conſiderer* is pleaſed to reprehend me for laying aſide the Thoughts of improving Optics by Refractions. If he had obliged me by a private Letter on this Occaſion, I would have acquainted him with my Succeſs on the Trials I have made of that kind, which, I ſhall now ſay, have been leſs than I ſometimes expected, and perhaps than he at preſent hopes for. But ſince he is pleaſed to take it for granted, that I have let this Subject paſs without due Examination, I ſhall refer him to my former Letters, by which that Conjecture will appear to be ungrounded. For what I ſaid there was in reſpect of Teleſcopes of the ordinary Conſtruction, ſignifying, that their Improvement is not to be expected from the well figuring of Glaſſes, as Opti-

cians have imagined; but I deſpaired not of their Improvement by other Conſtructions, which made me cautious, to inſert nothing that might intimate the contrary. For although ſucceſſive Refractions that are all made the ſame Way, do neceſſarily more and more augment the Errors of the firſt Refraction; yet it ſeemed not impoſſible for contrary Refractions ſo to correct each other's Inequalities, as to make their Difference regular; and if that could be conveniently effected, there would be no further Difficulty. Now to this end, I examined what may be done, not only by Glaſſes alone, but more eſpecially by a Complication of divers ſucceſſive Mediums, as by two or more Glaſſes or Chryſtals with Water or ſome other Fluid between them; all which together may perform the Office of one Glaſs, eſpecially of the Object-Glaſs, on whoſe Conſtruction the Perfection of the Inſtrument chiefly depends.

To the Aſſertion, that Rays are leſs true, reflected to a Point by a Concave, than refracted by a Convex, I cannot aſſent; nor do I underſtand, that the Focus of the latter is a leſs Line than that of the former. The Truth of the contrary you will rather perceive by the following Table, computed for ſuch a reflecting Concave, and the refracting Convex, on Suppoſition that they have equal Apertures, and collect parallel Rays at an equal Diſtance from their Vertex; which Diſtance being divided into 15000 Parts, the Diameter of the Concave Sphere will be 60000 of thoſe Parts, and of the Convex 10000; ſuppoſing the Sines of Incidence and Refraction to be, in round Numbers, as 2 to 3. And this Table following ſhews, how much the exterior Rays, at ſeveral Apertures, fall ſhort of their principal Focus.

The Diameter of the Aperture.	*The Parts of the Axis intercepted between the Vertex and the Rays.*		*The Errors by*	
	Reflected.	*Refracted.*	*Reflection.*	*Refraction.*
2000	14991⅔	14865	8⅓	135
4000	14966	14449	33	551
6000	14924	13699	76	1301
8000	14865	12475	135	2525
10000	14787	9472	213	5528

By this you may perceive, that the Errors of the refracting Convex are ſo far from being leſs, that they are more than 16 Times greater than the like Errors of the reflecting Concave, eſpecially in great Apertures; and that without reſpect to the heterogeneous Conſtitution of Light. So that, however the contrary Suppoſition might make the Author of theſe Animadverſions reject Reflections as uſeleſs for the promoting of Optics; yet I muſt for this, as well as other Conſiderations, prefer them in the Theory before Refractions.

Whether

Whether the *Parabolæ* be more difficult to defcribe than the *Hyperbola*, or *Ellipfis*, may be a Query; but I fee no abfolute Neceffity of endeavouring after any of their Defcriptions. For if Metals can be ground truly Spherical, they will bear as great Apertures, as I believe Men will be well able to communicate an exact Polifh to. And for Dioptrique Telefcopes, I told you, that the Difficulty confifted not in the Figure of the Glafs, but in the Difformity of Refractions; which if it did not, I could tell you a better and more eafy Remedy than the Ufe of the *Conic Sections*.

3. We fee that a Picture made by an Object-Glafs of 12 Foot in a dark Room, is too diftinct, and too well defined, to be produced by Rays, that fhould ftray the 50th Part of the Aperture. *Objections; by M.* ---------- N. 96. *p.* 6087. July, An. 1673.

To take away this Difficulty, I muft acquaint you, that though I put the greateft Lateral Error of the Rays from one another to be about $\frac{1}{50}$ of the Glafs's Diameter; yet their greater Error from the Points on which they ought to fall, will be but $\frac{1}{100}$ of that Diameter: And then, that the Rays, whofe Error is fo great, are but very few in Comparifon to thofe, which are refracted more juftly; for the Rays which fall upon the middle Parts of the Glafs, are refracted with fufficient Exactnefs, as alfo are thofe that fall near the Perimeter, and have a mean Degree of Refrangibility; fo that there remain only the Rays which fall near the Perimeter, and are moft or leaft refrangible, to caufe any fenfible Confufion in the Picture. And thefe are yet fo much further weakened by the greater Space through which they are fcattered, that the Light which falls on the due Point, is infinitely more denfe than that which falls on any other Point round about it. And by this Excefs of Denfity, the Light which falls in or invifibly near the juft Point, may, I conceive, ftrike the *Senforium* fo vigoroufly, that the Imprefs of the weak Light, which errs round about it, fhall, in Comparifon, not be ftrong enough to be animadverted, or to caufe any more fenfible Confufion in the Picture than is found by Experience. But if this fatisfy not, *N.* may try, if he pleafe, how diftinct the Picture will appear, when all the Lens is cover'd, excepting a little Hole next its Edge on one Side only: And if in this Cafe he pleafe to meafure the Breadth of the Colours thus made at the Edge of the Sun's Picture, he will perhaps find it to approach nearer to my Proportion than he expects. *Anfwered by Mr.* Newton. N. 97. *p.* 6110. Oct. An. 1673.

4. I am fatisfied with the manner whereby Mr. *Newton* reconciles the Effect of Convex Glaffes with his Theory; but then he is alfo to acknowledge, that this Aberration of the Rays is not fo difadvantageous to Optic-Glaffes, as he feems to have been willing to make us believe. His Invention is very good; but the Defect of the Metal feems to render it as impoffible to execute, as the Difficulty of the Form obftructs the Ufe of the *Hyperbole* of M. *Des Cartes*. *A Reply by M.* ---------- *Ibid. p.* 6112.

If M. *N*—— pleafes to compare the Errors of a Glafs and Speculum that collect Rays at equal Diftances, he will find how much he is miftaken; and that I have not been extravagant, as he imagines, in preferring Reflections. And as for what he fays of the Difficulty of the *Praxis*, I know it is very difficult; and by thofe Ways which he attempted it, I believe it impracticable. *Anfwered, by Mr.* Newton. N. 96. *p.* 6091. July, An. 1673.

practicable. But there is a Way insinuated above, by which it is not improbable, but that as much may be done in large Telescopes as I have thereby done in short ones; but yet not without more than ordinary Diligence and Curiosity.

A Cata-Dioptrical Telescope, by M. Cassegrain. N. 83. *p.* 4056. May, An. 1672. *Fig.* 100.

XIX. 1. M. *Cassegrain* has communicated the Figure of a Telescope, almost like that of Mr. *Newton.*

A B C D is a strong Tube, in the bottom of which there is a great *Concave Speculum* C D, pierced in the middle E.

F is a *Convex Speculum*, so disposed, as to its Convexity, that it reflects the Species, which it receives from the great Speculum, towards the Hole E, where is an Eye-Glass, which one looketh through.

The Advantage which I find in this Instrument above that of Mr. *Newton*, is, 1. That the Mouth or Aperture A B of the Tube may be of what Bigness you please; and consequently you may have many more Rays upon the *Concave Speculum*, than upon that of which you have given us the Description. 2. The Reflection of the Rays will be very natural, since it will be made upon the Axis itself, and therefore more vivid. 3. The Vision of it will be so much the more pleasing, in that you shall not be incommoded by the great Light, by reason of the bottom C D, which hideth the whole Face. Besides, you'll have less Difficulty in discovering the Objects, than in that of Mr. *Newton.*

Considered by Mr. Newton. *Ibid. p.* 4057.

2. When I first applied myself to try the Effects of Reflections, Mr. *Gregory*'s *Optica Promota* (printed in the Year 1663.) being fallen into my Hands, where there is an Instrument (described *p.* 94.) like that of Mr. *Cassegrain*, with a Hole in the midst of the Object Metal, to transmit the Light to an Eye-Glass placed behind it; I had thence an Occasion of considering that sort of Constructions, and found these Disadvantages in it; *viz.* 1. There will be more Light lost in the Metal by Reflection from the little Convex Speculum, than from the oval Plane. For it is an obvious Observation, That Light is most copiously reflected from any Substance when incident most obliquely. 2. The Convex Speculum will not reflect the Rays so truly as the oval Plane, unless it be of an hyperbolic Figure; which is incomparably more difficult to form than a Plane; and if truly formed, yet would only reflect those Rays truly which respect the Axis. 3. The Errors of the said Convex will be too much augmented by the too great Distance, through which the Rays reflected from it must pass, before their Arrival at the Eye-Glass. For which Reason, I find it convenient to make the Tube no wider than is necessary, that the Eye-Glass be placed as near to the oval Plane as is possible, without obstructing any useful Light in its Passage to the Object-Metal. 4. The Errors of the Object-Metal will be more augmented by Reflection from the Convex than from the Plane, because of the Inclination or Deflexion of the Convex on all sides, from the Points on which every Ray ought to be incident. 5. For these Reasons there is requisite an extraordinary Exactness in the Figure of the little Convex; whereas I find by Experience that it is much more difficult to communicate an exact Figure to such small Pieces of Metal,

Metal, than to thoſe that are greater. 6. Becauſe the Errors of the Perimeter of the Concave Object-Metal, cauſed by the Sphericalneſs of its Figure, are much augmented by the Convex, it will not with Diſtinctneſs bear ſo large an Aperture as in the other Conſtruction. 7. By reaſon that the little Convex conduces very much to the magnifying Virtue of the Inſtrument, which the oval Plane does not, it will magnify much more in Proportion to the Sphere, on which the great Concave is ground, than in the other Deſign; and ſo magnifying Objects much more than it ought to do in Proportion to its Aperture, it muſt repreſent them very obſcure and dark; and not only ſo, but alſo confuſed, by reaſon of its being over-charged. Nor is there any convenient Remedy for this. For if the little Convex be made of a larger Sphere, that will cauſe a greater Inconvenience, by intercepting too many of the beſt Rays; or if the Charge of the Eye-Glaſs be made ſo much ſhallower as is neceſſary, the Angle of Viſion will thereby become ſo little, that it will be very difficult and troubleſome to find an Object; and of that Object, when found, there will be but a very ſmall Part ſeen at once.

By this you may perceive, that the three Advantages, which Mr. *Caſſegrain* propounds to himſelf, are rather Diſadvantages. For according to his Deſign, the Aperture of the Inſtrument will be but ſmall, the Object dark and confuſed, and alſo difficult to be found. Nor do I ſee, why the Reflection is more upon the ſame Axis, and ſo more natural in one Caſe than in the other; ſince the Axis itſelf is reflected towards the Eye by the oval Plane, and the Eye may be defended from external Light, as well at the Side as at the Bottom of the Tube.

Mr. *Gregory* ſpeaking of theſe Inſtruments, in the aforeſaid Book, *p.* 95. ſaith; I ſhall ſay nothing about the Mechaniſm of theſe *Specula* and *Lenſes*, which has been tried in vain by others; and as to myſelf, I am but little verſed in Mechanics. So that there have been Trials made of theſe Teleſcopes, but yet in vain. And I am informed, that about 7 or 8 Years ſince, Mr. *Gregory* himſelf, at *London*, cauſed one of 6 Foot to be made by Mr. *Reive*, which I take to have been according to the aforeſaid Deſign deſcribed in his Book; but, though made by a ſkilful Artiſt, yet it was without Succeſs.

XX. S. *Salvetti* hath made a Proſpective-Glaſs according to Mr. *Newton*'s new Invention. It was not above half a Foot long, but had the ſame Effect of one of two. He is now making another after the Conceit of Mr. *Caſſegrain*, though he agrees not with him in making Convex the little Speculum, which one looks into through the Eye-Glaſs, but believes the *French* Author only deviſed that to diſguiſe as much as was poſſible his pretended new Invention, which he endeavours to make anterior to Mr. *Newton*'s moſt noble one.

A Cata-Dioptric Teleſcope; by S. Salvetti. N. 87. *p.* 5065. Sept. An. 1672.

XXI. 1. Oppoſite to the Place or Wall, where the Apparition is to be, let a Hole be made of about a Foot in Diameter, or bigger: If there be a high Window, that hath a Caſement in it, 'twill be ſo much the better. Without this Hole or Caſement opened, at a convenient Diſtance (that it may

To make the Picture of any thing appear in a Light Room; by Dr. Hook. N. 38. *p.* 741. Aug. An. 1668.

may not be perceived by the Company in the Room) place the Picture or Object, which you will represent inverted, and by means of Looking-Glasses placed behind, if the Picture be transparent, reflect the Rays of the Sun so, as that they may pass through it towards the Place where it is to be represented; and to the End that no Rays may pass besides it, let the Picture be encompassed on every Side with a Board or Cloth. If the Object be a Statue, or some Living Creature, then it must be very much enlightened by casting the Sun-Beams on it by Refraction, Reflection, or both. Between this Object and the Place where 'tis to be represented, there is to be placed a broad Convex-Glass, ground of such a Convexity, as that it may represent the Object distinct on the said Place; which any one, that hath an Insight in the Optics, may easily direct. The nearer it is placed to the Object, the more is the Object magnified on the Wall, and the further off the less; which Diversity is effected by Glasses of several Spheres. If the Object cannot be inverted (as 'tis pretty difficult to do with Living Animals, Candles, &c.) then there must be two large Glasses of convenient Spheres, and they placed at their appropriated Distances (which are very easily found by Trials) so as to make the Representations erect, as well as the Object.

These Objects, Reflecting and Refracting Glasses, and the whole Apparatus; as also the Persons employed to order, change, and make use of them, must be placed without the said high Window or Hole, so that they may not be perceived by the Spectators in the Room; and the whole Operation will be easily performed.

Whatsoever may be done by means of the Sun-Beams in the Day-time, the same may be done with much more ease in the Night, by the help of Torches, Lamps, or other bright Lights, placed about the Objects, according to the several sorts of them.

The Magick Lanthorn improv'd, by Sir Rob. Southwell. N. 245. p. 364. Oct. An. 1698.

2. There are every where made of these Lanthorns to represent and magnify Figures upon a Wall; but then 'tis only in the Dark: wherefore to give Variety of Colours, take Oil of Spike, and therein mix the several Colours, wherewith you will have your Glass to be stained; paint them finely on, they dry presently, and penetrate any Glass.

A Way to help Short-sightedness. by Dr. Hook. *Ph. Coll.* N. 3. p. 59. Dec. An. 1681.

XXII. Having found by many Trials, that some short-sighted Persons could find little or no Relief by the Use of Concave-Glasses for seeing Objects at any Distance distinct, and that any one may be made short-sighted, and to be able to distinguish nothing but what is placed very near his Eye, but within certain Limits of Distance, by putting on and looking through a very deep Pair of Spectacles, such as ancient Men use: I concluded that what Glasses should make this Man, whilst looking thro' these Spectacles, to see Things at a greater Distance, would also help any other Person that should be short-sighted by Nature. I then consider'd, that by the help of a Convex-Glass, placed between the Object and the Eye, the Image of the Object may be made to appear at any Distance from the Eye; and consequently all Objects may thereby be made to appear in any convenient Distance from the Eye: So that the short-sighted Eye shall contemplate the Picture of the Object,

Object, in the ſame manner as if the Object itſelf were in that Place. But then, becauſe the Pictures themſelves are ſo inverted, and therefore will be uncouth to one, not uſed to ſee them in that Poſture, I conſider'd of theſe Expedients to help that Defect alſo:

Firſt, If it be only for reading of a Book, or Writing, there needeth nothing but the Inverſion of the Book, and then holding the Convex at a due Diſtance; for the Picture of the Letters will appear erected in the due Place, for the Eye to ſee and diſtinguiſh them very plainly.

Secondly, For ſeeing to write, I thought this would be the beſt Expedient, That the Perſon ſhort-ſighted ſhould firſt learn to read with his naked Eye (both printed Letters and alſo written Hand) upſide downwards, which is quickly attained to by one that can do both the right Way.

Thirdly, For diſtinguiſhing Objects at a Diſtance, I can aſſert by my own Experience, that with a little Uſe of contemplating Objects inverted, one ſhall have as good an Idea, and as true a Knowledge of all manner of Objects, as if they were ſeen erected in their natural Poſture.

XXIII. 1. *Euſtachio Divini* hath made a Microſcope of a new Invention, wherein, inſtead of an Eye-Glaſs Convex on both Sides, there are two Plano-Convex-Glaſſes, which are ſo placed, as to touch one another in the middle of their Convex Surface. It hath this Peculiar, that it ſhews the Objects flat and not crooked; and although it takes in much, yet nevertheleſs magnifieth extraordinarily. *Microſcopes; by* S. Divini. N. 42. *p.* 842. Dec. An. 1668.

It is almoſt 16½ Inches high, and adjuſted at four different Lengths. In the firſt, which is the leaſt, it ſhews Lines 41 times bigger than they appear to the naked Eye; in the ſecond 90 times; in the third 111 times; and in the fourth 143 times: Whence one may eaſily calculate how much it augments Surfaces and Solidities.

2. *S. Salvetti* lately ſhew'd one of his Microſcopes, made in Imitation of thoſe of *Divini* and *Campani*, to the Great Duke of *Tuſcany*, which was judged by all much better than any of the beſt his Highneſs hath. It was found, for Magnifying, Defining, and Clearneſs, to be very excellent. *By* S. Piet. Salvetti. N. 87. *p.* 5065. Oct. An. 1672.

3. M. *Leeuwenhoeck* hath lately contrived Microſcopes, excelling thoſe that have been hitherto made by *Euſtachio Divini*, and others. *By M.* Leeuwenhoeck. N. 94. *p.* 6037. May, An. 1673.

4. I have Microſcopes of the manner lately brought out of *Holland* by Mr. *Huygens*, of ſeveral Faſhions ready made. I have tried ſeveral Ways for the making of Glaſſes of the Bigneſs of a great Pin's Head and leſs; as in the Flame of a Tallow-Candle, and of one of Wax. But the beſt Way of all I have yet found, to make them clear and without Specks, is with the Flame of Spirit of Wine well rectified, and burned in a Lamp. Inſtead of Cotton I make uſe of very ſmall Silver-Wire, doubled up and down like a Skein of Thread; which being wet with the Spirit of Wine, and made to burn in the Lamp, giveth through the Veril of the Lamp, a very ardent Flame. Then take your beaten Glaſs, being firſt waſhed very clean, upon the Point of a Silver Needle filed very ſmall, and wet with Spittle. Hold it thus in the Flame till it be quite round, and no longer, for fear of burning it; and *By Mr.* Butterfield. N. 141. *p.* 1026. Sept. An. 1678.

if the ſide of the Glaſs next the Needle be not melted, you may put it off, and take it up with the Needle on the round ſide, preſenting the rough ſide to the Flame, till it be every where round and ſmooth, then wipe and rub one or ſeveral of them together with ſoft Leather, which makes them much the better. Then put them between two Pieces of thin Braſs, the Apertures very round and without Bur, and that towards the Eye ſo big almoſt as the Diameter of the Glaſs, and ſo placed in a Frame with the Object conveniently for Obſervation.

By Mr. Stephen Gray. N. 221. p. 280. June, An. 1626.

5. I took a ſmall Particle of Glaſs, about the Bigneſs I deſigned my Globule, and laying it on the End of a Charcoal, I could, by the Help of a Blaſt-Pipe, with the Flame of a Candle, ſoon melt it into a Spherule; and by this means could make them indifferently clear, and the ſmalleſt very round, and I could make them much larger, than by the unaſſiſted Heat of the Candle: but theſe latter were attended with an Inconvenience; they were, on that ſide that reſted on the Coal, flatted, and received a rough Impreſſion from it. To remedy this Inconvenience, I was wont to grind them and poliſh them on a Braſs-Plane, and ſo reduce them to Hemiſpherules; but I found the clear ſmall Globules, not to mention that they magnify more, ſhew Objects more diſtinctly.

A Water Microſcope; by Mr. Stephen Gray. N. 221. p. 281. N. 223. p. 353.

XXIV. 1. A B, I call the Frame of the Microſcope. It may be about $\frac{1}{18}$ of an Inch in Thickneſs. At A there is a ſmall Hole, near $\frac{1}{30}$ of an Inch Diameter; this ſerves for the Aperture of the Water, being in the Center of a larger Spherical Cavity, about $\frac{1}{8}$ of an Inch Diameter, and in Depth ſomewhat more than half the Thickneſs of the Braſs. Oppoſite to this, at the other ſide, there is another Concave, but half the Breadth of the former; which is ſo deep, as to reduce the Circumference of the ſmall Hole in the Center, to almoſt a ſharp Edge. In theſe Cavities the Water is to be placed, being taken upon a Pin, or large Needle, and conveyed into them till there be formed a double Convex Lens of Water; which, by the Concave's being of different Diameters, will be equivalent to a double Convex, of unequal Convexities. By this means, I find the Object is rendered more diſtinct than by a Plano-convex of Water, or by a double one, formed on the plain Surface of the Metal.

Fig. 101.

C D E, is the Supporter, whereon to place the Object; if it be Water, in the Hole G; if a ſolid Object, on the Point F. This is fix'd to the Frame of the Microſcope by the Screw E, where 'tis bent upwards, that its upper Part may ſtand at a Diſtance from the Frame: 'tis moveable on the Screw as a Center, to the end that either the Hole C, or the Point F, may be expoſed before the Microſcope; and that the Object may be brought to, and fix'd in its Focus. There is another Screw, about half an Inch in Length, which goes through the round Plate into the Frame of the Microſcope A E, the Screw and Plate taking hold of the Supporter about D, where there is a Slit ſomewhat larger than the Diameter of the Screw, which is requiſite for the Admiſſion of the Hole C, or Point F, according to the Nature of the Object, into the Focus of the Glaſs; for by turning the Screw G, the

G, the Supporter is carried to or from the ſame; which may be ſooner done, if whilſt one turns the Screw with one Hand, the other hold the Microſcope by the End B, and one continue looking through the Water till the Object be ſeen moſt diſtinctly.

The Supporter muſt be made of a thin Piece of Braſs well hammer'd, that by its Spring it may the better follow the Motion of the Screw. I choſe rather to fix the Supporter by the Screw E, than by a Rivet; becauſe it may now, by help of a Knife, be unſcrew'd, and by the other Screw G, be brought cloſe to the Frame of the Microſcope without weakening its Spring, and ſo become more conveniently portable. If the Hole at G be filled with Water, but not ſo as to be Spherical, all Objects that will bear it, are ſeen therein more diſtinctly.

2. Having obſerv'd ſome irregular Particles in Globules of Glaſs, and finding them diſtinct, but prodigiouſly magnified, when held cloſe to the Eye; *Another.* Ibid. N. 221. *p.* 282. I concluded that if I convey'd a ſmall Globule of Water to my Eye, and that there were any opacous or leſs tranſparent Particles than the Water therein, I might ſee them diſtinctly. I therefore took on a Pin a ſmall Portion of Water, which I knew to have in it ſome minute Animals, and laid it on the End of a ſmall Piece of Braſs Wire (that lay then by me) of about $\frac{1}{1}$ of an Inch Diameter, till there was formed ſomewhat more than an Hemiſpherule of Water; then keeping the Wire erect, I applied it to my Eye, and ſtanding at a proper Diſtance from the Light, I ſaw them and ſome other irregular Particles, as I had predicted, but moſt enormouſly magnified; for whereas they are ſcarce diſcernible by my Glaſs-Microſcopes, or firſt Aqueous one, within the Globule they appeared not much different both in their Form, nor leſs in Magnitude than ordinary Peaſe. They cannot well be ſeen by Day-light, except the Room be darkened after the manner of the famous Dioptrical Experiment, but moſt diſtinctly by Candle-light; they may be very well ſeen by the full Moon-light. If the Water be conveyed into the Hole B (which may be about $\frac{1}{10}$ of an Inch Diameter) till there remain near N. 223. *p.* 355. an Hemiſphere of Water on each ſide of the Hole, the Objects are ſeen more diſtinctly; and the Spherical Form of the Water is this way better ſecured, than on the Point of a Pin-Wire.

The Reaſon of this Appearance may be thus explained. Let the Circle N. 221. *p.* 285. D B B D repreſent a Sphere of Water, A an Object placed in its Focus, ſending forth a Cone of Rays, two of which are A B, A B, which, Opticians *Fig.* 102. know, coming into the Water at B and B, will be refracted from their direct Courſe, and become B D, B D; at D they will, at their paſſing into the Air, be again refracted into D E, D E, and ſo run parallel to one another, and to the Axis of the Sphere A F C G. Now 'tis a known and fundamental Principle in Optics, that the Angle of Reflexion is equal to the Angle of Incidence: wherefore let the Rays B D, B D, be imagined to come from ſome Point of an Object placed within a Sphere of Water, by being reflected from the interior Surface of the Sphere at B B; C B D is the Angle of Reflexion; to which making C B F equal, F will be the Place where an Object ſending forth a Cone of Rays, two of which are F B, F B, which are reflected into the Rays B D, B D, and then coming to the other ſide the Sphere at D and D, they are refracted into D E, D E, as before; and conſequently be as fit for diſtinct Viſion, whether the Object be placed in F within, or in A without the Sphere, if its interior Surface be conſidered as a Concave Reflecting Speculum.

Microſcopes improv'd; by Mr. Newton. N. 88. *p.* 5096.

XXV. From the Diſtinction I have elſewhere given between *Compounded* and *Uncompounded Colours*, I take occaſion to communicate a Way for the Improvement of Microſcopes by Refraction; *viz.* By illuminating the Object in a darkened Room with Light of any convenient Colour not too much *Compounded*; for by that means the Microſcope will with Diſtinctneſs bear a deeper Charge and larger Aperture, eſpecially if its Conſtruction be ſuch as I may hereafter deſcribe; for the Advantage in ordinary Microſcopes will not be ſo ſenſible.

A Reflecting Microſcope; by Mr. Newton, N. 80. *p.* 3080.

Fig. 103.

XXVI. 1. I have ſometimes thought to make a Microſcope, which ſhould have, inſtead of an Object-Glaſs, a reflecting Piece of Metal. For theſe Inſtruments ſeem as capable of Improvement as Teleſcopes, and perhaps more; becauſe but one reflective Piece of Metal is requiſite in them, as you may perceive by the Diagram, where A B repreſenteth the Object-Metal, C D the Eye-Glaſs, F their common Focus, and O the other Focus of the Metal, in which the Object is placed.

By Mr. Stephen Gray. N. 228. *p.* 541.

Fig. 104.

2. A repreſents a ſmall flat Ring of Braſs, whoſe interior Circle muſt not much exceed $\frac{4}{10}$ of an Inch Diameter, and about $\frac{1}{10}$ of an Inch thick: This we may call the Frame or Cell of the Glaſs; it muſt be prepared for Uſe after the following manner. Take a ſmall Globule of Quick-ſilver, and diſſolve it in a few Drops of *Aqua Fortis*, to which you may add 10 Parts of common Water; dip the End of a Stick in this Liquor, and rub the inward Circle of the Ring with it; ſo as it will have acquired a mercurial Tincture, and being wiped dry, be fit for Uſe. Then let it be laid on the Table, and pour a Drop of Quick-ſilver within it, which preſs gently with the Ball of the Finger, and it will adhere to the Ring; then cleanſe it with a Hare's Foot, and you will have a Convex Speculum. Take up the Ring and Speculum carrying it Horizontal, and lay it on the Brims of the hollow Cylinder B; ſo will the Mercury become a Concave Reflecting Speculum, which from the Smallneſs of the Sphere of which it ſeems to be a Section, may be uſed as a Microſcope. The Cylindric Veſſel B has a Screw-Hole at the Bottom, by which it is ſcrew'd to the Top of the Pedeſtal C D; C E F G is the Supporter of the Object-Plate, which, as you ſee, may be raiſed higher, or let lower, as there is Occaſion, by the Screw on the Pedeſtal: The Object-Plate muſt be of Glaſs cemented to the Ring G.

This Inſtrument, with a little Variation, may be made a Microſcope of Water, if, inſtead of the Ring G, there be only a ſmall Arm with a Hole in it to receive a Drop of Water, and the Cylindric Veſſel B be either taken away, or ſcrewed on with its Bottom upwards, ſo as to make an Object-Plate.

This

This will be more convenient for viewing the Textures of opacous Objects, than that above described, which is more fit for fluid and transparent ones.

XXVII. 1. The Figure of it is round, being 30 Inches and somewhat better in Diameter. On one side it hath a Frame of a Circle of Steel, to the end that it may keep its just Measure. 'Tis easy to remove it from Place to Place, tho' it be above an Hundred Weight, and 'tis easily put in all sorts of Postures. The Burning Point is distant from the Center of the Glass about 3 Foot. The Focus is about half a *Louis d'Or* large. One may pass one's Hand through it, if it be done nimbly; for if it stay there the time of a Second of a Minute, there is danger of receiving much hurt. Green Wood takes Fire in it in an instant, as do also many other Bodies. *A Burning Concave at Lyons; made by M. de Vilette. N. 6. p. 95.*

	Seconds.
A small Piece of Pot-Iron was melted, and ready to drop down, in	40
A Silver Piece of Fifteen Pence was pierced, in	24
A Gross Nail (called *le Clou de Pisan*) was melted, in	30
The End of a Sword Blade of *Olinde* was burned, in	43
A Brass Counter was pierced, in	6
A Piece of Red Copper was melted ready to drop down, in	42
A Piece of a Chamber Quarry-Stone was vitrified, and put into a Glass-Drop, in	45
Steel, whereof Watchmakers make their Springs, was found melted, in	9
A Mineral-Stone, such as is used in Harquebusses *à rouët*, was calcined and vitrified, in	1
A Piece of Mortar was vitrified, in	52

In short, There is hardly any Body which is not destroy'd in this Fire. If one would melt by it any great Quantity of Metal; that would require much Time, the Action of Burning not being performed but within the Bigness of the Focus, so that ordinarily none but small Pieces are exposed to it. One M. *de Alibert* buys it, paying for it 1500 Livres.

You incline to believe, that the Glasses of *Maginus* and *Septalius* do approach to that of *Lyons*; but I can assure you they come very far short of it. You may consult *Maginus* his Book, where he describes his; and there are some Persons here who have seen one of his best, which had but about 20 Inches Diameter; so that this of *Lyons* must perform at least twice as much. As to *Septalius*, we expect the Relation of it from Intelligent and Impartial Men. It cannot well be compared with that of *Lyons*, but in Bigness; and in this Case, if it have five Palms (as you say) that would be but $3\frac{1}{2}$ Foot *French*, and so it were a Foot bigger, which would make it half as much greater in Surface: But as to the Effects, seeing it burns so far off, they cannot be very violent. And I have heard one say, that had seen it, that it did not set Wood on Fire but after the time of saying a *Miserere*. You may judge of the Difference of the Effects, since that of *Lyons* gathers its Beams *Ibid. p. 97.*

 together

together within the Space of 7 or 8 Lines; and that of *Septalius* must scatter them in the Compass of 3 Inches.

N. 49. p. 986. It was disposed of to the King of *Denmark*.

Another by the same. N. 49. p. 986. The same M. *de Vilette* of *Lyons* hath made another Burning Concave. It is of 34 Inches Diameter, and melts all sorts of Metals, and Iron itself of the Thickness of a Silver Crown, in less than a Minute of Time, and vitrifies Brick in the same Time; and as for Wood, whether green or dry, it sets it on Fire in a Moment. The King hath seen it, and the Performances of it, with great Satisfaction; and his Majesty is likely to make it his, and then to bestow it on his *Royal Academy* of Philosophers, for making of farther Experiments with it.

By - - - - - *Ibid.* p. 987. This kind of Concaves burning the most forcibly of any Fire we know of, would be of great Use, if they could be so contrived as to have a Focus of any considerable Largeness, to take in a good Quantity of combustible Matter at once.

By S. Settalla. N. 40. p. 796. 3. *S. Settalla* at *Milan* causeth to be made a Burning-Glass of 7 Foot in Diameter. He pretends to make it burn at the Distance of 50 Palms, which is about 33 Foot.

A burning Concave in Germany; by - - - - - - N. 188. p. 252. 4. The outer Circle of the Concave Burning Speculum, which I lately caused to be made in *Lusace*, is near 3 *Leipsick* Ells in Diameter, exceeding that great one at *Paris* by $\frac{3}{8}$ of such an Ell. It is made of a Copper Plate scarce twice so thick as the Back of an ordinary Knife, and may therefore be easily removed from Place to Place, and order'd for Use: And the Workmanship of it may, by the Contrivances I have invented, be easily, and in little Time performed by one Man. The Polish thereof is very good, and represents by distinct Reflections all those Appearances which arise from the Concave Figure thereof.

The Force of this Speculum is incredible. For, 1. A Piece of Wood put into the Focus (which is 2 Ells off) flames in a Moment, so as a fresh Wind can hardly put it out. 2. Water applied in an Earthen Vessel presently boils, so as to boil an Egg; and the Vessel being held there some Time, the Water evaporates all away. 3. A Piece of Tin or Lead 3 Inches thick, as soon as it is put into the Focus, melts away in Drops; and held there a little Time, is in a perfect Fluor, so as in two or three Minutes to be quite pierced through. 4. A Plate of Iron or Steel placed in the Focus, immediately is seen to be red-hot on the Backside, and soon after a Hole is burnt through: I have made three such Holes in a Plate in six Minutes Time. 5. Copper, Silver, and the like, applied to the Focus, melt; which I have tried with several Sorts of Coin; among the rest, with a *Rix-Dollar*; and the same happened to it as to the aforesaid Iron Plate in five or six Minutes. 6. Things not apt to melt, as Stones, Brick, and the like, soon become red-hot like Iron. 7. Slate at first is red-hot, but in a few Minutes turns into a fine sort of black Glass; of which, if any Part be taken in the Tongs and drawn out, it runs into Glass Threads. 8. Tiles, which had suffered the most intense Heat of Fire, in a little Time melt down in a yellow Glass: As do, 9. Pot-Shreads, not only well burnt at first, but much used in the Fire, into a black-a blackiſh yellow Glaſs. 10. Pumice-Stone, ſaid to be that of Burning Mountains, in this Solar Fire melts into a white tranſparent Glaſs. 11. A Piece of a very ſtrong Crucible put into the Focus, in eight Minutes was melted into a Glaſs. 12. I have ſeen Bones turned into a kind of opake Glaſs, and a Clod of Earth into a yellow or greeniſh Glaſs.

Theſe Experiments were made in *Auguſt* and *September*, when the Sun has not the ſame Force as when he is about the Summer Solſtice. The Beams of the Full Moon, concentred by this Speculum, did not produce any Degree of Heat, tho' the Light was not a little increaſed.

5. Some Years ago, Dr. *Hook* made a Propoſal to the *Royal Society* concerning the ſame Thing. He conceives one may be made of many Foot Diameter, for a ſmall Price, being hammered out of a Copper Plate, and tinned over with a Mixture of Tin, Lead, and Tin-Glaſs, which is found to bear a very good Poliſh. Such a Speculum might be of great Uſe in perfecting the Art of Paſtes, or fictitious Jewels, which require the moſt intenſe Degree of Heat, to bring them to an exact Mixture.

By Dr. Hook. *Ibid. p.* 354.

XXVIII. A Linnen-Cloth, firſt being wet in fair Water, and then laid on a Concave Cylinder, as the Verge of a Sieve, Keeler, or the like, its central Parts will deſcend ſo as to form a very regular Concave Superficies. And a Thread, being firſt wet in common Water, and then ſuſpended with its two Ends, or any two Points nearer than their utmoſt Extent, ſo as it might touch the Center of the ſuſpended Cloth, and its two oppoſite Points on the Ring, was found to have the ſame Curvature. My Buſineſs was then to examine the Figure of the Thread thus ſuſpended; which I did in manner following. On the ſide of a Wall I deſcribed *Parabola's* of ſeveral Species, whoſe Axes were perpendicular, and Perimeter horizontal; to which the Line being applied, ſo as it might touch the Vertex, paſs'd very nearly through all the intermediate Points of the *Parabola*, much nearer than the Portion of a *Circle*, which paſſed through the Extremity of the Perimeter, and *Latus rectum*, would do.

Concave Specula nearly of a Parabolic *Figure attempted by Mr.* Stephen Gray. N. 228. *p.* 542. N. 235. *p.* 787.

From hence I conclude, That a ponderous and pliable Subſtance, being ſuſpended on a Ring or hollow Cylinder, ſo as that its central Parts may deſcend, will form itſelf into a Figure that is more commodious for Burning-Glaſſes than the Spherical, of which they are now made, being much nearer their moſt abſolute Figure, the *Parabola*.

Now if there may be a Way found to give to Cloth or Leather a metalline Surface, or a Varniſh that may bear a good Poliſh; or if this be found impracticable, perhaps Plates of Metal may be beat out ſo thin, as being ſuſpended on a large Ring, will by their own Gravity receive their true Figure; one may make Speculums of what Largeneſs he pleaſeth.

Upon this Conſideration, I deviſed the following Experiment. There was taken a ſufficient Quantity of Potter's Clay, of which there was formed a plain circular Plate, by help of an Iron Ring about 13 Inches Diameter. This was laid on a leſſer Ring, which was ſupported by four Feet; and it immediately became a very regular Concave on its upper, and Convex on its

its under Superficies; but notwithstanding 'twas set to dry in the Shade, yet before it was dry enough, its central Parts extended so as to become almost plain, not without some Defects; if it had continued in its Regularity, I designed to have burned and glazed it in a Potter's Furnace.

To make the Globe Looking-Glass; by Sir R. Southwell. N. 245. p. 363.

XXIX. Take Quicksilver, Marchasite of Silver, each three Ounces; Tin and Lead, each half an Ounce; these two first throw on the Marchasite, and last of all the Quicksilver; stir them well together; but they must be taken from the Fire, and be towards cooling before the Quicksilver be added; let your Glass be well warmed, and pour in the Mixture, and roll it from Side to Side.

Note, This will do also when cold, but 'tis best when the Glass is heated and very dry.

Note also, That if at the Glass-House your Ball be of yellow Glass, then all will shine like Gold.

XXX. *Papers (of less General Use) omitted.*

Optic-Glasses by a Turn-Lathe. N. 2. p. 31. N. 4. p. 56.

1. DR. *Hook* having (in his *Micrographia*) described a new Engine for *Grinding Optic-Glasses* of very great Lengths, M. *Auzout* (in a small *French Tract*) objects several Difficulties to this Engine itself: But however he thinks it impracticable to make any Glasses of above 300 or 400 Foot at most (and fears that neither Matter nor Art will go even so far) which will be very far from shewing us *Plants* or *Animals* in the *Moon*; and then proposes Remedies to some of the Inconveniencies of the Turn. To all this, Dr. *Hook* here replies; He answers the Objections, and rejects the proposed Expedients. *Ibid. p. 63.*

Upon a Plane. N. 42. p. 838.

2. *Carlo Ant. Mancini* having, in his *Occhiale all' Occhio*, described a particular Way for making Convex-Glasses upon a Plane, his Method is here translated from the *Italian* into *English*. But 'tis added, That though the Contrivance be ingenious, yet it is conceived by skilful Artists, that it will be very difficult to put it into Practice.

XXXI. *Accounts of Books omitted.*

N. 79. p. 3068. 1. P*Hysico-Mathesis de Lumine, Coloribus, & Iride*, &c. *Auth.* Franc. Maria Grimaldo, *S. J.* Bononiæ 1665. *in 4to.*

N. 71. p. 2163. 2. *Cogitationes Physico-Mechanicæ de Natura Visionis. Auth.* Jo. Ott. *Schaphusa Helvetio.* Heidelbergæ 1670. *in 4to.*

N. 32. p. 626. 3. *Synopsis Optica. Auth.* Honorato Fabri. *Soc. Jesu.* Lugduni 1667. *in 4to.*

N. 42. p. 837. 4. *L' Occhiale all' Occhio, overo Dioptrica Prattica del* Carlo Ant. Mancini, *in* Bologna 1660. *in 4to.*

N. 75. p. 2258. 5. *Lectiones* xviii; *Cantabrigiæ in Scholis publicis habitæ, in quibus Opticorum Phænomenon genuinæ Rationes investigantur, & exponuntur, ab* Isaaco Barrow. Lond. 1669. *in 4to.*

6. *La*

6. *La Dioptrique Occulaire, par le Pere* Cherubin *d'* Orleans, *Capucin.* A Paris, 1671. *in Folio.* N. 78. *p.* 3045.

7. Christiani Hugenij *Astroscopia Compendiaria, Tubi Optici molimine liberata:* or, The Description of an *Aërial Telescope.* Hague, 1684. *in 4to.* N. 161. *p.* 668.

8. A Treatise of Dioptrics. By *Will. Molineux,* Esq; F. R. S. *in 4to.* N. 205. *p.* 967.

9. *Catoptricæ & Dioptricæ Elementa. Auctore* Davide Gregorio, *D. M.* Oxon. 1695. *in 8vo.* N. 219. *p.* 214.

CHAP. IV.

ASTRONOMY.

I. THE Island *Ween* (vulgarly termed the *Scarlet-Island*) famous for the Observations of *Tycho Brahe,* that renowned *Danish Astronomer* (with all Submission to better Judgments) was none of the fittest for Astronomical Observations of all sorts, such as the taking the exact Time of the true Rising and Setting of Celestial Bodies, together with their respective Amplitudes; because the Island lies low, and is Land-lock'd on all the Points of the Compass, save three. Besides, the sensible Land-Horizon of the *Ween* is extremely uneven and rugged, the North and Eastern Parts thereof being some rising Hills in the Province of *Schonen*; and the Western Part is mostly overspread with Trees on the Island *Zealand*; from the remotest of which Coasts the *Ween* is not distant above three Leagues.

The Observatory of Tycho Brahe; *by Mr.* Gourdon. N. 266. *p.* 692.

II. M. *Weighelius* hath invented an Instrument, which he calls *Astrodicticum,* by the means whereof very many Persons shall be able at one and the same Time to behold one and the same Star. He hath also invented an exceeding great Globe of the World, capable of 10 Persons to sit in it all at once, and to behold the Motions of the celestial Bodies, *&c.*

A new Astronomical Instrument by M. Weighelius. N. 74. *p.* 2219.

III. The Bigness of this Globe is only of four Inches Diameter. The Body of the Globe of burnished Steel, where all the Figures of the Constellations are designed in Silver-Colour, but the Stars themselves of all Magnitudes are put on in embossed Gold.

A Celestial Globe; by M. Didier, P. Alleman. N. 136. *p.* 905.

This Globe moves from East to West in 24 Hours; and you may there see the Sun exactly rise and set as in the great World, together with the Moon, as also the Stars of the Constellations; likewise, how the Sun of this Globe comes to his Meridian, with an admirable Regularity, conform to the *Primum Mobile.* And you may also there perceive the mean Motions of the Sun and Moon from West to East, and all the Lunations; and by the Diurnal Motion of the Moon, it shews the Flux and Reflux of the Sea.

The

The Meridian ſerveth for a Needle to ſhew the Hours, which hath two main Rays, one whereof goeth directly Northward, the other Southward. That of the North marks the Way, or Degree, which the Sun maketh from Weſt to Eaſt upon the Signs of the Zodiack, and upon a Circle of Silver, where the 360 Degrees of the Circle are marked. The other Ray of the South, marks upon another Circle of Silver the Days of the Month, where the 365 Days are noted. The Circles of the Longitude of the Stars, which ſeparate the Signs, and which come from the Poles of the Zodiack, are marked by Gold-Wires; as alſo the Equator, the Tropicks, and the Polar Circles.

There is but one great Spring, the *Primum Mobile*, which puts all the reſt in Motion: It is wound up by the *Antarctick* Pole, and you may wind it up to the Right or Left Hand, without wronging any contrary Motion: And by the *Arctick* Pole, you may advance and retard this Movement, if you ſhould find any Inequality, without altering at all the great Spring.

A Way to meaſure the Diameters of the Planets, and the Parallax of the Moon; by M. Auzout. N. 21. p. 373. Jan. An. 1666.

IV. I applied myſelf the laſt Summer to the taking of the Diameters of the Sun, Moon, and the other Planets, by a Method which M. *Picard* and myſelf have, eſteemed by us the beſt of all thoſe that have been practiſed hitherto; ſince we can take the Diameters to Second Minutes, being able to divide one Foot into 24000 or 30000 Parts, ſcarce failing ſo much as in one only Part, ſo as we can in a manner be aſſured not to deceive ourſelves in 3 or 4 Seconds. I ſhall not now tell you my Obſervations; but I may very well aſſure you, that the Diameter of the Sun has not been much leſs in his *Apogee*, than 31 min. 37 or 40 ſec. and certainly not leſs than 31 min. 35 ſec. and that at preſent in his *Perigee* it paſſes not 32 min. 45 ſec. and may be leſs by a Second or two: That which is at the preſent troubleſome, is, that the vertical Diameter, which is the moſt eaſy to take, is diminiſhed, even at Noon, by 8 or 9 ſec. becauſe of the Refractions, which are much greater in Winter than Summer at the ſame Height; and that the horizontal Diameter is difficult, becauſe of the ſwift Motion of the Heavens.

As for the Moon, I never yet found her Diameter leſs than 29 min. 44 or 45 ſec. and I have not ſeen it paſs 33 min. or if it hath, it was only by a few Seconds. But I have not yet taken her in all the Kinds of Situations of the *Apogees* and *Perigees* which happen, with the Conjunctions and Quadratures. I do not mention all that can be deduced from thence; I ſhall only tell you, that I have found a Way to know the *Parallax* of the Moon, by the means of her Diameter: *viz.* If on a Day, when ſhe is to be in her *Apogee* or *Perigee*, and in the moſt Boreal Signs, you take her Diameter towards the Horizon, and then towards the South, with her Altitudes above the Horizon. For if the Obſervation of the Diameters be exact, as in theſe Situations the Moon changes not conſiderably her Diſtance from the Earth in 6 or 7 Hours, the Difference of the Diameters will ſhew the Proportion there is of her Diſtance with the Semidiameter of the Earth. I do not enlarge, becauſe that as ſoon as one hath this Idea, the reſt is eaſy. The ſame would yet be practiſed better in the Places where the Moon paſſes through the Zenith, than here; for the greater the Difference is of the Heights, the greater is that of the

the Diameters. I do not note (for it eaſily appears) that if one were under the ſame Meridian or the ſame *Azimuth*, in two very diſtant Places, and took at the ſame Time the Diameter of the Moon, one would do the ſame Thing; tho' this Method goes not to Preciſeneſs.

From what has been ſaid may be collected the Reaſon of the Obſervation, which M. *Hevelius* made in the laſt Eclipſe of the Sun (*July* 2. *St. N.* 1666.) touching the Increaſe of the Moon's Diameter about the End. I am exceeding glad, that a Perſon, who probably knew not the Cauſe of it, has made the Experiment; but it is ſtrange, that until now no Aſtronomer has foreſeen that that ſhould happen, nor given any Precepts for the Change of the Moon's Diameter in the Eclipſes of the Sun, according to the Places where they ſhould happen, and according to the Hour and Height the Moon ſhould have: For what happened in that Eclipſe, of Augmentation, would have fallen out contrarily, if it had been in the Evening; for the Moon, which in that Eclipſe that began in the Morning was higher about the End than at the Beginning, was nearer us, and conſequently was to appear bigger: But if the Eclipſe ſhould happen in the Evening, ſhe would be lower at the End, and therefore more diſtant from us, and conſequently appear leſſer. So alſo in two different Places, whereof one ſhould have the Eclipſe in the Morning, and the other at Noon, the Moon ſhould appear bigger to him that hath it at Noon: And ſhe muſt likewiſe appear bigger to thoſe who ſhall have a leſſer Elevation of the Pole under the ſame Meridian, becauſe the Moon will be nearer them.

An Account of M. Gaſcoigne's *Micrometer; by Mr.* Richard Townley. N. 25. *p.* 457. May, An. 1667.

V. 1. I ſhould be looked upon as a great Wronger of our Nation, ſhould I not let the World know, that I have, out of ſome ſcattered Papers and Letters that formerly came to my Hands, of one Mr. *Gaſcoigne*'s, found out, that before our late *Civil Wars* he had not only deviſed an Inſtrument of as great a Power as M. *Auzout*'s, but had alſo for ſome Years made uſe of it; not only for taking the Diameters of the Planets, and Diſtances upon Land; but had farther endeavoured, out of its Preciſeneſs, to gather many Certainties in the Heavens; amongſt which I ſhall only mention one, *viz. The finding the Moon's Diſtance*, from two Obſervations of her Horizontal and Meridional Diameters; which I the rather mention, becauſe the *French Aſtronomer* eſteems himſelf the firſt that took any ſuch Notice, as thereby to ſettle the Moon's Parallax: For our Countryman fully conſidered it before, and imparted it to an Acquaintance of his, who thereupon propoſed to him the Difficulties that would ariſe in the Calculation; with Conſiderations upon the ſtrange Niceties, neceſſary to give him a Certainty of what he deſired. The very Inſtrument he firſt made, I have now by me, and two others more perfected by him; which doubtleſs he would have infinitely mended, had he not been ſlain unfortunately in his late Majeſty's Service. He had a *Treatiſe of Optics* ready for the Preſs; but though I have uſed my utmoſt Endeavour to retrieve it, yet I have in that Point been totally unſucceſsful: But ſome looſe Papers and Letters I have, particularly about this Inſtrument for taking of Angles, which was far from perfect. Nevertheleſs, I find it ſo much to exceed all others, that I have uſed my Endeavours to make it exact, and eaſily tractable; which above a Year ſince I effected to my own Deſire, by the Help of an ingenious and exact Watchmaker: Since which time, I have not altogether neglected it, but employed it particularly in taking the *Diſtances* (as Occaſion ſerved) of the *Circum-jovialiſts*, towards a perfect ſettling their Motion. I ſhall only ſay of it, That it is ſmall, not exceeding in Weight, nor much in Bigneſs, an ordinary Pocket-Watch, exactly marking above 40000 Diviſions in a Foot, by the help of two Indexes; the one ſhewing Hundreds of Diviſions, the other Diviſions of the Hundred; every laſt Diviſion in my ſmall one containing $\frac{1}{10}$ of an Inch, and that ſo preciſely, that, as I uſe it, there goes about 2 $\frac{1}{2}$ Diviſions to a Second. Yet I have taken Land-Angles ſeveral Times to one Diviſion, tho' (for the Reaſon mentioned by M. *Auzout*) it be very hard to come to that Exactneſs in the Heavens, (*viz.* the ſwift Motion of the Planets.) Yet, to remedy that Fault, I have deviſed a *Reſt*, in which I find no ſmall Advantage, and not a little pleaſing thoſe Perſons who have ſeen it, being ſo eaſy to be made, and by the Obſerver managed without the help of another; which ſecond Convenience my yet nameleſs Inſtrument hath in great Perfection, and is, by reaſon of its Smallneſs and Shape, eaſily applicable to any Teleſcope.

A Deſcription of it; by Dr. Hook. N. 29. *p.* 542. Nov. An. 1667.

Fig. 105.

2. *a a a a*, is a ſmall oblong Braſs Box, ſerving both to contain the Screws and their Sockets, or Female Screws, and alſo to make all the ſeveral moveable Parts of the Inſtrument to move very true, ſmooth, and in a ſimple direct Motion. To one End hereof is ſcrewed on a round Plate of Braſs *b b b b*, about 3 Inches over; the extreme Limb of whoſe Outſide is divided into 100 equal Parts, and numbred by 10, 20, and 30, &c. Through the Middle of this Plate, and the Middle of the Box *a a a a*, is placed a very curiouſly wrought Screw, of about the Bigneſs of a Gooſe-Quill, and of the Length of the Box; the Head of which is, by a fixed Ring or Shoulder on the Inſide, and a ſmall ſpringing Plate *d d* on the Outſide, ſo adapted to the Plate, that it is not in the leaſt ſubject to ſhake. The other End of this Screw is by another little Screw (whoſe ſmall Points fill the Center or Hole made in the End of the longer Screw for this Purpoſe) rendered ſo fixed and ſteddy in the Box, that there appears not the leaſt Danger of ſhaking. Upon the Head of this Screw, without the ſpringing Plate, is put on a ſmall Index *e e*, and above that a Handle *m m*, to turn the Screw round as often as there ſhall be Occaſion, without at all endangering the diſplacing of the Index, it being put on very ſtiff upon a cylindrical Part of the Head, and the Handle upon a Square. The Screw hath that Third of it, which is next the Plate, bigger than the other two Thirds of it, by at leaſt as much as the Depth of the ſmall Screw made on it: The Thread of the Screw of the bigger Third is as ſmall again, as that of the Screw of the other two Thirds. To the groſſer Screw is adapted a Socket *f*, faſtened to a long Bar or Bolt *g g*, upon which is faſtened the moveable Sight *h*, ſo that every Turn of the Screw promotes the Sight *h*, either a Thread nearer, or a Thread farther off from the fixed Sight *i*. The Bar *g g*, is made exactly equal, and fitted into two ſmall Staples *k k*, which will not admit of any ſhaking. There are 60 of theſe

Threads,

Threads, and anſwerable thereto are made 60 Diviſions on the Edge of the Bolt or Ruler *g g*, and a ſmall Index *l* fixed to the Box *a a a a*, denotes how many Threads the Edges of the two Sights *h* and *i* are diſtant; and the Index *e e*, ſhews on the circular Plate what Part of a Revolution there is more; every Revolution, as was ſaid before, being divided into 100 Parts. At the ſame Time that the moveable Sight *h* is moved forwards or backwards, one or more Threads of the coarſer Screw, is the Plate *p p*, by the means of the Socket *q*, to which it is ſcrewed, moved forward or backward, one or more Threads of the finer Screw: So that this Plate being fixed to the Teleſcope by the Screws *r r*, ſo as the middle betwixt the Sights may lie in the Axis of the Glaſs, however the Screw be turned, the midſt betwixt the Sights will always be in the Axis, and the Sights will equally either open from it, or ſhut towards it. *Fig.* 106.

It is conceived by ſome ingenious Men, that it will be more convenient, inſtead of the Edges of the two Sights *h* and *i*, to employ two Sights *r* and *s*, fitted with the Hairs *t* and *v*, ſo that they may be conveniently uſed in the Place of the ſolid Edges of the Sights *h* and *i*. *Fig.* 107.

The Inſtrument is thus applied to the Teleſcope. The Tube A D is divided into three Lengths, of which (as in ordinary ones) B C is to lengthen or contract, as the Object requires: But A B is here added, that at A you may put ſuch Eye-Glaſſes as ſhall be thought moſt convenient, and to ſet them ſtill at the Diſtance moſt proper from the Indexes or Pointers, which here are ſuppoſed to be at B, which Length alters alſo in reſpect of divers Perſons Eyes. E is a Screw, by which the great Tube can be fixed ſo, as by the help of the Figures any ſmaller Part of it can immediately be found, meaſuring only, or knowing the Diviſions on B C, the Diſtance of the Object-Glaſs from the Pointers. F is the angular Piece of Wood, that lies on the upper Screw of the Reſt. *Fig.* 108. *Fig.* 109.

This Reſt (by Dr. *Hook*'s Suggeſtion) may be rendered more convenient, if, inſtead of placing the Screw Horizontal, it be ſo contrived, that it may be laid parallel to the Equinoctial, or to the Diurnal Motion of the Earth; for, by that Means, the ſame Thing may be performed by the ſingle Motion of one Screw, which in the other Way cannot be done but by the turning of both Screws; as will eaſily appear to thoſe that ſhall conſider it. *Ibid. p.* 556.

3. I have by me two or three ſeveral Ways of Meaſuring the Diameters of the Planets, whether Horizontal, Perpendicular, or Inclined, to the Exactneſs of a Second, by the help of a Teleſcope; as alſo of taking the Poſition and Diſtance of the ſmall fixed Stars one from another, or from any of the leſs bright Planets, if the Diſtance be not above two or three Degrees. *More Ways to meaſure ſmall Diſtances intimated; by Dr.* Hook. N. 25. *p.* 459. May, An. 1667.

4. With a Micrometer and a Tube of 14 Feet; I have often meaſured the Diameters of the Planets, and their Diſtances from the fixt Stars, almoſt to Seconds; which, without having tried it, you would hardly believe. *Excellence of the Micrometer; by Mr.* Flamſtead. N. 96. *p.* 6099.

Plain Sights rejected; by Mr. Flamstead. N. 89. *p.* 5119. N. 96. *p.* 6100.

VI. 1. It may be proved by many Arguments, that *Tycho* erred from the Truth, by two, three, nay ſometimes four or five whole Minutes, both in the Places and Latitudes aſſigned to ſome of the fixt Stars. We have heard that that great Man *John Hevelius* has undertaken the Reſtitution of the fixt Stars; yet as it is reported he makes uſe of Sights without Glaſſes, it is doubtful whether we ſhall have their Places much more correct from him than thoſe left us by *Tycho*, unleſs where he has been very much miſtaken.

Plain Sights preferred to Telescopic; by M. Hevelius. N. 102. *p.* 27. Apr. An. 1674.

2. I perceive that all your People do not agree with me, in the Buſineſs of Sights, concerning which I have treated in the Organographia of my *Machina Cœleſtis*. But tho' Mr. *Hook* and Mr. *Flamſtead*, and others are of a different Opinion, yet I have been taught by daily Experience, and am ſtill convinced, that the Matter is far otherwiſe in thoſe great Inſtruments, as Quadrants, Sextants, and Octants, and chiefly Azimuth Quadrants, and other Quadrants conſtructed by Rulers, which cannot ſo eaſily or indeed by any means be diſturbed and inverted (which happens to Teleſcopic Sights when they are examined) as thoſe Inſtruments of three or four Feet conſtructed with a Perpendicular. The Matter chiefly amounts to this, that they can undertake no Obſervation with their Teleſcopic Sights, till they examine and rectify them anew; in which Examination there is Room to miſtake perpetually, and different Ways, tho' you perform it never ſo induſtriouſly. And indeed I cannot underſtand by what Method this Examination can be performed, in Azimuthal Quadrants, Octants, and Sextants, at all Times, with Convenience, and without a great Loſs of Time.

I ſee there are ſome alſo (among whom is Mr. *Flamſtead)* who have undertaken to give Judgment upon our Obſervations, whatever they may be, before they have ſeen or examined them, or can know any Thing about them. I do not deſire to be a vain Boaſter of my own Affairs, nor did I ever imagine, that in this Attempt of the Reſtitution of the fixt Stars, knowing my own Weakneſs, that I ſhould be perfect in every thing. But this I am convinced of, that if I had undertook the Buſineſs with the help of Teleſcopic Sights, I muſt not only have waſted many Years with fruitleſs Examinations, but doubtleſs I ſhould have been diſappointed of my Hopes, and that on various Accounts, which it is not neceſſary to mention here. Hence I congratulate with myſelf, that I never could embrace that Opinion, but that I performed every Thing by my own Method, whatever by the Aſſiſtance of God I have performed. Now when we ſhall have Obſervations on both Sides, continued for the Space of 20 or 30 Years; that is, as well thoſe that are made with Teleſcopic Sights, as thoſe which are derived from the Heavens by our plain Sights, the Matter will then be brought to a fair Trial. In the mean Time let every one enjoy his own Opinion, and proceed in his own Way.

Why Celeſtial Objects appear greater when nigh the Horizon than when higher elevated;

VII. 1. It is well known that the mean apparent Magnitude of the Moon is 30 min. 30 ſec. we will take it *Numero rotundo* to be 30 min. at a Full Moon in the midſt of Winter, and when ſhe's in the Meridian, and at her greateſt Northern Latitude, and conſequently the utmoſt that ſhe can be elevated

vated in our Horizon: 'Tis as well known alſo, that when ſhe is in this Poſture, being looked upon by the naked Eye, ſhe appears (that we may accommodate all to ſenſible Meaſures) to be *Magnitudinis Pedalis*, about a Foot broad. But the ſame Moon being looked upon juſt as ſhe riſes, ſhe appears to be three or four Foot broad, and yet if with an Inſtrument we take her Diameter, both in one Poſture and the other, we ſhall find that ſtill ſhe ſhall be but 30 min. That this Matter of Fact is true, beſides the Authority of many Authors, I can aſſert that I have accurately tried it myſelf, and I have ſo found it. One of the Ways I proceeded was thus: I took a very good Teleſcope of about 6 Foot long, in the inward Focus of whoſe Eye-Glaſs I applied a very fine Lattice made of the ſingle Hairs of a Man's Head; then looking with this at the Moon, when ſhe was juſt riſen, and looked extraordinary big, I obſerved what Number of the Squares of the Lattice were occupied by her Body; and then obſerving her again, when more elevated and free from all extravagant Greatneſs, I ſtill found the ſame Squares of the Lattice poſſeſſed by her. This Way is equivalent to that now more uſed, of taking her Diameter by Mr. *Townley*'s Micrometers; but I have alſo tried and found the ſame Thing by an accurate Sextant, taking the Diſtance of the Moon's oppoſite Limbs.

Examined by Mr. Will. Molineux. N. 187. *p.* 314. Apr. An. 1687.

The celebrated *Des Cartes* attributes this Appearance rather to a deceived Judgment, than to any natural Affection of the Organ or Medium of Senſe: For the Moon (ſays he) being nigh the Horizon, we have a better Opportunity and Advantage of making an Eſtimate of her, by comparing her with the various Objects that incur the Sight, in its Way towards her; ſo that tho' we imagine ſhe looks bigger, yet 'tis a meer Deceit; for we only think ſo, becauſe ſhe ſeems nigher the Tops of Trees, or Chimneys, or Houſes, or a Space of Ground, to which we can compare her, and eſtimate her thereby; but when we bring her to the Teſt of an Inſtrument, that cannot be deluded or impoſed upon by theſe Appearances, then we find our Eſtimate wrong, and our Senſes deceived. Theſe Thoughts, methinks, are much below the accuſtomed Accuracy of the noble *Des Cartes*; for certainly if it be ſo, I may at any Time increaſe the apparent Bigneſs of the Moon, tho' in the Meridian; for it would be only by getting behind a Cluſter of Chimneys, a Ridge of a Hill, or the Tops of Houſes, and comparing her to them in that Poſture, as well as in the Horizon; beſides, if the Moon be looked at juſt as ſhe is riſing from an Horizon determined by a ſmooth Sea, and which has no more Variety of Objects to compare her to, than the pure Air, yet ſhe will ſeem big, as if looked at over the rugged Top of an uneven Town, or rocky Country. Moreover, all Variety of adjoining Objects may be taken off, by looking through an empty Tube, and yet the deluded Imagination is not at all helped thereby.

The famous *Thomas Hobbes* gives this Solution. Let the Point G be the Center of the Earth, and F the Eye on the Surface of the Earth; on the ſame Center G let there be ſtruck the two Arches E H, determining the Atmoſphere, and A D to repreſent that blue Surface in which we imagine the Fixed Stars, and let F D be the Horizon: Divide the Arch A D into three * *Fig.* 110.

equal

equal Parts by the Lines B F, C F; it is manifeſt that the Anglé A F B is greater than the Angle B F C, and this again is greater than the Angle C F D. Wherefore (ſays he) to make the Angle C F D equal to the Angle C F B, the Arch C D muſt be greater than the Arch C B; and conſequently, that the Moon may in the Horizon appear under the ſame Angle, as when elevated, ſhe muſt cover a greater Arch, and therefore ſeem greater; that is, the Moon in the Meridian appearing under the Angle B F C, that ſhe may appear under an equal Angle in the Horizon, as ſuppoſe C F D, 'tis neceſſary that the Arch C D ſhould be greater than C B; and conſequently, tho' ſhe appear to ſubtend a greater Arch when in the Horizon than when elevated, yet ſhe appears under the ſame Angle; and all this without Refraction. The Geometry of this Figure is moſt certainly true and demonſtrable. At this I quarrel not; but it makes no more in our preſent Difficulty than if nothing had been ſaid: For he has made the Circle G F, repreſenting the Earth, very large in Proportion to the Circle A D; and then indeed taking the Point F in the Earth's Surface, and by Lines from thence dividing the Angle A F D into whatever equal Parts, the intercepted Arches A B, B C, C D, ſhall be unequal. But if he had conſidered, that the Earth is, as it were, a Point in reſpect of the Sphere of the Fixed Stars, nay the very annual Orbit of the Earth is almoſt imperceptible, he would have found that the Lines F B, F C, F D, muſt be all conceived as drawn from the Point G, and then equal Angles will intercept equal Arches, and equal Arches equal Angles: And ſo it happens (at leaſt beyond the Poſſibility of the Diſcovery of Senſe) to the Eye on the Surface of the Earth; ſo that his drawing his Lines ſo far from G as F is, and to another concentric Circle ſo nigh as A D, deceived him in this Point.

The famous *Gaſſendus* has written four large *Epiſtles* on this Subject, the Subſtance of all which is, That the Moon being nigh the Horizon, and looked at through a more foggy Air, caſts a weaker Light, and conſequently forces not the Eye ſo much as when brighter; and therefore the Pupil does more enlarge itſelf, thereby tranſmitting a larger Projection on the Retina. In this Opinion I find he is not alone; for this Diſquiſition being lately revived by a *French Abbé*, he therein follows the Sentiment of *Gaſſendus*, with this Addition, That this contracting and enlarging of the Pupil cauſeth a different Shape in the Eye; an open Pupil making the Cryſtalline flatter, and the Eye longer, and the narrower Pupil ſhortening the Eye, and making the Cryſtalline more convex: The firſt attends our looking at Objects which are remote, or which we think ſo; the latter accompanies the viewing Objects nigh at hand. Likewiſe an open Pupil and flat Cryſtalline attends Objects of a more ſedate Light, whilſt Objects of more forcible Rays require a greater Convexity and narrower Pupil. From theſe Poſitions the *Abbé* endeavoured to give an Account of our *Phænomenon*, as follows: When the Moon is nigh the Horizon, by Compariſon with interpoſed Objects, we are apt to imagine her much farther from us than when more elevated; and therefore (ſays he) we order our Eyes as for viewing an Object farther from us; that is, we ſomething enlarge the Pupil, and thereby make the Cryſtalline more flat: more-

moreover, the Duſkineſs of the Moon in that Poſture does not ſo much ſtrain the Sight; and conſequently the Pupil will be more large, and the Cryſtalline more flat. Hence a larger Image ſhall be projected on the Fund of the Eye, and therefore the Moon ſhall appear larger. And this Diſpoſition of the Eye that magnifies her, magnifies alſo the Diviſions of our forementioned Lattice, and conſequently ſhe by her Body ſhall poſſeſs no more of the Diviſions than when ſhe ſeems leſs. Theſe two forementioned Accidents, *viz.* The Moon's imaginary Diſtance and Duſkiſhneſs, gradually vaniſhing as ſhe riſes, a different Species is hereby introduced in the Eye, and conſequently ſhe ſeems gradually leſs and leſs, till again ſhe approaches nigh the Horizon. Theſe two Opinions of *Gaſſendus* and the *Abbé* being ſo near a-kin, I ſhall conſider them both together: And firſt I aſſert, That a wider or narrower Aperture of the Pupil increaſes not, neither diminiſhes the Projection on the Retina. I know, *Honoratus Faber*, in his *Synopſis Optica*, endeavours to prove the clear contrary to this my Aſſertion, and that after this manner: A B is an Object, E F the greater Aperture of the Pupil, admitting the Projection K I on the Retina, whereas the leſſer Aperture C D, admits only the Projection G H; but G H is leſs than K I, wherefore a leſſer Aperture diminiſhes the Projection. I admire that any Man that undertook (as *Honoratus Faber*) to write of *Optics* more accurately than all that went before him, ſhould be guilty of ſo very groſs an Error; and I do more admire, that the celebrated *Gaſſendus*, and with him the noble *Hevelius*, ſhould be of the ſame Opinion: For tho' the aforeſaid Demonſtration hold moſt certainly true in direct Projections, as in a dark Room with a plain Hole; yet it will not hold in Projections made by Refraction, as it is in thoſe on the Retina in the Eye, by means of the Cryſtalline, and other Coats and Humours of the Eye. For let A B be a remote Object, and E F the Cryſtalline at its large Aperture, projecting the Image I M on the Rtina. Let then C D be the leſſer Aperture of the Pupil before the Cryſtalline: I ſay, the Image I M ſhall be projected as large as before; for the Cone of Rays E A F conſiſts partly of the Cone of Rays C A D; therefore where the former E A F is projected, the latter C A D, as being a part of the former, ſhall be projected alſo. So that no more is effected by this narrow Aperture, but that the Sides of the radiating Cones are intercepted, and conſequently the Point I ſhall be affected with leſs Light, but it ſhall ſtill be in the ſame Place: What is ſaid of that Cone and that Point, may be ſaid of all other Cones and other Points of the Object. From hence appears, *Firſt*, The Invalidity of the Account given of the Moon's Appearance by *Gaſſendus* from this Reaſon. *Secondly*, The Reaſon appears why a Teleſcope's leſſer or greater Aperture, makes no Difference in the Angle it receives: For imagine E F to be an Object-Glaſs of a Teleſcope, and 'tis plain. *Thirdly*, 'Tis evident why a greater or leſs Aperture on a Teleſcope ſhould make the Objects appear lighter, or darker; for thereby more or leſs Rays are admitted to determine on the Projection of each Point. But all this by the by: And this is ſufficient for a Confutation of *Gaſſendus* and *Faber*. But our forementioned *Abbé* ſuperadds to a greater or leſſer Aperture of the Pupil, as a neceſſary Conſe-

Fig. 111.

Fig. 112.

quent,

quent, a greater and leffer Convexity of the Cryftalline, as alfo a Lengthening and Shortening the Tube of the Eye. And this I muft confefs would do fomething, if we find it true in our Cafe; and this let us try. *Firft*, (fays he) The Dufkifhnefs of the Moon nigh the Horizon admits the Pupil to enlarge itfelf, the Cryftalline to flatten, and the Eye to lengthen: But what if we change our Object, and inftead of the Moon take the Diftance between fome of the Fixed Stars (as fuppofe thofe of *Orion's Girdle*) we fhall find the fame *Phænomenon* in them, and yet I hope neither he nor *Gaffendus* will affert, that they at one Time ftrain the Eye more than at another, or that at any time their Fulgur ftrains the Eye at all; if he do, let him take Stars of the leffer Magnitudes, nay even thofe that can but juft be perceived, and then he will be convinced: Or let him confider, whether this will hold in looking at the Sun through very dark Glaffes, which render the Sight thereof as inoffenfive to the Eye as that of a green Field; but perhaps he will then fay, that this other Reafon holds, which is, *Secondly*, That the greater imaginary Diftance, at which we think the Moon near the Horizon, than when more elevated, makes us contemplate her as if really fhe was fo, *viz.* with ample Pupils, *&c.* But this I have fufficiently overthrown in my Remarks againft *Des Cartes:* Therefore I pafs it over, only fubjoining, that if there were any thing in this Surmife, methinks the horizontal Moon fhould rather be fancied nigher to us than farther from us; for if we are for trying natural Thoughts, let us take Children to determine the Matter, who are apt to think, that could they go to the Edge of that Space that bounds their Sight, they fhould be able (as they call it) to touch the Sky; and confequently the Moon feems then rather nigher to us than farther from us.

After I had writ thus far, I accidentally caft my Eye upon *Riccioli's* Treatife of *Refraction*, at the End of his Second Volume of *Almageft*, *Lib.* 10. *Sect.* 6. *Cap.* 1. *Queft.* 13. wherein he fpeaks of our prefent Difficulty; but to my wonder I find him affert, That he and Father *Grimaldi* had often taken the horizontal Sun and Moon's Diameters by a Sextant, when to the naked Eye they appeared very large (*Grimaldus* directing his Sight to the left Edge, and *Ricciolus* to the right) and that even by the Inftrument they always found the Diameters greater than when more elevated, the Sun often fubtending an Angle of almoft a Degree, and frequently 45 Minutes, the Moon alfo 38 or 40 Minutes. This is downright contrary to the Matter of Fact which I have before alledged, and directly repugnant to the Matter of Fact afferted by the forementioned *French Abbé:* Whether of us be in the right, I leave to accurate Experiment to determine, and fubmit the Whole to the Decifion of the illuftrious *Royal Society*. Only give me leave to add one Word againft *Riccioli*; for had his Experiments been accurately profecuted, he fhould have tried them when the horizontal Moon had looked ten times more large in Diameter than ordinary; and then, if it be true, that even by an Inftrument fhe will be found proportionally broader; then really fhe fhould fubtend an Angle of 300 Min. or 5 Deg. for very often I have feen the Moon when fhe appeared ten times broader than ordinary,

which

which the ſmall Addition of 8 or 10 Min. to her uſual Diameter will never cauſe.

2. I diſcourſed of this Appearance near 40 Years ago with Mr. *Foſter*, then *Profeſſor of Aſtronomy* in *Greſham* College, who did then aſſure me (from his own Obſervation I ſuppoſe) that the apparent Magnitude taken by Inſtruments (however the Fancy may apprehend it) is not greater at the Horizon than when higher. Mr. *Caſwell* affirms the ſame Thing; and I do not doubt but the Thing is ſo: For though Refraction near the Horizon alters the Altitude of the Thing ſeen; yet it cannot alter the Azimuth at all. For ſince this equally reſpects all Points of the Horizon; let the Refraction be what it will, the whole Horizon can be but a Circle: So that there is no room for the Breadth of a Thing (as to the Angle at the Eye) to be made greater, whatever its Tallneſs may (the Refraction not equally affecting all Parts in the Circles of Altitude). Nor is there any Reaſon, why this ſhould rather thruſt the other, than the other thruſt this, out of Place. Whereas, in the Altitude, it is otherwiſe: For while what is near the Horizon is enlarged, that which is further off is thereby contracted: which, as to the Azimuth, or Horizontal Poſition, cannot be.

This Phænomenon conſider'd; by Dr. Wallis. Ibid. p. 323.

Suppoſing then that the Sun's apparent Horizontal Diameter, taken by Inſtrument, is the ſame near the Horizon, as in a higher Poſition; I take its imaginary Greatneſs, which is fancied near the Horizon, to be only a Deception of the Eye, or rather the Imagination from the Eye.

For ſure it is, that the Imagination doth not eſtimate the Greatneſs of the Object ſeen, only by the Angle which it makes at the Eye; but, by this compared with the ſuppoſed Diſtance. True it is, that, *cæteris paribus*, we judge that to be the greater Object which makes at the Eye the greater Angle; but not ſo, if apprehended at different Diſtances.

For if through a Caſement (or leſſer Aperture) we ſee a Houſe at 100 Yards Diſtance; this Houſe (though ſeen under a leſs Angle) doth not to us ſeem leſs than the Caſement through which we ſee it, (or this greater than that, becauſe it makes at the Eye the greater Angle) but the Imagination makes a comparative Eſtimate from the Angle and Diſtance jointly conſidered.

So that of two Things ſeen under the ſame or equal Angles, if to one of them there be ought which gives the Apprehenſion of a greater Diſtance, that to the Imagination will appear greater. Now ſure it is, that one great Advantage for eſtimating the Diſtance of a Thing ſeen, is from the Variety of intermediate Objects between the Eye and the Thing ſeen. For then the Imagination muſt allow room for all theſe Things.

Now when the Sun or Moon is near the Horizon, there is a Proſpect of Hills, and Valleys, and Plains, and Woods, and Rivers, and Variety of Fields and Incloſures, between it and us; which preſent to our Imagination a great Diſtance capable of receiving all theſe: Or if it ſo chance that (in ſome Poſition) theſe Intermediates are not actually ſeen; yet having been accuſtomed to ſee them, the Memory ſuggeſts to us a View as large as is the viſible Horizon.

 But

But when the Sun or Moon is in a higher Poſition, we ſee nothing between us and them (unleſs perhaps ſome Clouds) and therefore nothing to preſent to our Imagination ſo great a Diſtance as the other is.

And therefore, though both be ſeen under the ſame Angle, they do not appear (to the Imagination) of the ſame Bigneſs; becauſe not both fancy'd at the ſame Diſtances: But that near the Horizon is judged bigger (becauſe ſuppoſed farther off) than the ſame when at a greater Altitude.

'Tis true, that as to ſmall and middling Diſtances (beſides this Eſtimate from Intermediates) the Eye hath a Means within itſelf to make ſome Eſtimate of the Diſtance. As, when we already know the Bigneſs of a thing ſeen, to which we have been accuſtomed; as, a Man, a Tree, a Houſe, or the like: If ſuch thing appear to us under a ſmall Angle, and indiſtinct, and faintly coloured, the Imagination doth allow ſuch Diſtance as to make ſuch a thing ſo to appear. And if this, through a Perſpective-Glaſs, be repreſented to us under a bigger Angle, and more diſtinct, it is accordingly apprehended as ſo much nearer. But the Caſe is otherwiſe, when we do not, by the known Bigneſs, judge the Diſtance; but, by the ſuppoſed Diſtance, judge of the Bigneſs, as in the Caſe before us. And accordingly, different Perſons, according to different fancied Diſtances, judge very differently.

Again: In our two Eyes (when the Object is ſeen by both) there is yet another Means of eſtimating how far off it is. (And it is this by which we judge of Diſtances.) Namely, there are from the ſame Object, two different viſual Cones, terminated at the two Eyes; whoſe two Axes contain, at the Object, different Angles, according to different Diſtances; an acuter Angle at a greater Diſtance, and more obtuſe when nearer.

Now, that ſuch Object may be ſeen by both Eyes clearly, it is requiſite that the Eyes be put in ſuch a Poſition, as that the Sight of each Eye receive the reſpective Axis at Right Angles; which requires a different Poſition of the two Eyes, according to the different Diſtance of the Object: As will manifeſtly appear, if we look with Attention on a Finger (or other ſmall Object) at 2 or 3 Inches Diſtance from the Eye, and then upon another like Object at 3 or 4 Yards beyond it (and this alternately ſeveral times.) For it will be manifeſt, that while we look intently on the one, we do not ſee the other (or but confuſedly) though both be juſt before us. And, as we change our View, from the one to the other, we manifeſtly feel a Motion of the Eyes (by their Muſcles) from one Poſture to another.

And according to the different Poſture in the Eyes, requiſite to a clear Viſion by both, we eſtimate the Diſtance of the Object from us.

And hence it is, that they who have loſt the Sight of one Eye, are at a great Diſadvantage, as to eſtimating Diſtances, from what they could do while they had the Uſe of both.

But now when the Diſtance grows ſo great, as that the Poſition of theſe viſual Axes become parallel, or ſo near to parallel as not to be diſtinguiſhable from it, this Advantage is loſt, and we can thenceforth only conclude, that it is far off; but not how far. Hence it is, that our View can make no Diſtinction of the Moon's Diſtance from that of the other Planets, or even of the fixed Stars: But they seem to us as equally remote from us; though we otherwise know their Distances from us to be vastly different; because the Parallax (as I may so call it) from the different Position of the two Eyes, is quite lost, and undiscernable in Distances much less than the least of these.

So that, though as to small Distances we may make some Estimate from the known Magnitude of the Object; and as to middling Distances, from the Parallax (as I may call it) arising from the Interval of the two Eyes: Yet even this latter will hardly reach beyond, if so far as, the visible Horizon, and all beyond it is lost. And therefore, there being nothing left to assist the Fancy in estimating so great a Distance, but only the intermediate Objects; where these Intermediates appear to the Eye (as when the Sun or Moon are near the Horizon) the Distance is fancied greater, than where they appear not (as when farther from it) and consequently (though both under the same or equal Angles) that near the Horizon is fancied the greater: And this I judged to be the true Reason of that Appearance.

VIII. We took a Cylinder of cast Brass, ABCD, and cut one End of it CD, perpendicular to the Axis *acx*; the other End AB, inclined to it at an Angle of about 27 deg. 30 min. and therefore the Perpendicular to this inclining Plane *pc*, and the Axis of the Cylinder *acx*, comprehended an Angle *pca*, of about 62 deg. 30 min. These Ends were ground very true upon a Glass-Grinder's Brass Tool, and each of them was compass'd about with a narrow Feril of thin Brass *bbbb*. Into the upper Side of the Cylinder, at E, was soldered the Brass-Pipe EF, and into the under Side, at G, the other Brass-Pipe GH; the former of these Pipes being about 3 Inches long, and the latter 6 Inches. Upon the Plate *ddd*, were fixed two other Plates, LL, perpendicular to it, and parallel to each other. Each of these two Plates had an Arch of a Circle (whose Diameter was equal to that of the Cylinder) cut out of its proper Edge; so that when the Pipe GH was let thro' a Hole near the Middle of the Plate *ddd*, the Cylinder fell into the Arches; and being fastened there with Solder, the Axis *acx* lay Parallel to the Plate *ddd*, and about an Inch and an half above it. The perpendicular End of the Cylinder, DC, was closed with an Object Glass of a $7\frac{1}{2}$ Foot Telescope *oo*, and the inclining End AB, with a well polished flat Glass, *ff*; which was carefully chosen to transmit the Object distinct enough, notwithstanding its Obliquity to the visual Rays. The Ferils were filled with Cement round about the Edges of the Glasses, which lay flat, and every where touched the smooth Ends of the Cylinder, that they might firmly support the Weight and Pressure of the excluded Air.

An Experiment of the Refraction of the Air; by Mr. Lowthorpe. N. 257. *p.* 329. Mar. An. 1699.

Fig. 113.

Instead of a Cistern (as in the *Torricellian* Experiment) we made use of the inverted Syphon of Brass MNO, solder'd to the Plate *ggg*. One of the Sides MN, stood perpendicular to the Plate *ggg*, and the other Side NO, inclined to it, and was supported near the upper End O, with a little Piece of Brass, *kk*.

Fig. 114.

We then placed the Cylinder upon a Table, which was well faſtened to a firm Floor: The Pipe G H, was let through a Hole in the Top of the Table; and the Plate *d d d*, was nailed down to it: The Tube of the Teleſcope *s s s*, with the Eye-Glaſs in it, was applied to the Object-Glaſs, and a Hair fixed at *x*, the common Focus of both Glaſſes, in the Axis of the Cylinder continued to it. Upon the Floor (under the Cylinder) we nailed the Plate *g g g*, with the inverted Cyphon upon it, and joined M to H, by the Inſertion of the Glaſs Tube T. The Joints were very carefully cloſed with Cement, and then covered over with Pieces of a Bladder wrapped hard with ſtrong Thread. There was alſo a Bladder tied below each Joint at *m*, and when it was filled with Water it was tied about at *n*; ſo that no Air could come to the Cement, to inſinuate itſelf through its Pores or Fiſſures, if any happened to be left uncloſed.

Fig. 115.

It will not (I hope) be thought more than neceſſary, that in this Account of the *Apparatus*, I have mentioned ſo many minute Circumſtances; for we found it difficult enough to exclude the Air, and almoſt impoſſible to diſcover the very little Holes through which ſo ſubtle a Fluid would freely enter and poſſeſs the Spaces deſerted by the *ſubſiding Mercury*. But, with all this Precaution, the Experiment ſucceeded at laſt, as I wiſhed; after this Manner:

We placed the Object *a* (which was a black Thread faſtened in a little Frame over a Piece of white Paper) in the Axis of the Cylinder *x c a*: We filled the Pipes and Cylinder with *Mercury*; and having ſtopped the upper End of the Pipe at F, with the little Iron Stopple K, and cloſed it, at the upper Part of the Tube and other Joints, we let the *Mercury* run out gently at O (into the Bladder *u*) till it remained ſuſpended at the uſual Height (as in the *Barometer*) leaving the upper Part of the Tube, and the Cavity of the Cylinder between the Glaſſes *o o*, and *f f*, void of Air. We then ſaw the Object, which before appear'd in the Axis at *x*, raiſed conſiderably above it; and we reduced it to appear again at *x*, by removing it from *a* to *α*. The Axis therefore of the viſual Ray (which was alſo the Axis of the Cylinder) *x c a*, falling perpendicularly on the void Space, paſſed through it without any Refraction: but emerging obliquely into the Air, it was refracted towards the Perpendicular *p c*, and received a new Direction to *α*. And therefore the Diſtance *a α*, ſubtended the Angle of Refraction *a c α*; all which we meaſured, and found as follows; *viz.*

	Inches.	*Dec. Parts.*
The Height of the Object above the Axis, or the unrefracted viſual Ray *a α* - - - - - - -	000	425
The Diſtance of the Object from the refracting Plain *α c*, about 51 Feet, or — — —	612	000

	Deg.	*Min.*	*Sec.*
Therefore the Angle of Refraction *a c α*, was —	00	02	23
The Angle of Emerſion *p c a*, (by the Construction of the Cylinder) was — — — —	62	30	00

There-

	Deg.	Min.	Sec.
Therefore the Angle of Incidence $p c \alpha = p c a +$ $a c \alpha$, was — — — — — — —	62	27	37

And therefore *univerſally*, (according to the known Laws of Refraction)

The Sines of the Angles of Incidence being — — — —	100000
The Sines of the Angles of Emerſion are — — — —	100036
And the refractive Power of the denſe Air — — — — —	36

By the *refractive Power* of a pellucid Body, I mean that Property in it whereby the oblique Rays of Light are diverted from their direct Courſe, and which is meaſured by the proportional Differences (always obſerved) between the Sines of the Angles of Incidence and Emerſion.

This Property is not always proportional to the Denſity (at leaſt not to the Gravity) of the refracting Medium: For the refractive Power of Glaſs to that of Water is as 55 to 34, whereas its Gravity is as 87 to 34; that is, the *Squares* of their refractive Powers are (very near) as their reſpective Gravities. And there are ſome Fluids, which, tho' lighter than Water, yet have a greater Power of Refraction: Thus the refractive Power of Spirit of Wine (according to Dr. *Hook*'s Experiment, *Micrógr. Obſ.* lviii. *p.* 220.) is to that of Water, as 36 to 23; and its Gravity *reciprocally* as 23 to 36, or $36\frac{1}{2}$. But the refractive Powers of Air and Water ſeem to obſerve the *ſimple* Proportion of their Gravities *directly*, as I have compared them in the following Table. The Numbers there expreſſing the Refraction of Water are taken from the Mean of Nine [a] Experiments, made at ſo many ſeveral Angles of Incidence, *Jan.* 25, $164\frac{0}{1}$, by Mr. *Gaſcoigne*, (the ingenious firſt Inventor of the Micrometer, and the Ways of meaſuring Angles by Teleſcopes) and thoſe of Air are produced by the preceding Experiment.

	Water.	Air.
The (aſſumed) Sines of the Angles of Incidence on the Void from — — — — — —	100000	100000
The Sines of the correſpondent Angles of Emerſion out of — — — — — — —	134400	100036
The refractive Power of — — — — —	34400	36
The ſpecifick Gravity (if as 900 to 1 at the Time of the Experiment) of — — — —	34400	38
Or (if as 850 to 1) of — — — — — —	34400	40

[a] I am indebted for theſe Experiments to the Reverend and very accurate Aſtronomer Mr. *Flamſtead*; who copied them, together with many other Obſervations and ſeveral Paſſages relating to them, from Mr. *Gaſcoigne*'s *Letter* to Mr. *Crabtree:* They were happily preſerved, in the Time of our Civil War, by the late Sir *Jonas Moor*, and Mr. *Chr. Townley*; and they are now in the Hands of Mr. *Rich. Townley*, of *Townley* in *Lancaſhire*, by whom they were imparted ſome Time ago to Mr. *Flamſtead*.

From

From hence it ſeems very probable, that their reſpective Denſities and refractive Powers are in a juſt *ſimple* Proportion. And if this ſhould be confirmed by ſucceeding Experiments, made at different Angles of Incidence, and with Cylinders continuing exhauſted through ſeveral Changes of the Air, it would be more than probable that the refractive Powers of the Atmoſphere are every where, and at all Heights above the Earth, proportional to its Denſities and Expanſions: And then it would be no difficult Matter to trace the Light through it, ſo as to terminate the Shadow of the Earth, and (together with proper Expedients for meaſuring the Quantity of Light illuminating an opake Body) to examine at what Diſtances the Moon muſt be from the Earth to ſuffer Eclipſes of the obſerved Duration.

To find the Parallax of the Fixed Stars; by Dr. Wallis, *to Mr.* William Molyneux. July, An. 1693. N. 202. *p.* 844.

IX. Give me leave to ſuggeſt a Speculation, which hath been in my Thoughts theſe forty Years or more; but I have not had the Opportunity of reducing it to Practice: It is concerning the Parallax of the fixed Stars, as to the Earth's annual Orbit.

Galileo complains of it a great while ſince (in his *Syſtema Coſmicum*) as a Thing not attempted to be obſerved with ſuch Diligence as he could wiſh; and I doubt we have the ſame Cauſe of complaining ſtill. I know that Dr. *Hook* and Mr. *Flamſtead* have attempted ſomewhat that way, but have deſiſted before they came to any Thing of Certainty. What hath been done to that Purpoſe Abroad I know not.

Galileo hath ſuggeſted divers Things conſiderable in order to it; as, the Times of Obſervation, the Stars to be obſerved, and the Manner of obſerving them; which yet I doubt is not practicable. That which occurred to my Thoughts upon theſe Conſiderations, was to this purpoſe: That ſome circumpolar Stars (nearer to the Pole of the Equator than is our *Zenith*, and not far from the Pole of the Zodiack) ſhould be made choice of for this purpoſe. And in caſe the meridional Altitude be diſcernibly different at different Times, ſo will alſo be their utmoſt Eaſt and Weſt Azimuth, which may be better obſerved than their Riſing or Setting: And this will not be obnoxious to the Refraction, as is the meridional Altitude (for though the Refraction do affect the Altitude, yet not the Azimuth at all;) and we may here have choice of Stars for the purpoſe; which, in Obſervations from the Bottom of a Well, we cannot have; being there confined to thoſe only which paſs very near our Zenith, tho' very ſmall Stars.

I would then take for granted, as a Thing at leaſt very probable, that the fixed Stars are not all (as was wont to be ſuppoſed) at the ſame Diſtance from us, but the Diſtance of ſome vaſtly greater than of others; and conſequently, though as to the more remote, the Parallax may be undiſcernible, it may, perhaps, be diſcernible in thoſe that are nearer to us.

And thoſe we may reaſonably gueſs (though we are not ſure of it) to be neareſt to us, which to us do appear biggeſt and brighteſt, as are thoſe of the *Firſt* and *Second* Magnitude; and there are at leaſt of the *Second* Magnitude pretty many not far from the Pole of the Ecliptic (as that in particular in the *Shoulder* of the *Leſſer Bear:*) And, in caſe we fail in one, we may try again

again and again on ſome other; which may chance to be nearer to us than what we try firſt. And Stars of this Bigneſs may be diſcerned by a moderate Teleſcope, even in the Day-time; eſpecially when we know juſt where to look for them.

The Manner of Obſervation, I conceive, may be thus. Having firſt pitched upon the Star we mean to obſerve, and having then conſidered (which is not hard to do) where ſuch Star is to be ſeen in its greateſt Eaſt or Weſt Azimuth; it may be then convenient to fix (very firm and ſteddily on ſome Tower, Steeple, or other high Edifice, in a convenient Situation) a good Teleſcopic Object-Glaſs in ſuch Poſition as may be proper for viewing that Star. And at a due Diſtance from it, near the Ground, build on purpoſe (if already there be not any) ſome little Stone Wall, or like Place, on which to fix the Eye-Glaſs, ſo as to anſwer that Object-Glaſs: And having ſo adjuſted it, as through both to ſee that Star in its deſired Station (which may beſt be done while the Star is to be ſeen by Night in ſuch Situation, near the Time of one of the Solſtices) let it be there fixed ſo firmly, as not to be diſturbed (and the Place ſo ſecured, as that none come to diſorder it) and care be taken ſo to defend both the Glaſſes, as not to be endangered by Wind and Weather. In which Contrivance, I am beholden to Mr. *John Caſwel*, M. A. of *Hart-Hall* in *Oxford*, for his Advice and Aſſiſtance, with whom I have many Years ſince communicated the whole Matter.

This Glaſs being once fixed (and a Micrometer fitted to it, ſo as to have its Threads perpendicular to the Horizon, to avoid any Inconvenience which might ariſe from Diverſity of Refraction, if any be) the Star may then be viewed from Time to Time (for the following Year, or longer) to ſee if any Change of Azimuth can be obſerved.

This I thought fit to recommend to your Conſideration, who do ſo well underſtand Teleſcopes, and the Managery of them: But when I ſuggeſt (as a convenient Star for this purpoſe) the *Shoulder* of the *Leſſer Bear* (as being the neareſt to the Pole of the Zodiack of any Star that is of the Firſt or Second Magnitude) I do not confine you to that Star; but (without retracting that) ſuggeſt another; namely, the *Middle Star*, in the *Tail* of the *Great Bear*, which (though ſomewhat further from the Pole of the Zodiack) is a brighter Star than the other, and may be nearer to us.

But I do it principally upon this Conſideration; namely, That there is adhering to it a very ſmall Star (which the *Arabs* call *Alcor*, of which they have a proverbial Saying, when they would deſcribe a ſharp-ſighted Man, That he can diſcern the *Rider* on the *Middle Horſe* of the *Wayn:* And of one who pretends to ſee ſmall Things, but overlooks much greater, *Vidit Alcor at non Lunam Plenam*) which *Hevelius* in his Obſervations finds to be diſtant from it about nine Minutes and five or ten Seconds: So that beſides the Advantage of diſcovering the Parallax of the greater Star, if diſcernible; the Difference of the Parallax of that and of the leſſer Star (being both within the Reach of a Micrometer) may do our Work as well. For if that of the greater Star be diſcernible, but that of the leſſer be either not diſcernible or leſs diſcernible, their different Diſtances from each other at different Times

of

of the Year may perhaps (without farther *Apparatus*) be discerned by a good Telescope of a competent Length, furnished with a Micrometer, if carefully preserved from being disordered in the Intervals of the Observations; and discover at once, both that there is a Parallax, and that the Fixed Stars are at different Distances from us; wherein, that I may not be mistaken, my Meaning is not that the Instrument or Micrometer should be removed for the observing of the Lesser Star, but that (when the Azimuth of the Greater Star is taken) by a Micrometer (consisting of divers fine Threads parallel and transverse) may (at the same Time) be observed the Distance of the two Stars, each from other, in that Position (both being at once within the Reach of the Micrometer) Which Distance (the Instrument remaining unmoved) if it be found (at different Times of the Year) not to be the same, this will prove that there is a different Parallax of these two Stars.

This latter Part of the Observation (of their different Distances at different Times) I suggest as more easily practicable, though not so nice as the former: For it may be done, I think, without any further *Apparatus* there than a good Telescope of ordinary Form, furnished with a Micrometer, (this being carefully kept unvaried during the Interval of these Observations.) And if this Part only of the Observation (without the other) be pursued, it matters not though the two Observations (near the two Solstices) be, one at the Eastern, the other at the Western, Azimuth (whereby both may be taken in the Night-time) for the Distance must (at both Azimuths) be the same. If, after observing the Azimuth of the greater Star, it be necessary to move the Micrometer for measuring its Distance from *Alcor*, that may be done another Night, (and it is not necessary to be done at one Observation) for that Distance cannot be discernibly varied in a Night or two.

Concerning the Distance of the Fixed Stars; by Mr. Francis Roberts. *N.* 209. *p.* 101.

X. Since the *Pythagorean System* of the World has been revived by *Copernicus*, (and now by all Mathematicians accepted for the true one) there seemed Ground to imagine, that the Diameter of the Earth's annual Course (which, according to our best Astronomers, is at least 40000 Times bigger than the Semidiameter of the Earth) might give a sensible Parallax to the Fixed Stars, and thereby determine their Distance. But there are some Considerations which make us suspect that even this Basis is not large enough for that Purpose.

M. *Huygens* (who is very exact in his Astronomical Observations) tells us, He could never discover any visible Magnitude in the Fixed Stars, though he used Glasses which magnified the apparent Diameter above 100 Times.

Now, since in all likelihood the Fixed Stars are Suns, (perhaps of a different Magnitude) we may, as a reasonable Medium, presume they are generally about the Bigness of our Sun.

Let

Let us then (for Example) ſuppoſe the *Dog-Star* to be ſo. The Diſtance from us to the Sun being about 100 Times the Sun's Diameter, it is evident, that the Angle under which the *Dog-Star* is ſeen in Mr. *Huygens*'s Teleſcope, muſt be near the ſame with the Angle of its Parallax to the Sun's Diſtance, or Semidiameter of the Earth's annual Courſe; ſo that the Parallax to the whole Diameter can be but double ſuch a Quantity as even to Mr. *Huygens*'s nice Obſervation is altogether inſenſible.

The Diſtance therefore of the Fixed Stars ſeems hardly within the reach of any of our Methods to determine: But from what has been laid down, we may draw ſome Concluſions that will much illuſtrate the prodigious Vaſtneſs of it.

1. That the Diameter of the Earth's annual Orb (which contains at leaſt 160 Millions of Miles) is but as a Point in compariſon of it; at leaſt it muſt be above 6000 Times the Diſtance of the Sun: For if a Star ſhould appear through the aforeſaid Teleſcope half a Minute broad, (which is a pretty ſenſible Magnitude) the true apparent Diameter would not exceed 18''', which is leſs than the 6000th Part of the apparent Diameter of the Sun; and conſequently the Sun's Diſtance not the 6000th Part of the Diſtance of the Star.

2. That could we advance towards the Stars 99 Parts of the whole Diſtance, and have only 100th Part remaining, the Stars would appear little bigger to us than they do here: For they would ſhew no otherwiſe than they do through a Teleſcope which magnifies an hundred-fold.

3. That at leaſt 9 Parts in 10 of the Space between us and the Fixed Stars can receive no greater Light from the Sun, or any of the Stars, than what we have from the Stars in a clear Night.

4. That Light takes up more Time travelling from the Stars to us, than we in making a *Weſt-India* Voyage (which is ordinarily performed in ſix Weeks:) That a Sound would not arrive to us from thence in 50000 Years, nor a Cannon-Bullet in a much longer Time. This is eaſily computed, by allowing (according to Mr. *Newton*) 10 Minutes for the Journey of Light from the Sun hither, and that a Sound moves above 1300 Feet in a Second.

The Places of the chiefeſt Fixed Stars, according to the beſt ancient Obſervers; by Dr. Edward Bernard, *to* Dr. Robert Huntington. N. 158. *p.* 567.

XI. Among your *Arabick* Books in the Library of *Merton* College (of which you have above forty, which abound with the Doctrine and Obſervations of the Heavens) in the *Ilchanic* Tables, by the Care of that famous *Perſian Choaga Naſirodinus Tuſius*, I have found it repreſented in a ſhort Page, what were the Latitudes and what the Longitudes of ſome of the principal Fixed Stars, according to the Obſervations of divers Aſtronomers. This little Canon I have enlarged, as you ſee, partly from your own Stock, and partly from others. I would not pretend to have done any great Matter in this,

this, but that the preſent Age may have ſome Notion of the Aſtronomy of the Eaſt, where it is plain this Science had its firſt Original. Certainly there are many Things that recommend to us the Aſtronomy of the Eaſtern People: The peculiar Felicity and Serenity of the Regions in which they obſerved; the Largeneſs and Accuracy of their Machines, being ſo great that we can hardly conceive how they applied them to the Heavens; beſides the great Number of Obſervers and Writers, ten Times more than the *Greeks* or *Latins* can boaſt of; to which you may add, that their Princes were ten Times more powerful and munificent, who ſupplied ingenious Men with Wealth, and a neceſſary Apparatus for Celeſtial Obſervations. But what the *Arabian* Aſtronomers have juſtly reprehended in *Cl. Ptolomy*, the great Conſtructor of the Celeſtial Art; how diligently they diſtinguiſhed and meaſured the ſmalleſt Parts of Time by Drops of Water, by vaſt Sun-Dials, nay (which you will wonder at) by the Vibrations of a pendulous Thread; how ſkilfully and accurately they were converſant in that great Attempt of Human Ingenuity, concerning the Extent and Diſtances of the two great Luminaries and of our Earth; are too much for one Epiſtle to declare.

A Table

A Table of the principal Fixed Stars, according to the Observations of the Antients.

			Magnit.	By *Ptolomy*, in his *Magna Syntaxis*. A. C. 137. Long. S. ° ′	Lat. ° ′
1	34	The last Star of *Fluvius.*	1	0 10 30 al. 50	53 30 *s.*
2	12	The bright Star of *Cassiopeia*'s Chair.	3	0 7 50	51 40 *n.*
3	12	*Perseus*'s Head of *Medusa Algol.*	2	9 29 40 al. 20	23 0 *n.*
4	14	The Southern Eye of the *Bull.*	1	1 12 40 al. 20	5 10 *s.*
5	35	The Left Foot of *Orion. Rigel.*	1	1 20 50	31 30 *s.*
6	3	The little Kid of *Auriga.*	1	1 25 0	22 30 *n.*
7	2	*Orion's* Right Shoulder.	1	2 2 0	17 0 *s.*
8	1	The *Dog-Star. Alhabor.*	1	2 17 40 al. 20	39 10 *s.*
9	2	The *Little Dog. Algomeisa.*	1	2 29 30 al. 10	16 10 *s.*
10	8	The *Lyon's* Heart. *Regulus.*	1	4 2 30 al. 10	0 10 *n.*
11	14	*Spica Virginis.*	1	5 26 40	2 0 *s.*
12	23	*Arcturus.*	1	5 27 0	31 30 *n.*
13	8	*Antares.* The *Scorpion's* Heart.	3	7 12 40 al. 20	4 0 *s.*
14	1	The Head of *Serpentarius.*	2	7 24 50	36 0 *n.*
15	1	The bright Star of the *Harp.*	1	8 17 20	62 0 *n.*
16	3	The bright Star of the *Eagle.*	2	9 3 50	29 10 *n.*
17	5	The bright Star in the Tail of the *Swan.*	2	10 9 10	60 0 *n.*
18	3	The bright Star in the Right Leg of *Pegasus. Seat.*	2	11 2 10	35 0 *n.*
19	2	The last Star of *Pegasus*'s Wing. *Algenib.*	2	11 12 10	12 30 *n.*
20	7	The bright Side of *Perseus.*	2	1 4 50	30 0 *n.*
21	27	The *Lyon's* Tail.	1	4 24 30	11 50 *n.*
22	1	The Mouth of the *South Fish.*	1	10 7 0	23 0 *s.*
23	44	*Canopus.*	1	2 17 10	75 0 *s.*

A Table

A Table of the principal Fixed Stars, according to the Observations of the Antients.

	Ali Abolcasimus. A. C. 938.					*Abdorahmanus Sophius.* A. C. 964.[a]			*Ebnolalamus.* A. C. 980.				
	Long.			Latit.		Long.			Long.			Latit.	
	S.	°	′	°	′	S.	°	′	S.	°	′	°	′
1	0	11	50	53	30	0	12	53	0	16	42	53	30
2	0	20	20	51	45	0	20	32	0	24	9	51	45
3	1	12	17	22	45	1	12	22	1	15	1	22	45
4	1	24	35	5	15	1	25	22	1	28	40	5	15
5	2	2	1	31	4	2	2	32	2	5	55	31	20
6	2	6	49	22	50	2	7	42	2	10	50	22	50
7	2	13	16	16	45	2	14	42	2	17	21	16	45
8	2	29	30	39	20	3	0	22	3	3	40	39	20
9	3	10	40	16	0	3	11	12	3	15	45	16	0
10	4	14	40	0	15	4	15	12	4	18	45	0	15
11	6	8	23	2	6	6	9	22	6	12	33	2	6
12	6	8	50	31	12	6	9	42	6	12	55	31	12
13	7	24	35	4	24	7	25	22	7	28	40	4	24
14	8	6	53	36	0	8	7	32	8	11	2	36	0
15	9	0	40	61	45	9	0	2	9	4	45	61	45
16	9	15	53	29	12	9	16	32	9	20	58	29	14
17	10	20	4	59	36	10	21	52	10	24	9	59	36
18	11	14	0	31	10	11	14	52	11	18	54	31	10
19						11	24	52	11	24	52	12	30
20	1	16	15	30	8	1	17	32					
21	5	6	40	11	50	5	7	12					
22						10	18	12					
23						2	29	52					

[a] He agrees with *Ptolemy* as to Latitude.

A Table

A Table of the principal Fixed Stars, according to the Obſervations of the Antients.

	From the Hacimic Tables of Johanides Ægyptius. A. C. 996.					Choaga Naſirodinus Tuſius, *in the Ilchanic Tables.* A. C. 1233.					*From the Sultanic of* Ologbec. A. C. 1437.				
	Long.			Latit.		Long.			Latit.		Long.			Latit.	
	S.	°	′	°	′	S.	°	′	°	′	S.	°	′	°	′
1	0	16	20	53	28	0	24	55	51	45	0	15	40	53	45
2	0	24	34	51	50	0	24	35	51	40	0	28	1	50	48
3	1	15	24	22	39	1	16	25	23	0	1	18	54	22	0
4	1	29	7	5	15	1	29	22	5	13	2	2	31	5	15
5	2	5	30	31	35	2	6	35	31	30	2	9	25	31	18
6	2	11	32	22	3	2	11	10	22	40	2	14	43	22	42
7	2	17	46	16	50	2	18	0	16	50	2	21	13	16	43
8	3	4	2	39	30	3	3	50	39	10	3	6	19	39	30
9	3	15	52	16	2	3	15	45	16	5	3	18	22	16	0
10	4	19	10	0	10	4	19	14	0	17	4	22	13	0	9
11	6	12	58	2	10	6	13	25	1	52	6	16	10	2	9
12	6	13	49	31	33	6	13	0	31	25	6	16	31	31	18
13	7	29	9	4	25	7	29	0	4	10	8	2	16	4	30
14	8	11	34	35	59	8	11	15	35	55	8	15	13	35	51
15	9	5	0	61	55	9	4	40	61	50	9	8	19	62	0
16	9	20	34	29	10	9	20	40	29	15	9	24	10	29	15
17	10	23	31	59	38	10	24	30	59	50	10	28	46	59	42
18	11	18	44	31	12	11	18	44	31	12	11	21	37	30	51
19						11	18	55	31	1	0	1	22	12	34
20						1	21	35	30	0	1	25	7	29	21
21						5	11	55	11	50	5	13	49	12	0
22						10	23	45	23	0	10	20	40	21	30
23						3	3	55	7	0			*		

* The Grandſon of *Timurus* never ſaw the bright *Canopus*, nor any other Aſtronomer of this Catalogue, except the *Alexandrines*.

A Table

A Table of the principal Fixed Stars, according to the Observations of the Antients.

	Abdolgalilus Segazius *in his* Genethliacs. A. C. 1261.			*From the* Persian *Tables of* Chrysococca A. C. 1115.			*From the* Persian *Tables*, *Pemb.* A C. 1346. Melixa 338.			*From the* Arnoldine Code *in* Gassendus, *for* A. C. 1364.		
	Long.			Long.			Long.			Long.		
	S.	°	′	S.	°	′	S.	°	′	S.	°	′
1	0	6	45	0	15	10				0	18	20
2	0	25	2	0	22	50						
3	1	16	52	1	14	40		18	10	1	17	45
4	1	29	45	1	27	0	2	1	30	2	1	0
5	2	6	52	2	4	50		8	20	2	8	0
6	2	11	43	2	10	50		13	3	2	13	10
7	2	19	12	2	17	0		20	30	2	18	10
8	3	4	28	3	2	40				3	6	0
9	3	16	11	3	14	10		18	0	3	17	20
10	4	19	42	4	17	30		9	31	4	20	40
11	6	13	26	6	11	40		15	10	6	15	10
12	6	13	47	6	12	0		15	30	6	14	10
13	7	29	45	7	27	40	8	1	10	8	27	40
14	8	11	49									
15	9	5	38	9	2	20		5	0	9	5	30
16	9	20	56	9	18	50		22	20	9	22	0
17	10	26	15	10	24	10		10	20	9	27	18
18	11	18	58	11	17	10		20	40	11	20	20
19				11	27	10						
20	1	22	2	1	19	50						
21	5	11	38				5	13	2	5	12	40
22	10	23	53	10	22	00						
23	3	4	3	2	2	10						

A Table of the principal fixed Stars according to select Observations.

	From the Books of Savil *and* Bodley, *about* A. C. 750.			*From* Mohammed Tizinius. A. C. 1533.				Sahebodinus Alepensis, *in the Ilchanics, for* A. C. 1436.			
	Long.			Asc. Rect.		Declin.		Asc. Rect.		Declin.	
	S.	°	′	°	′	°	′	°	′	°	′
1	0	12	20	130	17	41	0	132	10	41	30
2				86	55	56	41	84	2	55	45
3	1	2	50	130	14	39	43	127	44	39	4
4	1	19	50	153	0	15	43	150	40	15	20
5				163	43	9	13	162	20	9	20
6	2	2	10	161	39	45	0	158	30	44	43
7	2	9	10	173	15	6	28	171	55	6	15
8	2	24	50	187	0	15	50	185	45	15	43
9	3	6	40	199	0	6	5	197	25	6	7
10	4	9	39	136	0	14	8	234	0	15	10
11	6	4	50	185	36	8	29	283	40	7	30
12	6	4	10	299	0	22	14	297	39	33	8
13	7	19	20	330	57	22	42	331	0	24	12
14				348	57	13	9	347	5	13	30
15	8	24		38	37	5	29	38	32	4	20
16	9	15	0	21	5	7	24	20	5	7	3
17				36	40	43	50	36	20	43	15
18				71	0	25	16	68	50	24	30
19				88	10	18	23	85	54	11	30
20				133	46	47	52	130	20	47	11
21	5	1	45	161	20	17	55	259	30	17	56
22				68	45	33	51	67	25	35	2
23				183	40	51	35	183	30	5	25

A Table of the principal fixed Stars according to select Observations.

	Oladinus Saterides *in the* Damascene *Tables.* A. C. 1480.								*From the* Rodolphine *Tables,* A. C. 1600. *at the Considerations of* Tycho Brahe.				
	Long.			Ascens.		Declin.			Long.			Latit.	
	S.	°	′	°	′	°	′		S.	°	′	°	′
1	0	20	34	129	30	17	0		0	21	10	53	30
2	0	18	16	83	50	55	50		0	29	35½	51	14½
3	1	20	4	127	55	38	50		1	20	37	22	22
4	1	3	4	149	50	15	0		2	4	12½	5	31
5				167	50	5	10		2	11	37	31	11½
6	2	15	24	157	40	44	40		2	16	16	20	50½
7	2	22	24	170	10	6	10		2	15	23	16	36
8	4	4	4	184	20	15	45		3	8	35½	39	30
9	4	19	44	196	20	6	30		3	20	18½	15	57
10	4	24	44	233	30	15	5		4	24	17	0	26½
11	6	16	30	283	20	7	30		6	18	16	1	59
12	6	17	24	297	0	23	30		6	18	39½	31	2½
13	8	3	4	322	0	24	15		8	4	13	4	27
14									8	16	50	35	57
15	9	7	44	4	0	38	30		9	9	43	61	47½
16	9	20	14	20	0	7	5		2	26	9	29	21½
17				35	10	4	30		10	29	53½	59	56½
18	11	22	34	68	20	24	0		11	23	49½	31	7½
19	0	2	34	85	5	11	30		0	3	28½	12	35
20				127	20	1	40		1	26	17	30	5
21	5	14	54	259	5	18	10		5	16	3	12	18
22	10	24	24						10	28	11½	21	0
23				181	15	51	50						

A Table of the principal Fixed Stars, according to the Observations of the Antients.

By Ricciolus Bononiensis, *in his* Astronomia Reformata.

	Long.				Latit.			Ascens.			Declin.		
	S.	°	′	″	°	′	″	°	′	″	°	′	″
1	0	22	0	14	53	30	0						
2	1	0	22	0	51	17	0	357	44	33	57	18	40
3	1	11	32	10	22	22	40	41	33	54	39	36	30
4	2	5	1	43	5	30	50	64	6	58	15	46	10
5	2	12	3	10	31	10	10	74	32	38	8	37	30
6	2	17	6	15	22	51	45	72	52	20	45	36	0
7	2	16	13	0	16	52	30	76	45	4	5	59	50
8	3	9	3	0	39	32	5	97	30	18	16	16	30
9	3	21	6	30	15	57	10	110	22	32	6	4	0
10	4	26	4	45	0	26	20	147	31	14	13	36	30
11	6	19	6	0	1	59	30	196	51	0	9	20	30
12	6	19	30	40	31	0	40	210	4	38	20	59	50
13	8	5	1	40	4	26	30	242	10	40	25	33	30
14	8	17	43	20	35	56	15	259	47	14	12	52	30
15	9	10	32	40	61	47	0	276	19	32	30	30	40
16	9	16	58	30	29	20	40	293	31	59	8	1	20
17	11	0	41	25	59	57	20	307	26	35	44	6	40
18	11	24	40	20	31	8	20	341	51	48	29	15	50
19	0	4	40	20	12	37	0	358	57	0	13	19	20
20	1	27	0	8	30	6	40	44	52	30	48	34	30
21	5	16	53	0	12	16	20	172	53	58	16	27	40
22	10	29	2	56	20	59	40	339	37	0	31	20	10
23													

The Distances of the principal Fixed Stars, according to select Observations.

			°	′		°	′
1	The last Star of *Fluvius.*						
2	The bright Star of *Cassiopeia's* Chair.	from *Seat.*	33	4	from Tail of the *Swan.*	33	$32\frac{1}{2}$
3	*Perseus's* Head of *Medusa Algol.*	from the Side of *Perseus.*	9	$23\frac{1}{7}$	from *Capella.*	23	37
4	The Southern Eye of the *Bull.*	from *Sirius.*	45	$58\frac{1}{3}$	from *Algomeisa.*	46	22
5	The Left Foot of *Orion. Rigel.*	from the *Bull's Eye.*	26	33	from *Capella.*	54	$15\frac{1}{4}$
6	The little Kid of *Auriga.*	from the same.	36	$43\frac{1}{2}$	from the Side of *Perseus.*	19	$11\frac{1}{12}$
7	*Orion's* Right Shoulder.	from the same.	15	$47\frac{3}{5}$			
8	The *Dog-Star. Alhabor.*	from *Algomeisa.*	25	42	from *Rigel.*	23	40
9	The *Little Dog. Algomeisa.*	from *Regulus.*	37	20	from the same.	38	$37\frac{1}{2}$
10	The *Lyon's* Heart. *Regulus.*	from *Spica Virginis.*	54	2	from the Tail of *Swan.*	24	$39\frac{1}{3}$
11	*Spica Virginis.*	from *Arcturus.*	33	2	from *Antares.*	45	52
12	*Arcturus.*	from *Regulus.*	59	49	from the same.	56	$4\frac{1}{6}$
13	*Antares.* The *Scorpion's* Heart.	from bright Star of *Eagle.*	60	$9\frac{1}{2}$	from the *Lion's Tail*	24	$39\frac{2}{3}$
14	The Head of *Serpentarius.*	from *Spica Virginis.*	36	$14\frac{1}{2}$	from bright Star of *Harp.*	29	$33\frac{2}{3}$
15	The bright Star of the *Harp.*	from *Seat.*	55	$30\frac{1}{3}$	from *Spica Virginis.*	9	$20\frac{1}{3}$
16	The bright Star of the *Eagle.*	from bright Star of *Harp.*	34	9	from Tail of the *Swan.*	38	$4\frac{1}{3}$
17	The bright Star in Tail of the *Swan.*	from the same.	23	52	from *Seat.*	32	$57\frac{1}{8}$
18	Bright Star in R. Leg of *Pegasus Seat*	from *Algenib.*	20	37	from the bright Star in		
19	The last Star of *Pegas.* Wing. *Algenib.*	from the Side of *Perseus.*	51	$45\frac{1}{6}$	the Chair of *Cassiopeia.*	22	4
20	The bright Side of *Perseus.*	from the *Bull's Eye.*	36	$20\frac{1}{3}$			
21	The *Lyon's* Tail.	from *Spica Virginis.*	35	$2\frac{1}{8}$			
22	The Mouth of the *South Fish.*						
23	*Canopus.*						

The

The Declinations of eight of the principal Fixed Stars, by the Industry of the Antients; the noble Tycho Brahe *being also consulted.*

		By Aristyllus. Y. b. C. 300.	*Timocharis.* Y. b. C. 295.	*Hipparchus.* Y. b. C. 128.	*Meneláus.* A. C. 97.	*Ptolemy.* A. C. 137.	*Tycho.* A. C. 1600
4	The *Bull's Eye.*		8 45 n.	9 45 n.		11 0 n.	15 28 n.
6	*Capella.*	20 0 n.		40 24 n.		41 10 n.	25 28½ n.
8	*Sirius.*		15 20 s.	16 0 s.		16 45 s.	16 11 s.
10	*Regulus.*		21 20 n.	20 40 n.		19 50 n.	13 53½ n.
11	*Spica Virginis.*		1 24 n.	0 36 n.	0 40 s.	0 36 s.	9 1 s.
12	*Arcturus.*		31 30 n.	31 0 n.		29 50 n.	21 18½ n.
13	*Antares.*		18 20 s.	19 0 s.		20 25 s.	25 26 s.
16	Bright Star in *Aquila*		5 48 n.	5 48 n.		5 50 n.	7 54 n

Longitude of the Bull's Eye *according to*

	Hermes.	♓	25	17
	Hipparchus.	♈	10	0
A. C. 140.	*Ptolemy.*	♈	12	40
A. C. 851.	*Abomasar.*	♈	19	15
A. C. 831.	*Thabetus.*	♈	21	17
	Arzachel.	♈	23	20
	Albatanius	♈	24	30
	R. Grostet.	♈	28	40
A C. 1316.	*W. Evesham.*	♈	29	0

Longitude of Spica Virginis *according to*

Y. b. C. 295.	*Timocharis.*	♍	22	20
Y. b. C. 283.		♏	22	30
Y. b. C. 128.	*Hipparchus.*	♍	24	0
A. C. 97.	*Menelaus.*	♍	25	45

Longitude of Regulus *according to*

Y. b. C. 128.	*Hipparchus.*	♋	29	50
A. C. 137.	*Ptolemy.*	♌	2	30
A. C. 879.	*Albatanius.*	♌	14	0

Therefore in the Space of 742 Years, 11°. 50′, or rather 11°. 30′, because of the *Ptolomaic* Longitude of *Regulus* ♌ 2°. 30′, not 2°. 10′, as was read formerly by the Astronomer of *Racca*.

Added to the Ptolomaic *Longitudes of the Fixed Stars, by*

A. C. 1303.	*Alphonsus.*	17	8
A. C. 1320.	*Wymundus.*	15	52
A. C. 1440.	*Walter Vigorn.*	19	5

The first Star of *Aries* is distant from the Vernal Equinox 25°. 40′.
All these according to *Walter Vigorniensis, Cod.* 13. among those of *Digby*.

The

The Fixed Stars go forward one Degree in Solar Years.

1. According to *Hipparchus*, *Ptolemy*, *Theo*, *Proclus*, and *Alferganus*, 100
2. *Timocharis Alexandrinus*, who observed *Spica Virginis* in the Years of *Nabonassar* 454, 466; *Abdorahmanus Salchius*, and *D. Petavius*, 72; or $\frac{60 \times 12}{10}$; and 5″ in every Year.
3. By *Johannides Ægyptius*, the Compiler of the *Hacimic* Tables, $70\frac{3}{4}$
4. By *Jahias Abomansor*, and other Authors of what they called the approved Astronomy; also by *Nasirodinus Tusius*, *Cothodinus Sirasius*, *Ologbec* Prince of the *Mogols*, *Xacholgius*, *Abolphetachus*, *Abenesdra*, *Maimonides*, and most of the Moderns — — — 70. and 51″. 26‴.
5. *Chrysococca* in *Persic.* and *Astron. Anglic. An. Chr.* 1300.—68. and 52″. 23‴.
6. By most of the *Arabian* Astronomers under Prince *Mamon* — $66\frac{2}{3}$.
7. By *Abdorahmanus Sophius*, *Bahoninus Chorcius*, King *Alphonsus*, *Albatanius* of *Racca*, (which is *Callinicos* of *Mesopotamia*) *Abdolgalilus Segazius*, *Levi* and *Zacutus* the *Jews*, and some of the *Maragensian* Observers 66. and 53″. 33‴.
8. By *Copernicus*, *Mæstlin*, and others upon their Credit,—near 71. and 50″. 12‴. 5⁗.
9. By some in *Chorcius* the *Arabian* — — — — 54″.
10. By *Tycho Brahe*, *Kepler*, *Bullialdus*, from the Obliquity of the *Zodiac* $23\frac{1}{2}°$. $70\frac{7}{12}$. and 51″.
11. By *Longomontanus* — — — — $72\frac{1}{3}$. and 49″. 54‴.
12. By *Gassendus* — — $70\frac{1}{7}$. and 51″. 19‴. 24⁗.
13. By *Ricciolus* in *Astr. Reform.* from the Obliquity of the *Zodiac* 23°. 30′. 20″. 71. $19\frac{1}{2}°$. 50″. 40‴.
14. By us, and the *Hierophants* of the *Ægyptians*, 71. $9\frac{2}{7}$ *mens.* & 50″. $9\frac{3}{4}$‴. *fere.*

The Pleiades observed, in 1671. by Mr. Flamsteed. N. 79. p. 3061, 3062.

XII. I have a Tube of $13\frac{1}{3}$ Feet, furnished with Convex Lens's, and a most exact *Townley*'s Micrometer, with which, in the serene Nights of the Months of *October* and *November* last past, I have often measured the minute Distances of the *Pleiades*, and that with such Success, that my repeated Observations never differed from one another 20″, and very seldom 10″. They are confirmed by the preceding Observations of the deceased Mr. *Gascoigne*, and the late ones of Mr. *Townley* (what great Men!) which were performed in the same Manner. These most correct Distances are as follows.

Stars.	Distances according To Me	Distances according To Mutus	Stars.	Distances according To Me	Distances according To Mutus
	′ ″	′		′ ″	′
a b	35 40		a d	18 30	22
a e	27 40	31	e d	26 10	30
e b	20 00	32	d i	16 25	
c b	21 45	22	a i	18 18	
e c	10 00	11	f i	29 04	
e g	14 40		f a	23 00	27
c g	11 55		h a	23 20	
b d	22 04	24	f a	04 45	04

Vinc. Mutus adds in his Epiſtle to the moſt learned *Ricciolus* (which he mentions in his Appendix to *Alm. No. Tom.* 1. *Pag.* 747) that the Weſtern brighter Star paſſed over the Meridian juſt at the ſame Altitude as the bright Star of the *Pleiades*. Relying upon which Notice, and the obſerved Diſtances, I have aſſigned their Places to thoſe Stars as below; firſt having given the ſame Place and Latitude to the middle bright Star, as the *Caroline* Author has thought fit; and the reſt alſo being ſettled from thence. All which however, if I might follow my own Opinion in this Matter, I ſhould advance three Minutes, or two at leaſt: And I ſhould aſſign them a greater Latitude from the Ecliptic. At the Beginning of the Year 1672 were conſtituted

The Stars of the Pleiades.	Long. ♉ ° ′ ″	N. Lat. ° ′ ″	mag.
The Weſtern brighter Star — — —	24 45 15	4 08 51	5
Between this and the Northerly Teleſcopic Star	24 46 47	4 19 21	8
The Weſtern and more Northerly — —	24 54 48	4 28 19	6
The higheſt in the Quadrilaterum —	25 01 24	4 20 39	5
The loweſt Southern oppoſite — — —	25 02 18	3 53 59	6
The middlemoſt bright Star — — —	25 19 48	4 00 00	3
That in the Point to the Eaſt — — —	25 41 29	3 52 19	5
The upper Teleſcopic of the Eaſtern Stars	25 42 55	3 56 51	7
Another Teleſcopic Star — — — —	25 14 04	3 42 37	9

A Nebulous Star, by M. Cassini. N. 123. *p.* 565.

XIII. 1. Between the *Great Dog* and the *Ship* I lately discovered a *Nebulous* Star, which was very beautiful to behold, if it was viewed with large Telescopes; being composed of Stars very close together. With the *Lesser Dog* it divides the Heaven into equal Parts.

By Mr. Flamsteed. *Ibid. p.* 567.

2. Viewing the Heavens below the *Lesser Dog*, I found a *Nebulous* Star, broad and very thick, set with small Stars. I suppose this to be the same as was observed by Mr. *Cassini*.

The first of Aries *a double Star; by Dr.* Hook. *Phil. Coll.* N. 4. *p.* 108. *Marg.*

XIV. *Ann.* 1664. I discovered the first Star in the Head of *Aries* to be a double Star, made of two considerable Stars, so near as not to be discovered two, but by a Glass of six or eight Feet long.

Changes amongst the Fixed Stars, by S. Montanari. N. 73. *p.* 2202. *Marg.*

XV. 1. There are wanting in the Heavens two Stars of the second Magnitude, in the Stern of the Ship and its Hatches, according to *Bayer* β and γ, near the *Greater Dog*, which were observed and recognized by me and others, chiefly on occasion of the Comet, *An.* 1664. To what Year we are to refer its Disappearance I cannot tell; but this is certain, that from the 10th Day of *April*, 1668, I can no longer observe any Traces of them; while the other Stars about them, even of the fourth and fifth Magnitude, continue immoveable. I have taken Notice of above an hundred Changes in the other fixed Stars, but not of such Consequence.

By M. Cassini. N. 73. *p.* 2201.

2. M. *Cassini* hath discovered many new Stars; *viz.* One of the Fourth Magnitude, and two of the Fifth, in *Cassiopeia*. He hath discovered two others towards the Beginning of *Eridanus*, where we were sure they were not yet about the End of the Year 1664. considering that this Place of the Heavens, where passed the then appearing *Comet*, was diligently beheld by many, who perceived divers others small Stars, without observing those two. The same hath also observed, towards the *Arctick* Pole, four of the Fifth or Sixth Magnitude.

He hath also observed, That the Star which *Bayerus* puts near that which he marketh in the Figure of *Ursa Minor*, appears no more; that that which is marked A, in the Figure of *Andromeda*, is also disappeared; that in lieu of that which is marked υ, at the *Knee* of the same Figure, there are two others more Northward; and that that which is ξ, is very much diminished; the Star which *Tycho* placeth at the Extremity of *Andromeda*'s *Chain*, and calls it of the Fourth Magnitude, is now so small that one can scarce see it; and that which is in his *Catalogue* the 20th of the Constellation of *Pisces*, is now no more seen.

The New Star in Pectore Cygni; *by M.* Hevelius. N. 19. *p.* 349. N. 21. *p.* 372.

3. On the 24th of *Sept.* (*St. N.*) 1666, I have observed that New Star in *Pectore Cygni*, (which from the Year 1662 until this Time, hath been almost altogether hid) not only with my naked Eye, like a Star of the Sixth or Seventh Magnitude, but also with a very great Sextant. It is still in the very same Place of the Heavens where it was from *Ann.* 1661 to almost 1662. For its Distance from *Scheat Pegasi* hath been by me found 35°. 51'. 20", and from *Marcab*, 43°. 10'. 50". which Distances are altogether equal to those which I observed *Ann.* 1658. the First of *November*. For the Distance from

Scheat at that Time was 35°. 51′. 20″. and from *Marcab*, 43°. 10′. 25″. where that former from *Scheat* exactly anſwers to the Recent; and that from *Marcab*, 'tis true, differs in a very few Seconds; but that Diſparity is of no moment, ſince it only proceeded from thence, that this New Star is not yet ſo diſtinctly to be ſeen as at that Time, when it was of the Third Magnitude. It is therefore certain, that it is the ſelf-ſame Star which *Kepler* did firſt ſee *Ann.* 1601, and continued till *Ann.* 1662. He that will obſerve this Star, muſt take care leſt he miſtake the Three more Southern ones of the Sixth Magnitude; the higheſt of which is diſtant from *Scheat Pegaſi*, 36°. 25′. 45″. the middlemoſt from the ſame 37°. 25′. 20″. and the loweſt 38°. 4′. 30″.

An. 1662. *Nov.* 28. That new Star in the Swan's Breaſt, which for ſome Time, from *An.* 1662, was intirely hid, the Heaven being clear, ſeemed as it were to revive. N. 134. p. 855.

An. 1666. *Sept.* 21. It appeared to the naked Eye, even when the Moon ſhined. *Sept.* 24. It was leſs than thoſe three preceding in the Neck, and ſcarcely ſeemed of the ſixth Magnitude.

An. 1670. *Aug.* 26. It ſeemed ſenſibly to increaſe, though not yet greater than Stars of the ſixth Magnitude. *Sept.* 3, It ſeemed ſtill to increaſe. 8, We found it ſtill increaſing. *Octob.* 13, It appeared plainly enough. N. 65. p. 2089.

An. 1671. *Apr.* 29. It hardly appeared greater than in the foregoing Year, for it was equal to Stars of the ſixth Magnitude. N. 134. p. 855.

An. 1671. *Jun.* 26. It almoſt ſeemed greater.

An. 1672. *March* 29. It ſtill ſeemed to increaſe.

An. 1675. *July* 22. It appeared ſtill as a Star of the ſixth Magnitude.

An. 1677. It was not yet arrived to its former Magnitude, which was that of the third, nor had it attained its uſual Brightneſs and Splendor, as it appeared in the Years 1657, 1658, 1659; for it did not yet ſhine but as a Star of the ſixth Magnitude. N. 154. p. 854.

Ann. 1681. *Aug.* 18. The new Star in the *Swan*'s Neck was hardly to be ſeen by the naked Eye becauſe of its Smallneſs and Obſcurity, yet at laſt was found by the Teleſcope. Ph. Coll. N. 5. p. 162.

The New Star, ſub Capite Cygni.

4. 1. Don *Anthelme*, a *Carthuſian* at *Dyon*, on the 20th of *June*, *An.* 1670, diſcovered a Star of the Third Magnitude beneath the *Head* of *Cygnus*, ſituated in the Section of the two ſtreight Lines, one of which goeth from *Lyra* to the neareſt of the *Quadrangle* in the *Dolphin*, and the other from the *Eagle* to the Star, which is on the Top of the *Upper Wing* of *Cygnus*. He ſent the News of this Diſcovery to M. *L'Abbe Mariotte*, one of the *Royal Academy*, who communicated it to the reſt. They all agree 'tis a *New* Star, though M. *B*——— oppoſed it at firſt, affirming it to be in *Bayerus*'s Tables; but they prove that Star in *Bayerus* to be another; giving for Diſtinguiſhment theſe Meaſures. N. 65. p. 2092. N. 73. p. 2198.

	°	′	″
The bright Star *ad Roſtrum Cygni*, its *Aſcenſio Recta*	289	22	00
Declinatio Borealis	27	19	20
But this *New* Star's *Aſcenſio Recta* is ——— ———	293	33	00
Declinatio Borealis	26	33	20

	°	′	″
Longitudo ♒	1	55	
Latitudo	47	28	10
Its Distance from that *ad Rostrum Cygni* towards *Jaculum*	3	47	30
From the Tail of *Cygnus*	20	54	30
And from the *Lucida Lyræ*	18	39	40
It came to the Meridian after the Star *in Rostro Cygni*		16	44
And before the *Lucida Aquilæ* — — — —		0	27

In the Beginning of *July*, this Star was observed to decrease: *July* 11, it scarce appeared of the Fourth Magnitude.

Aug. 10. It was of the Fifth, and continued to decrease till it wholly disappeared.

Anno 1671. *March* 17, D. *Anthelme* spied it again of the Fourth Magnitude.

April 4. M. *Cassini* found it greater than the two Stars of the Third Magnitude that are below in the Constellation of *Lyra*, and a little smaller than that in the Beak of *Cygnus*, but more radiant.

April 9. He found it a little diminished, and almost equal to the greatest of the two Stars that are below in *Lyra*.

The 12th, it was equal to the least of these two Stars.

The 15th, he perceived that it increased, and found it equal the second time to the greatest of these two Stars.

From the 16th unto the 27th, it appeared of different Magnitudes, being sometimes equal to the biggest of these two Stars, sometimes equal to the least, and now and then between both.

But the 27th and 28th, it was become as big as the Star in the *Swan*'s *Beak*.

The 30th, it appeared a little clearer; and the first six Days in *May* it was greater.

The 15th of *May*, it was seen smaller than the same Star.

The 16th, it was in Bigness between the two Stars that are below in *Lyra*: And ever since she hath still diminished.

Thus this Star hath been twice in her greatest Splendor; first on the 4th of *April*, and the second time in the Beginning of *May*.

By M. Hevelius. *N.* 65. *p.* 2087.

I write you this to acquaint you with a certain remarkable Observation, and at the same Time to let you know my Mind of the Matter. I mean of that new fixed Star, almost of the third Magnitude, about and below the *Swan's Head*, and conspicuous among the unformed Stars. Its Longitude is now 1° . 52′ . 26″ . ♒ and Latitude 47° . 25′ . 22″, as plainly appears by my Observations, *An.* 1670. *July* 25. There is no Reason to doubt but that this is intirely a new Star, and altogether inconspicuous in the Heavens in the Year 1660. For it happened that in the Years 1659, 1660, 1661, I observed almost all those Stars, that appear in the Constellation of the *Swan*, with the utmost Diligence and with proper Instruments; and so took Notice of of all thoſe about the Neck and Head, and meaſured their Diſtances from ſeveral fixt Stars. But I found no Star of the third Magnitude in that Place where the above-mentioned new Star is now to be ſeen; which if it had been there I muſt have ſeen it. So that, firſt, I am ſure from hence, that in the Years 1660 and 1661 this Star was not yet viſible; and then it clearly appears from *Bayer*'s *Uranometria*, that this now mentioned new Star did not appear in the Year 1603, and conſequently not to *Tycho*, and much leſs to *Hipparchus*. For *Bayer* would have found a Star of that Magnitude, ſince he deſcribes one of the ſixth Magnitude not far from it; as may be ſeen in his Conſtellation of the *Swan*. But perhaps you will ſay, this is the very ſame that you call a *new one*; for ſince *Bayer* did not obſerve the Stars with proper Inſtruments, it may eaſily be, that he might err a Degree or two from the true Place. But this cannot be the Thing, ſince that ſmall Star ſtill continues in the ſame Place where *Bayer* puts it, nor is it greater than a Star of the ſixth Magnitude, as he obſerved it. For, as I have lately found, it is diſtant from *Pegaſus*'s Mouth 32°. 39′. 00″. and from *Pegaſus*'s Right Knee 39°. 23′. 45″. Hence its Longitude comes out 00°. 06′. 28″. ♒, and its Latitude 46°. 11′. 14″ North, to the current Year 1670, in *July*. But the new Star is diſtant from *Pegaſus*'s Mouth 32°. 31′. 25″. and from the Right Knee of *Pegaſus* 38°. 18. 50″. From which Diſtances the Longitude is found to be 1°. 52′. 26. ♒, and Northern Latitude 47°. 25′. 22″. So that this new Star is plainly different from that of the ſixth Magnitude obſerved by *Bayer*, though theſe two are not above two Degrees removed from each other. And from what is ſaid it is manifeſt, that this new Star did not ſhine among the other Stars, neither *An*. 1603, nor *An*. 1670.

When it was firſt obſerved by me, as to Magnitude and Brightneſs it was not inferior to the Star in the *Eagle's Breaſt*, unleſs that its Light was a little more obtuſe. As to its Situation in reſpect of the other Stars, it was placed in a Right Line with that in the bending of the upper Wing of the *Swan*, and that in the Shoulder of the *Eagle*; as alſo with the bright Star of the *Harp*, and that in the *Rhombus* of the *Dolphin*, which is the more Northern of the middle ones. It made an Equilateral Triangle with that in the Head and Beak of the *Swan*.

It wonderfully decreaſed in the Month of *September*, ſo that on the 14th of *October* I could not obſerve it at all with my Sextant, though I uſed all my Induſtry for that Purpoſe. N. 66. *p*. 2028. N. 132. *p*. 855.

An. 1671. *Apr*. 29, I obſerved again. It exceeded that in the *Swan*'s *Beak*, and likewiſe that in the bending of the lower Wing of the *Swan*, and was almoſt equal to that in the *Swan*'s *Breaſt*, except that it ſhone with a Light a little more dull and reddiſh. But upon what Day it firſt began to ſhine I dare not affirm. This I am ſure of, that it was not conſpicuous in the Months of *December*, *January*, or even *February*. For after *Octob*. 14, when it ceaſed to be ſeen, I remember I often ſought for it in its Place, but it did not appear. Therefore as far as I can recollect, it hardly came into Sight again before the Beginning of *March*, or rather later. On *April* 30, I meaſured its Diſtance from the other fixed Stars. It is diſtant from the N. 73. *p*. 2197. N. 134. *p*. 856.

Swan's Tail 20°. 55'. 20". From the bending of the upper Wing of the *Swan* 17°. 47'. 50". From the Head of *Serpentarius* 34°. 19'. 40". ſo that it ſtill continues in the ſame Place where it was.

N. 134. p. 856. *May* the 17th, it ſeemed ſomething leſs than the *Swan*'s Beak, and that in the Shoulder of the *Eagle*, as alſo duller in its Light; but greater than that in the Point of *Sagitta*, and almoſt equal to that following in the Body of the *Harp*.

May 25. It ſeemed leſs than on the 29th of *April*, when it was firſt ſeen, ſo that it ſeemed to decreaſe. Leſs than that in the *Swan*'s Beak, or than that in the bending of the Southern Wing; or even leſs than thoſe in the Belly of the *Harp* and the *Eagle*'s Shoulder. It appeared hardly greater than the leſſer of the two in the *Swan*'s Foot, and that in the Breaſt of the *Eagle*.

Jun. 26. It appeared leſs than that in the *Swan*'s Neck, ſo that it had decreaſed notably.

July 3. Leſs than that in the *Swan*'s Neck; and on the 18th it hardly ſeemed equal to Stars of the fifth Magnitude.

Aug. 2. It hardly appeared of the ſixth Magnitude, nay leſs than all the other Stars about the Neck and Head of the *Swan*. It only twinkled now and then.

Sept. 11. It was not to be ſeen any more.

N. 81. p. 4018. *Ann.* 1672. *Mar.* 6. I obſerved it again; but it can hardly be ſeen with the naked Eye.

N. 134. p. 857, 854. *Mar.* 29. It hardly appeared of the ſixth Magnitude; from which Time to *An.* 1667. it came no more into Sight, though I often ſought for it very diligently,

The Nebuloſa *in the Girdle of* Andromeda; *by M.* Bullialdus. N. 25. p. 459. 5. *Ann.* 1667. in *Jan.* The *Nebuloſa* in *Andromeda*'s Girdle (which may well enough be ſeen by the bare Eye) appeared much obſcurer than the Year before. In the Months of *February* and *March* I did not ſee it.

The New Star in Collo Ceti; *by M.* Bullialdus. *Ibid.* 6. 1. *Ann.* 1667. *Jan.* 20. The *New Star* in the *Neck* of the *Whale*, did approach to the Bigneſs of a Star of the ſixth Magnitude, and grew bigger afterwards.

Feb. 12. I ſaw it at leaſt of the Fourth Magnitude.

Feb. 24. It was equal to the Stars of the Third Magnitude, ſhining very bright.

Feb. 26. and 27. It appeared yet to increaſe.

By M. Hevelius. N. 25. p. 460. N. 134. p. 855. 2. *Ann.* 1667. In the Beginning of *January* this Star did not appear.

Jan. 23. I found a little Star of the Sixth or Seventh Magnitude about the ſame Place where the ſaid *New Star* uſes to appear. But it then ſeemed to me not the genuine *New Star*, but another; to wit, preceding the *New*, whoſe Longitude in *An.* 1660. was defined by me, ♈ 25° 43' 3", and the Latitude 14° 41' 32".

Feb. 2. It appeared very bright, and that, when the Moon ſhone, of the Bigneſs of that in the *Mouth* of the *Whale*, or *Nodo Lini*; from which time I always obſerved it to grow bigger.

Mar. 13: I did ſtill find it extremely bright, but could not by my naked Eye, becauſe of the vivid Crepuſcle, and the low Sight of the Star, accurately determine its Magnitude.

An. 1668. *Octob.* 26. The new Star in the *Whale*'s Neck was firſt ſeen, but like the ſmalleſt of the fixed Stars. N. 132. *p.* 855.

Nov. 7. The new Star in the *Whale*'s Neck was almoſt equal to the middle Star in the Mouth.

An. 1669. *Jan.* 28. It was leſs than that in the Mouth.

Sept. 26. It appeared like a Star of the ſixth Magnitude.

Oct. 16. It was greater and brighter than that in the Mouth.

Oct. 27. It was equal to the bright Star in the Jaw.

Nov. 19. It was greater than that in the Mouth, and leſs than that in the Jaw.

An. 1670. *Aug.* 27. It ſhined with very much Light, and was almoſt equal to the Stars of the ſecond Magnitude in the *Whale*'s Jaw.

Sept. 3. It was very bright, and on the 8th was equal to the *Whale*'s Jaw.

To the middle of the Month of *October* it was almoſt equal in Magnitude to that in the *Whale*'s Jaw, and nearly exceeded it in Brightneſs; ſo that this Year it was of the ſecond Magnitude, and greater than in the former Years, excepting *An.* 1660, when I found it to be even greater than the *Whale*'s Jaw. At other Times I do not remember that it exceeded Stars of the third Magnitude. It is therefore certain, that it did not always appear of the ſame Magnitude or Brightneſs, however it may be in its greateſt Increaſe. N. 66. *p.* 2023.

Dec. 5. It had ſo dwindled away, that it was hardly equal to a Star of the ſixth Magnitude. N. 134. *p.* 856.

An. 1671. *Aug.* 14. It was equal to the Star at the Cheek, nay it ſeemed to be ſomething larger.

Sept, 12. It was equal to that in the Mouth, of the fourth Magnitude.

Oct. 30. It appeared to be hardly of the ſixth Magnitude.

Nov. 3. It appeared no more.

An. 1672. *Aug.* 9. It ſhined with very bright Rays, and was greater than that in the Mouth, and leſs than that in the Jaw.

Sept. 17. Leſs than that in the Cheek, was hardly of the fourth, nay of the fifth Magnitude, and on the 25th was hardly of the ſixth Magnitude.

From about the Month of *October* to *December* 23, 1676, it did not once come to view, though I directed my Eyes towards it very attentively, whenever I applied myſelf to Obſervations on a clear Night. *Ibid. p.* 854.

An. 1676. *Dec.* 10. I remember very well, I could not ſee the new Star in the *Whale*'s Neck, though I obſerved very many little Stars in that Part of the Heavens. *Ibid. p.* 858.

Dec. 23. The Heaven being very clear, we ſaw very plainly the new Star in the *Whale*'s Neck, It ſhone with ſo much Brightneſs, and was of ſuch a Magnitude, that it was not only equal to, but even exceeded the Jaw of the *Whale*.

Dec. 31. It was rather greater than the Jaw, that is, of the ſecond Magnitude.

An. 1677. *Jan.* 1. It again ſhone very brightly, rather greater than the

Whale's Jaw, and rather greater than that in the Extremity of the Wing of *Pegaſus*, and *Marcab*, in Colour and Light not unlike to the Jaw. Yet I remember to have obſerved formerly, when it was of the ſecond Magnitude, that it was a little whiter and brighter.

Phil. Coll. N. 5. *p.* 162.

An. 1681. *Aug.* 18. The new Star in the *Whale*'s Neck this Night, tho' the Moon was full and ſhining, was greater than that in the *Whale*'s Mouth, but yet not equal to the bright Star in the Jaw.

By M. Caſſini. N. 123. *p.* 565.

3. *An.* 1676. *March.* I viewed the new Star in the *Whale*'s Mouth, which had diſappeared for ſome Years, being immerſed in the Sun's Beams, at the Time of its greateſt ſhining. Now it plainly exceeds Stars of the third Magnitude.

By Mr. Flamſtead. *Ibid. p.* 567.

4. For eight Months before, I have often ſeen the new Star in the *Whale*'s Breaſt, which was not leſs than Mr. *Caſſini* mentions.

A new Star in Eridanus; *by M.* Caſſini. N. 35. *p.* 683.

7. *March* 10. 1668. Not far from the Star in *Eridanus*, which is called the 14th by *Bayerus*, there appeared a Star equal to the brighteſt of the 4th Magnitude, almoſt in the ſame Place where was obſerved the Comet of *An.* 1664. *Dec.* 31. which Star was not then ſeen, nor at other Times elſewhere, nor is deſcribed in any Catalogue, on any Globe or Map, that I can learn; which therefore I deem to be a *New* one, that is, of *New Appearance.*

A New Star in Taurus; *by M.* Caſſini. N. 82. *p.* 4046.

8. The Comet, *Anno* 1672, had (on the 1ſt of *April, N. S.*) paſſed 45′ beyond the moſt Northern Star of the *Head* of *Taurus*, and was diſtant 1° 43′ from the Star that was neareſt to that towards the South. M. *Caſſini* having conſidered theſe two Stars, obſerved that the Second is not leſs bright than the Firſt, and yet that *Bayerus* hath not marked it; and that at firſt ſight it ſeems that *Tycho* hath left it out in his Catalogue: For he puts four Stars in the Place he calls *in Quadrilatero Cervicis*; and he ſpeaks not of this, which is the fifth, and maketh, with the other four, an irregular Pentagon. This Omiſſion of *Bayerus*, and the Denomination which *Tycho* uſeth to denote theſe Stars, which ſuits not with the Number nor the Configuration that now appears, do adminiſter Cauſe to doubt whether the Star in queſtion be not one of thoſe that appear from Time to Time.

To find the Aphelia *of the Planets directly*; *by M.* Caſſini. *Conſidered, by Mr.* Nic. Mercator. N. 57. *p.* 1168. Mar. An. 1670.

XVI. 1. Mr. *Caſſini* ſuppoſes, that to the Planet moving in an Ellipſis two Right Lines are extended from the two Foci, one of which is the Line of mean Motion, and the other of true Motion. Now the Conſtruction is this.

Fig. 117.

L is the Center of the Concentric ABCDE.
BLD is the Diameter.
BA, BC, BP, are appearing Intervals.
DE, DF, DQ, are Intervals of mean Motion.
BE, BF, BQ, as alſo DA, DC, DP, are Right Lines.
BE cuts DA in H; BF cuts DC in G, BQ cuts DP in R.
RHG is a Right Line.
BI is perpendicular to RHG.
I is the Center of the Ellipſis.
LI is the Excentricity.
IO = LI.
O is the Focus; about which the mean Motion is performed; L about which the true.
IM = IN = LB.
M is the Apogeum, N the Perigeum, BLM the true Anomaly.

Demonſtration. 1. The moſt illuſtrious and Right Reverend *Seth Ward*, Biſhop of *Saliſbury*, in his Examination of the Philolaic Aſtronomy, has taught

taught us a Method, from the mean Anomaly of the Planets being given, to find the true one, which is thus:

C is the Center of the Ellipsis A E P, F the Focus about which the mean Motion is performed, S the Focus of the true Motion, A the Apogeum, P the Perigeum, E the Planet, A F E the mean Anomaly, A S E the true Anomaly, F E T a Right Line, E T = S E. S T is a Right Line. *Fig.* 118.

In the Triangle S F T are given, 1. S F, the Distance of the Foci. 2. F T = F E + E S = A P. 3. A F T the external Angle, or the mean Anomaly, equal to the Sum of the Angles F S T and T. Therefore F S E may be found, or the true Anomaly, equal to the Difference of the Angles F S T and T; thus,

As half the Sum of the Sides F T *and* F S, *is to half the Difference of the same, so is the Tangent of half the Sum of the Angles* F S T *and* T *to the Tangent of half their Difference.*

But the Half-sum of the Sides F T and F S is found, by substituting for F T its Equal A P, whose half is A C, which added to C S, half of F S, makes the Semi-sum A S, the Planets greatest Distance.

Then if from the Half-sum A S be taken the lesser Side F S, there remains the half-difference of the Sides F A equal to P S, the least Distance of the Planet. Then from the mean Anomaly to find the true one, the Rule is,

As A S, *the greatest Distance of the Planet, is to* P S *the least Distance, so is the Tangent of half the mean Anomaly to the Tangent of half the true Anomaly.*

Corol. 1. If S E is continued as far as V, so that E V = F E, and the whole S V = Axis A P; the Angle V of the Triangle F S V will be half the Prosthapheresis F E S, and therefore equal to the half-difference of the Angles of the mean and true Anomaly, that is, of the Angles A F E and A S E. (And the external Angle A F V is equal to half the Sum of the same Angles A F E and A S E) by taking away the Semi-difference V F E from the greater A F E; whence arise these two Analogies,

1. *As the Sine of half the Sum of the mean and true Anomalies* A F V, *to the Sine of half the Difference of the same* V; *so is* S V, *equal to the transverse Axis* A P, *to* S F *the Distance of the Foci.*

2. *As the Sine of half the Sum of the mean and true Anomaly* A F V, *to the Sine of the true Anomaly*, F S V; *so is* S V, *or the Axis* A P, *to* F V *the Subtense of the true Anomaly*; *and so is the Semi-axis* A C, *to the Semi-subtense* V X *or* F X.

Corol. 2. If in the same Triangle F S V, from the middle Point X of the Subtense F V, be raised the Perpendicular X E; it will divide S V into two Parts, one of which V E is equal to the Line of mean Motion F E, the other S E is the Line of true Motion itself.

2. Let *a* be the Center of the Concentric *c b f i*.
c a d the Diameter, and likewise the Line of the *Apsids*.
c b the Arch of the true *Anomaly*, to which answers,
d i the Arch of mean *Anomaly*; therefore
c d b is the Angle of half the true *Anomaly*, and *Fig.* 119.
d c i the Angle of half the mean *Anomaly*.
c i and *d b* are Right Lines, which interfect one another in *g*.

From

From the Point of Interſection g let fall gb perpendicular to cd;

Then $db.bg$: : Radius . Tang. bdg or cdh.

And $cb.bg$: : Radius . Tang. bcg or dci.

Therefore $db \times$ Tang. $cdh = bg \times Rad. = cb \times$ Tang. dci.

Wherefore $db.cb$: : Tang. dci. Tang. cdh.

That is, db will be to cb, as the Tangent of half the mean Anomaly to the Tangent of half the true Anomaly: And therefore by the Rule above-mentioned, as the greateſt Diſtance of the Planet to the leaſt Diſtance. Therefore db will be equal to the greateſt Diſtance of the Planet, cb will be equal to the leaſt, and ab to the Eccentricity..

And ſince the ſame Thing may be demonſtrated in the ſame Manner of all the other Points of Interſection, that is, that Perpendiculars from them to the Line cd will fall upon the Point b, 'tis neceſſary that a Right Line joining thoſe Interſections muſt be congruous with the Perpendicular bgf.

3. Drawing the Diameter hak, make the Arch $kl = id$, and draw kc and hl cutting one another in p. From h upon bgf let fall the Perpendicular hr, and the ſame is parallel to the Line of Apſids cd. Then the Angle rhs will be the half-difference of the Arches of the true Anomaly ch and of the mean di. Then from the ſame Point h let the Right Line $h\beta$ be drawn, making an Angle with kh equal to the Angle rhs, and meeting the Line of Apſids in β; then the Angle βah of the Triangle $a\beta h$ will be the Meaſure of the Arch ch, or of the true Anomaly; and βha the half-difference of the true and mean Anomaly, by Conſtruction; and the external Angle $c\beta h$ (equal to the two internal and oppoſite Angles βah and βha, and therefore compounded of the true Anomaly and its half-difference from the mean) will be the ſemi-ſum of the true and mean Anomaly. Therefore by the firſt Analogy of the firſt Corollary, as the Sine of $c\beta h$ to the Sine of βha, ſo is Radius ah to the Excentricity $a\beta$. But we have demonſtrated above, that ab is equal to the Excentricity. Therefore the Point β is congruous with the Point b.

Then from b let bt be raiſed perpendicular to hb. I ſay, that this being continued will fall upon the Point of Interſection p. For the Triangles rhs and bht are ſimilar by Conſtruction. Wherefore alſo the Triangle hpk is ſimilar to the Triangle hgi, ſince the Angles pkl and gih, inſiſting upon the ſame Arch ch, are equal; as alſo the Angles phk and ghi are equal, as inſiſting upon equal Arches kl and id. Therefore the third hpk is equal to the third hgi. And from Equals phk and ghi taking away Equals bht and rhs, there remain Equals phb and ghr. Whence I argue thus, $srh = tbh$, and $rhs = bht$; therefore $hsr = htb$, and therefore the Complements of theſe to a Semicircle are equal, that is, $rsi = btk$, and $sig = tkp$. Therefore alſo $igs = kpt$, which being taken from Equals igh and kph, there remains $hgs = hpt$, and $ghr = phb$. Therefore alſo $hrg = hbp$. But hrg is a Right Angle, and therefore alſo hbp is a Right Angle. And ſince by the Conſtruction hbt is a Right Angle, thence tb will make a Right Line with bp. And ſince the ſame Thing may be demonſtrated after the ſame Manner of any other Interſection of Lines from h and k, drawn to congruous Points of the true and mean Anomaly; it is plain, that

not

not only the Right Line that joins the Intersections, will pass through the Point *b*, but also the Line *b b* will be perpendicular to the same joining Line. *Q. E. D.*

Corollary. If from any Point of the true Anomaly, suppose *b*, to the corresponding Point *i* of the mean Anomaly, a Right Line *b i* be drawn; *b f* perpendicular to *c b d*, being drawn from the Center of Excentricity *b*, will cut *b i* in *s*, in the Ratio of the Line of the mean Motion to the Line of the true Motion.

For by the latter Analogy of the first Corollary, *b b* is the Semi-subtense; therefore by the second Corollary, a Perpendicular *b t* erected at *b* cuts the Diameter *b k* in *t*, in the same Ratio that the Line of mean Motion has to the Line of true Motion. Therefore *r s* or *b f* cuts the Line *b i* in the same Ratio in *s*; because of the Similitude of the Figures *t b b k p b b* and *s r b i g b r* just now demonstrated.

But from the above-quoted Method of the Right Rev. Dr. *Ward*, for finding the first Inequality, it will not be difficult to produce still another Way of investigating the Apogeum and the Excentricities, which is not less direct and Geometrical, and admits of any Number of Observations; which I shall explain in a few Words. The Lovers of Astronomy may find several Ways in the Right Rev. Author's *Astronomia Geometrica*, to which therefore I refer them. But now

Let *l* and *d* be the two Foci of the Ellipsis, *t* and *u* two Points of the Planet's true Motion, *t u* an Arch of the Ellipsis, which from *l* is viewed under the Angle *t l u*, and from *d* under the Angle *t d u*; also the Distance of the Foci *l d* is viewed from *t* under the Angle *d t l*, and from *u* under the Angle *d u l*. I say, the Difference of the Angles *t l u* and *t d u* is equal to the Difference of the Angles *d t l* and *d u l*. *Fig. 120.*

For since all the three Angles of the Triangle *l u x* taken together are equal to all the three Angles of the Triangle *d t x* when taken together, if from each be taken away the equal Angles *l x u* and *d x t*, the Sum of the other two *u l x* + *l u x* will be equal to the Sum of the others *t d x* + *d t x*; and if from these equal Sums be taken away Unequals, that is *u l x* from the former and *t d x* from the latter; the Difference of the Remainder *l u x* and *d t x* will be equal to the Difference of the Angles taken away *u l x* and *t d x*. Which was the Thing proposed.

With Center *l*, and Distance of the transverse Axis *m n*, let a Circle *a b c* be described, whose Arch *a b* is again viewed from *l* under the Angle *a l b*, and from *d* under the Angle *a d b*. Also the Distance of the Foci *l d* is viewed from *a* under the Angle *l a d*, and from *b* under the Angle *l b d*. Therefore again the Difference of the Angles *a l b* and *a d b* is equal to the Difference of the Angles *l a d* and *l b d*. But by *Corol.* 1. the Angle *l a d* is half the Angle *l u d*, and the Angle *l b d* is half the Angle *l t d*. Therefore the Difference of these Angles *l a d* and *l b d* is equal to half the Difference of the Angles *l u d* and *l t d*. Therefore also the Difference of the Angles *a l b* and *a d b* is equal to the half-difference of the Angles *u l t* and *u d t*, the former of which is the apparent Interval of the two Observations, and the latter

is

is the Interval of the mean Motion. Therefore the Difference of these Intervals being given, half this Difference is also given. or the Difference of the Angles *a l b* and *a d b*. But *a l b* is the same as the given Angle *u l t*; therefore the Angle *a b d* is also given, under which the Arch *a b* is viewed from *d*.

In a like manner it may be shewn, that the Difference of the Angles *t l y* and *t d y* is equal to the Sum of the Angles *l t d* and *l y d*; also the Difference of the Angles *b l c* and *b d c* is equal to the Sum of the Angles *l b d* and *l c d*. And since *l b d* is half of *l t d*, and *l c d* half of *l y d*; the Sum of *l b d* and *l c d* will be equal to half the Sum of the Angles *l t d* and *l y d*; that is, the Difference of the Angles *b l c* and *b d c* will be equal to the half Difference of the Angles *t l y* and *t d y*, of which the first is the apparent Interval of the two Observations, and the latter the Interval of the mean Motion. Therefore the Difference of these Intervals being given, half of this Difference is also given, or the Difference of the Angles *b l c* and *b d c*. But *b l c* is the same with the given Angle *t l y*; therefore the Angle *b d c* is also given, under which the Arch *b c* is viewed from *d*.

Whence it appears, that the mean and apparent Intervals of the Observations being given, the Angles also are given, under which any Arches of the Circle *a b c* are seen from *d*, which Arches are intercepted by Lines of the true Motion. Therefore by *Herigon*'s *Theory of the Planets*, *lib*. 1. *cap*. 3. *Prop*. 12. *Schol*. 1. so many Segments of a Circle may be described, capable of receiving Angles under which those Arches are viewed from *d*, all which Segments will intersect one another in *d*. Therefore by this Method the Apogees and Excentricities of the Planets may be found by a Geometrical Delineation, and applying any Number of Observations: Nor is it more difficult to draw Circles than Right Lines.

But to grant what is true, that Mr. *Cassini*'s Geometrical Delineation is something more expeditious; it is however to be feared, that if we pursue that Exactness required by Astronomers, it requires Diagrams of an enormous Size, and thereby becomes more operose than the Calculation itself. But if we make use of this, we shall find both Methods to be equivalent. Now lest any one should think, that the Difference from the Truth, of the Apogeum and Excentricity found by either Method, is to be imputed to an Error of Calculation; we shall now discuss the Hypothesis itself.

The Invention of the Elliptic Orbit without any doubt is owing to *Kepler*; but to determine by what Degrees of Acceleration and Retardation the Planets move, does not less belong to the completing the Hypothesis, than to determine the Orbit itself. Though from Mr. *Cassini*'s Words, or those of his Interpreter, it no where appears; yet it is plain from his Construction of the Problem, and from his Analysis, that he supposed the Planet, if seen from the upper Focus, to move with an equable Motion. This was because *Kepler* thought the same, as may appear to those who will consult his Writings. But when he perceived that this by no means agreed with the Observations, he changed his Opinion, and espoused this, that the Line of the Planet's true Motion described equal Elliptical Areas in equal Times. But that

that Point from whence the Planet may be ſeen to proceed exactly with an equable Motion, is no where to be found in the Univerſe, unleſs we have a Mind to make it fluctuating. Yet no Point comes nearer to this equable Motion of the Planet, than that of the upper Focus of the Ellipſis. Nor is any one yet found that will deny, but that *Kepler*'s Area's may ſatisfy the Phænomena; but ſince neither he himſelf, nor any one ſince his Time, has been able to exhibit them by a direct Calculation, ſome have been apt to blame *Kepler*, as laying too great a Streſs upon Phyſical Cauſes, and thereby departing from Geometry. As though Phyſical Cauſes can be contrary to Geometry, or as if the Problem is leſs Geometrical which is thus propoſed, without making any mention of Phyſical Cauſes: *The Area of the Trilinium being given, which is comprehended between the Lines of the Apſids, of the true Motion, and alſo the Elliptical Arch; to find the Angle at the Sun.* They that object to this, a departing from Geometry, may take *Kepler*'s Anſwer; Let them go and ſolve the Problem.

But though *Kepler* was ſo ſcrupulous, as not to give up an Hypotheſis which, he was fully perſuaded, obtained in Nature, yet it may be free for others to make a Tryal, whether any other Way may be found, by which the firſt Inequality of the Planets may be inveſtigated by a direct *Calculus*. Therefore the learned *Bullialdus* undertook to ſearch out by Geometrical Reaſonings, in what Path, and with what Degrees of Intenſion and Remiſſion the Planets might be urged, ſo that by the Rule of equable Motion which was aſſumed by the Aſtronomers before *Kepler*, we might be brought to that Inequality we behold. The Monuments of that great Man are ſtill in being, whence the Lovers of Aſtronomy may be informed of his whole Method. The Right Rev. *Seth Ward* has embraced the ſame, and is the firſt that has ſhewed, that it performs the ſame Thing as a Line of equable Motion revolving about the other Focus of the Ellipſis. He has alſo ſupplied it with a direct Method of Calculation, the ſame which we have recited a little before. So that nothing ſeems to be farther required, than that *Urania* would proſper ſuch happy Attempts. And in her Name it was that the illuſtrious Count *Pagan*, in a Treatiſe publiſhed two Years after, of the ſame Tenour, ventured ſo far to aſſert the Truth of this Hypotheſis, as to chuſe to aſcribe to the Ignorance of Aſtronomers that Diſcrepancy that was diſcovered about the Octants. But the learned *Bullialdus* judged it ſafer to hear Aſtronomy herſelf, ſpeaking as it were by the Mouth of Obſervers; and by his ſecond Endeavours he exterminated that Diſcrepancy, by a certain Limitation which he annexed to his former Diſcoveries. Whence we may finally conclude, that this Hypotheſis, on which Mr. *Caſſini* has founded his Inveſtigation of the Apogee's and Excentricities, is ſo far removed from the Truth, as to make *Bullialdus*'s Limitation neceſſary; and from that Defect proceeds the Diſagreement between the Calculation and the Heavens themſelves.

2. The Annual Motion of the Earth through the Ecliptic occaſions an Optical Inequality in the Motions of the other Planets, which is well known to Aſtronomers that embrace the *Copernican* Syſtem, by the Name of the Paral-

By Mr. Edm. Halley. Aug. An. 1676. N. 128. *p.* 683.

Parallax of the Orbit. And this Inequality, which without much Labour is derived from Obſervations, I lay down as the ſtrongeſt Foundation of the following Method. In which, beſides Obſervations, nothing elſe is ſuppoſed, than that the Orbits of the Planets are Ellipſes, and that the Sun is placed in the common Focus of all the Orbits; and laſtly, that the Periodical Times of them all are ſo well known, that no Error can be perceived at leaſt in two or three Revolutions. Theſe Things being granted, firſt I muſt begin with the Motion of the Earth, which is neceſſarily required to account for the Motions of the other Planets.

Fig. 121. Let S be the Sun, A B C D E the Orbit of the Earth, P the Planet *Mars*, which for many Reaſons is chiefly to be preferred for this Purpoſe. And firſt let the true Time and Place be obſerved, when *Mars* is oppoſite to the Sun; for then the Sun and Earth coincide in the ſame Right Line with *Mars:* or, if he has Latitude, (which almoſt always happens) with that Point where a Perpendicular from *Mars* falls upon the Plain of the Ecliptic. Thus in the Scheme S, A, and P are in a Right Line. Again, after 687 Days *Mars* returns to the ſame Point P where he was oppoſed to the Sun in the former Obſervation; but as the Earth does not return to A till after $730\frac{1}{2}$ Days, in B it regards the Sun in the Line S B, but *Mars* in the Line B P; and the Longitudes of the Sun and *Mars* being obſerved, all the Angles of the Triangle P B S are given, and P S being ſuppoſed 100000, in the ſame Parts the Length of the Line S B is found. In like manner, after another Period of *Mars*, the Earth being in C, the Line S C is found, and ſo likewiſe the Lines S D, S E, S F; and the Differences of the obſerved Places of the Sun are the Angles at the Sun A S B, B S C, C S D, D S E. Thus we come at laſt to this Geometrical Problem, *Three Lines being given both in Length and Poſition, meeting in one of the Focus's of an Ellipſis, to find the Length of the tranſverſe Diameter, and the Diſtance of the Foci.* The Reſolution of this Problem may be extended alſo to the other Planets, if, after the Theory of the Earth's Motion is known, we find out (according to the Method propoſed by the Right Rev. the Biſhop of *Saliſbury* in his Geometrical Aſtronomy, *Lib.* 2. *Part* 2. *Cap.* 5.) three Diſtances of any Planet from the Sun with its Poſitions. Now becauſe the Biſhop ſuppoſes the Planet ſo to move in its Orbit, that in equal Times it compleats equal Angles at the other Focus of the Ellipſis, and upon this Suppoſition builds his Calculation; it will not be improper to ſhew how the ſame Thing may be done without that Suppoſition; which Obſervation obliges us to reject.

Fig. 122. Let S be the Sun, A L B K the Earth's Orbit, P the Planet, or the Point in the Plain of the Ecliptic marked out by the Perpendicular from the Planet; A B the Line of the Earth's Apſids. Firſt let the Longitude and Latitude of the Planet be obſerved, and alſo the Sun's Longitude from the Earth in K; and after a Period of the ſame Planet, the Earth being in L, let two Poſitions of the Planet and the Sun be again obſerved as before. Now from the obſerved Longitudes of the Sun and the Earth's Aphelion are given the Angles A S K, A S L, and conſequently the Sides S K, S L. Now in the Triangle K S L are given the Sides K S, L S, and the Angle K S L;

required

required the Side K L, and the Angles S K L, S L K. Then in the Triangle K L P are given K L, K P L the Difference of the obſerved Longitudes of the Planet, and P K L the Difference of the Angles S K L laſt found, and of S K P the Planet's Elongation from the Sun in the firſt Obſervation; required L P. Then in the Triangle L S P are given the Sides L S, L P, and the Angle P L S, the Planet's Elongation from the Sun in the ſecond Obſervation; required the Side S P and the Angle L S P; which being found it is, as S P to L P, ſo is the Tangent of the Latitude obſerved at L, to the Tangent of Inclination or Latitude to the Sun; and as the Co-ſine of Inclination to Radius, ſo is S P, the curtated Diſtance, to the true Diſtance of the Planet from the Sun. So at laſt we have found the deſired Poſition and Longitude. It remains to ſhew, how from three given Diſtances from the Sun, with the intercepted Angles, to find the middle Diſtance with the Excentricity of the Ellipſis.

Let S be the Sun, and S A, S B, S C, three Diſtances in due Poſition, and drawing A B, B C, let A B be the Diſtance of the Foci in an Hyperbola, and $SA - SB = EH$ be the tranſverſe Diameter. Theſe Things being premiſed, let that Hyperbolical Line be deſcribed, whoſe internal Focus is at the Point A, and the Extremity of the longer Line S A. In like manner let B, C, be the Foci of another Hyperbola, whoſe Diameter is $SB - SC = KL$; from which let the Hyperbolical Line be deſcribed, having its internal Focus at the Point B. I ſay theſe two Hyperbola's thus deſcribed will interſect one another in the Point F, which is one of the Foci of the Ellipſis required; and drawing the Line F A, F B, or F C, either $SA + FA$, $SB + FB$, or $SC + FC$, will be equal to the tranſverſe Diameter, and S F is the Diſtance of the Foci. Theſe being ſuppoſed, the Deſcription of the Ellipſis will be very eaſy. But whereas the Reaſon of this Conſtruction may not be obvious to every one, it will not be improper to give ſome Illuſtration of it. I ſay therefore, that from the moſt known Property of the Ellipſis, 'tis $SB + FB = SA + FA$, and tranſpoſing the Parts of the Equation $FB - FA = SA - SB$, ſo that though we did not know F B and F A, yet their Difference is equal to $SA - SB$, that is, to E H. And ſince it is from the Nature of the Hyperbola, that it has any two Lines from their Foci to any Point in the Curve, conſtantly differing by the Quantity of the tranſverſe Diameter; it is plain that the Point F is ſomewhere in the Curve of the Hyperbola, whoſe tranſverſe Diameter is equal to $SA - SB$, and its Foci A and B. In a like manner it may be demonſtrated, that the Point F is in an Hyperbola, whoſe Diameter is $SB - SC$, and its Foci B and C. Therefore it muſt neceſſarily be in the Interſection of thoſe two Hyperbola's, which, as they interſect one another in one Point only, plainly ſhew where the other Focus of the Ellipſis required muſt be. *Fig.* 123.

Now that the ſame Thing may be performed Analytically, ſuppoſe it done, and let $FB = a$, $Sa - SB = FB - FA = b$, $AB = c$, $SB - SC = FC - FB = d$, $BC = f$, and let the Sine of the Angle $ABC = S$, and the Coſine of the ſame $= s$.

 Then

Then $c \,.\, b :: 2a - b \,.\, \frac{2ab - bb}{c}$; and $\frac{2ab - bb + cc}{2c} = BD$, by 36. 3. *Eucl.* And $f \,.\, d :: 2a + d \,.\, \frac{2ad + dd}{f}$; and $\frac{ff - 2ad - dd}{2f} = BG$, by the same. Now to abbreviate the Calculation, make $\frac{cc - bb}{2c} = g$, and $\frac{b}{c} = h$; alſo make $\frac{ff - dd}{2f} = k$, and $\frac{d}{f} = l$. Then $BD = g + ha$, and $BG = k - la$. And becauſe in every

$\left\{ \begin{array}{l} \text{Obtuſe-angled} \\ \text{Acute-angled} \end{array} \right\}$ Triangle the Square of the Baſe is equal to the $\left\{ \begin{array}{c} \text{Sum} \\ \text{Difference} \end{array} \right\}$ of the Squares of the Sides, and of the double Rectangle of the Sides into the Coſine of the contained Angle; it will be $gg + 2gha + hhaa + kk - 2kla + llaa + 2gks - 2glsa + 2khsa - 2hlsaa$ is equal to the Square of DG. But DG is equal to the Sine of the Angle DFG or DBG drawn into FB or a; (for FBDG is a Quadrilaterum inſcribed in the Circle whoſe Diameter is FB) therefore $SSaa = gg + 2gha + hhaa + kk - 2kla + llaa + 2gks - 2glsa + 2khsa - 2hlsaa$: Which Equation is eaſily reſolved, ſince it does not exceed an affected Quadratick, and is always compoſed of thoſe Squares and Rectangles. Yet the Signs + and —, becauſe of the different Conſtitution of the three Lines, muſt be applied to the Rectangles with good Caution.

The Obliquity of the Eclipt ick, from the Obſervations of the Ancients; by Dr. Ed. Bernard. Sept. An. 1684. N. 163. p. 721.

XVII. 1. *An.* 230. before the Birth of *Chriſt*, *Eratoſthenes* found the Obliquity of the Ecliptic, 23°. 51′. 19″. 31‴. 5⁗.

For according to him the Diſtance of the Tropicks was $\frac{11}{83}$ of the Circle of the Meridian, or 47° $\frac{59}{83}$. *Ptolemy*'s *Magna Syntaxis*, *p.* 18. 21. Wherefore *Eratoſthenes*'s Obliquity was leſs than *Ptolemy*'s by only $\frac{3}{83}$ of a Second, which is a very contemptible Difference.

Eratoſthenes according to *Cleomedes* (as derived by *Ricciolus*) makes it 23 Degrees, and 46 Minutes beſides.

Eratoſthenes, as corrected by *Ricciolus*, 31′, 5″. (above 23°).

Hipparchus (140 Years before *Chriſt*) has retained the Obliquity of *Eratoſthenes*. *Ptol. Mag. Syntax*, *p.* 18. and *p.* 60.

Theo, as taken more exactly, 51′. 19″. 31‴. 5⁗.

Yet the *Chovareſmic* Tables, compiled 830 Years after *Chriſt*, exhibit the Canonic Obliquity of the *Alexandrians*, according to a *Latin* Manuſcript of D. *Hatton*, 51′.

Pytheas Maſſilienſis, 324 Years before *Chriſt*, (in *Ricciolus*) 52′. 41″.

Ariſtarchus, before *Chriſt* 280 Years, by the illuſtrious *Savil*'s Computation, 51′. 20″.

Ariſtarchus, as *Ricciolus* has deduced it, 30′. 00″.

Strabo the Geographer, *p.* 93. 30 Years after *Chriſt*, makes it $\frac{4}{60}$ of a Circle, or above 23°, yet 1 more, or 60′.

Nor otherwiſe *Geminus*, in *Chriſt*'s Time, *Chap.* iv. *Elem. Aſtron.* And *Tatius*,

Tatius, *cap*. 26. and *Proclus* of the Sphere. And the Aſtrologers in *Noddamus* the *Arabian*, *Abraham Abeneſdra*, *&c*.

Noddamus the Aſtronomer, who flouriſhed about *An. Dom.* 1200, takes Notice, that the Obliquity was never obſerved greater than 24 Degrees, nor leſs than 23° . 33′, and yet that it continually decreaſes.

Claud. Ptolemeus, after *Chriſt* 140. having often tried it with his Ring and his Table, always found it nearly the ſame with that of *Eratoſthenes*, 51′ . 20″.

For the Diſtance of the Tropicks was between 47⅔ and 47¾. But he choſe for his little Table 47° . 42′ . 40″ . *Mag. Syntax*, *p*. 18. 20, 21, and 27. He took nearly the middle, 23° . 51′ . 20″ ; nor otherwiſe in his Hypotheſes of the Planets. But *Theo* in his ſhorter Tables, for the Sake of Expedition, omits the Seconds. But *Ricciolus* is miſtaken, when from the Climate of *Rhodes* he deduces the Meaſure of the Obliquity for *Ptolemy* to be 23° . 30′.

Pappus of *Alexandria*, (390 Years after *Chriſt*) *l*. 6. *Theor*. 35. by *Ricciolus* 30′.

Pappus, as *Fr. Commandinus* computes it, 50′ . 00″ . 00‴.

Theo, (after *Chriſt* 370 Years) *p*. 88. more accurately, 51′ . 20″ . 00″.

Elſewhere in a round Number, as *p*. 57. and frequently in his ſhorter Tables not yet publiſhed, 51′ . 00″ . 00‴.

Almamon the Prince, *An. Chriſt*. 825. of the *Hegira* 210, makes it 23° . 35′. *Grav*. *p*. 44. from *Ebn-Shatir* of *Damaſcus*, MS. *Selden*. many Aſtronomers aſſiſting him. For ſo *Abeneſdras* relates, MS. *Lat*. in the Archives of *Digby*. Alſo an uncertain Aſtronomer in *Archiv. Seld*. affirms, that *Jabia Ebn Albimanſur*, with many other Philoſophers, in the Time of *Almamon*, found the Obliquity to be by Obſervation 23° . 35′.

The moſt learned *Al Noddam*, in his Commentaries upon the Aſtronomical Works of *Hoſein Niſaburienſis*, ſays the ſame Thing of the Obſervations of *Almamon*. To which he adds, that in the ſame Age *Beni Muſa* often obſerved the ſame Meaſure to be 23° . 35′. in the Neighbourhood of *Bagdad*. MS. *Arab. Coll. St. John Oxon*. And this was approved by moſt of the Aſtronomers that ſucceeded. At leaſt *Alferganus* acquieſces in it in his Aſtronomy, *Chap*. 5.

Mohammed Ebn Gaber Al Batanius (or *Bategnius*) at *Racca*; according to *Ricciolus*, *An. Dom*. 880. *Savil*. 890. *Gravius p*. 44. 882. of the *Hegira*, 269. He died in the Year of the *Hegira*, 317. *An. Dom*. 929. In the Hiſtory of *Abolfaragus*, *p*. 191. *Obliq*. 35′ . 00′.

Al Batanius in this Affair makes no Scruple of preferring his own Obſervations before the Words of *Ptolemy*, *cap*. 4, and ſays, that being aſſiſted with a very long *Albidada*, or Parallactical Ruler, in Reſemblance of thoſe of *Ptolemy*, with great Care and Diligence he found at *Racca*, that the Diſtance of the Tropics was 47° . 10′ . (that is, 59° . 36′ — 12° 26′) and therefore the Latitude of *Racca* was 35° ; which yet *Ulocbeg* makes 36° . 10′ ; *Schickard* in *Curtius*, (*p*. 33.) and *Ricciolus* make it 36°.

Thabet Ebn Corra, (with *Ricciolus*, *An. Dom*. 1210. more truly 901, in the 289. of the *Hegira*) found the Obliquity to be 33′ . 30″.

Abul

Abul Hosein Ebn Suphi, 35′. 00″.

Abul Waffi Albuziani, and *Abn Hamed Saganiensis*, a very ingenious Person, (*A. D.* 987. *Heg.* 377.) at *Bagdad* found the Obliquity to be very near 35′.

So a *Persian* Author in the Archives of *Selden*, 35′.

In like manner the *Persic* Tables of *Crysococca*, 35′.

Al Batrunius Abul Rihan, (*A. D.* 995. of the *Hegira* 385. *Abolfaragius* puts him at 463. of the *Hegira*, or *A. D.* 1070.) made use of a Quadrant whose Radius was 15 Cubits (*Grav.* p. 54. from an *Arabic* Book of *Birunius*) 35′.

But *Abu Joafer Alchazan*, with his Associate *Abufaldus Harwanensis* at *Edessa*, and others of that Age, (*A. D.* 970.) observed that the Obliquity did not quite come up to 23°. 35′, but was something less.

Almæon Son of *Almansor* (*A. D.* 1140. *Ricc.*) 33′. 30″. But according to *Clavius* and *Mæstlin* he made it 33′ only.

Ismael Abulfeda Prince of *Hama*, (*A. D.* 1311. of the *Hegira* 711.) in his Manuscript Tables *Arab. Coll. St. John*, retains 35′. 00″. perhaps on the Authority of *Almamon.*

Prophatius the *Jew*, (*A. D.* 1300. *Ricc.* 1303. *Mæstlin* in *Curtius* p. 40. 230 Years after *Arzachel*, saith *Copernicus*) and in *Ricciolus*, and a Manuscript of *Merton* College, 32′. 00″.

Abu Mahmud Al Chogandi, (*A. D.* 992. of the *Hegira* 382.) in the Time of *Fecrodaula*, with a Sextant whose Radius was 40 Cubits, and the Limb was divided into Seconds, found the Obliquity less than it had ever been taken by any of his Ancestors; that is, 32′. 21″.

Hence *Noddamus* the Astronomer affirms, (MS. *Coll. St. John*) that the Sun's greatest Declination was hardly ever found less than 23°. 33′.

Arzachel of *Spain*, (*Grav.* p. 44. *A. D.* 1089. of the *Hegira* 482. *Ricc.* 1070. *Mæstlin* in *Curtius*, p. 35. 1075. *Copernicus*, l. 3. c. 6. 190 Years after *Al Batanius*) has proposed the Obliquity 23°. 33′. 30″. So MS. *Coll. Mert. Oxon.* where it is said, that there is a Difference of 17′. 30″. between the Obliquity of *Ptolemy* and that of *Arzachel.*

At *Maraga* the most noble *Persian Chojah Nasiroddinus Tusensis*, *A. D.* 1629. of the *Hegira* 668. (but *Grav.* p. 44. 1261. *Hegir.* 660.) observed the Obliquity most accurately, and found it 23°. 30′. 00″.

This is the least of the Sun's greatest Declinations, that has been found to this Day, says the very learned Commentator upon the Astronomical Works of *Hosein Nisaburiensis.*

Ebn Shatir Damascenus, MS. *Seld. A. D.* 1363. says that he corrected the Obliquity, not neglecting the Sun's Horizontal Parallax, which was found 2°. 59′. Hence the Sun's greatest Declination, 23°. 31′. 00″.

Olocbegus the Prince, *A. D.* 1437. *Hegir.* 841. with *Ali Cushgius* and other Astronomers, with very great Care and the largest Instruments, (see *Graves*, p. 44.) found the Obliquity 23°. 30′. 17″. So MSS. *Coll. St. John* and of the *Savilian* Library. For *Selden*'s Manuscript makes it 23°. 30′. 27″.

Rabbi

Rabbi Moyſes Ben Maimon, the moſt learned of the *Jews*, ſays in *Jad. de Conſecratione Calendarum*, c. *ult. ſect.* 4. that the greateſt Obliquity of the Zodiac, *A. D.* 1174, was 23° . 30′, very near.

I muſt let you know, that I have conſulted ſcarce half of the Oriental Aſtronomers, whoſe Writings are preſerved in the Libraries of the Univerſity of *Oxford*. But from theſe Obſervations, and ſome others which I keep to myſelf from the Vulgar, I conclude, that the Obliquity of the Zodiac has always been the ſame from the Beginning of the World. For the latter Ages, as you may perceive, by the Aſſiſtance of better Inſtruments, have truly corrected the Error and Exceſs of the antient Aſtronomy.

The Obliquity of the Ecliptick and Elevation of the Pole continue unaltered; by - - - - - - - Nov. An. 1687. N. 190. p. 403.

2. Whether the Poles and Axis of the Earth be really fixed in the Globe, or ſubject to be transferred from Place to Place, is an old Enquiry, though now lately revived by Mr. *Hook*, in his ingenious Eſſays upon the great Mutations and Cataſtrophes which, in all appearance, have happened to the Earth's Surface. A neceſſary Conſequence of ſuch a Tranſlation of the Poles would be the Change of the Latitudes of Places, which would increaſe in thoſe Regions towards which the Poles approach, and decreaſe in thoſe from which they recede: and under the Meridian, 90 Degrees removed from that in which the Poles ſhift, the Latitudes continuing the ſame, the Meridian Line would only alter; but not two Places conſiderably differing in Longitude can be ſuppoſed, wherein, if there be any ſenſible Motion of the Poles, it ſhall not be perceived by the Alteration of the Latitude of one or both of them.

The accurate M. *Wurtzelbaur* has lately furniſhed us with the Means of examining this Hypotheſis by Obſervation, having ſent us the Meridian Altitude of the Sun taken at *Nuremberg* about the two Solſtices in the Year 1686. *June* 10. he found the Meridian Altitude of the Sun 64° 2′ 20″, and the next Day 64° 2′ 25″. And on *Decemb.* 14. (three Days after the Solſtice, wherein the Sun was got two Minutes higher) he found the Meridian Altitude 17° 9′ 10″. wherefore the ſolſtitial Altitude was 17° 7′ 10″. Theſe Heights were taken by an Inſtrument of 6 Foot Radius of Braſs; and the Skill and Diligence of the Obſerver is not to be doubted.

To compare with theſe, I find among *Bernard Walther*'s Obſervations, made in the ſame City of *Nuremberg* two hundred Years before, *viz.* in the Year 1487. that the Meridian Altitude of the Sun in the Summer Solſtice was obſerved by the parallactick Inſtrument of *Ptolemy*, whereby the Chord of the Sun's Diſtance from the Zenith was obſerved 44890 Parts of 100000 Radius; the ſame being obſerved by the Concurrence of the Obſervations of ſeveral Years both before and after. The Arch anſwering to this Chord gives the Sun's Diſtance from the Zenith 25° 56′ 30″, and conſequently the Meridian Altitude, its Complement to a Quadrant, 64° 3′ 30″. Again, the ſame Year 1487. the Chord of the Meridian Diſtance of the Sun from the Zenith, on the Day of the Winter Solſtice, was found 118790, confirmed likewiſe by many ſubſequent Obſervations; the Arch anſwering to this Chord is 72° 52′ 40″. and its Complement 17° 7′ 20″, the Meridian Height of the Sun in the Winter Solſtice.

Hence

Hence it appears, That the Solſtitial Heights were very nearly the ſame at *Nuremberg* 200 Years ago as now they are; that of the Summer Solſtice being but one Minute differing, the other only 10′; both which may poſſibly ariſe from the Defects of the Inſtruments of theſe Obſervers, being made with Plane Sights: But what I ſhall neceſſarily conclude from hence, is, That if there be ſuch a Motion of the Poles, it is either very ſlow, or elſe nearly at Right Angles to the Meridian of *Nuremberg*; in which latter caſe, the Latitudes of Places about *Tunking*, *Siam*, *Malacca*, and *Java*, on the one Side, and in our *American* Plantations of *New-England*, *Virginia*, *Jamaica*, &c. on the other, ought to change faſteſt: But I have never yet heard of any ſuch thing obſerved by any of our Navigators; whence, if there be ſuch a Change of the Earth's Poles, it muſt neceſſarily require a long time to become ſenſible.

Beſides, from theſe Obſervations, it appears, That the Obliquity of the Ecliptick has continued unaltered for theſe 200 Years laſt paſt; that is to ſay, that the Angle which the Earth's Axis makes with the Plane of the Ecliptick or Orb wherein ſhe moves annually round the Sun, has been without ſenſible Change in all that Time; which will be very hard to conceive, if we allow a Tranſlation of the Earth's Poles; for the Direction of the Axis being perfectly at Liberty, it muſt be purely caſual, if it ſo hit, that after ſuch Change, it make the ſame Angle with the Ecliptick as before.

A farther Argument of this Slowneſs of the Change of the Poles, is the Latitude of *Alexandria*, the Habitation of thoſe famous Aſtronomers of Antiquity, *Eratoſthenes*, *Timocharis*, *Hipparchus*, and *Ptolemy*; and for that Reaſon it may be concluded, that this, of all the Latitudes the Ancients have left us, ought to be one of the moſt Correct. This by *Ptolemy* is ſaid to be 30° 58′ North, (which he uſes in all his Computations in his *Almagiſt*, and ſeems derived from the Proportion of the Gnomon to its Equinoctial Shadow, as 5 to 3, but in his *Geography*, 31° juſt.) In the Year 1638, the curious and ingenious Mr. *Graves*, when he went to viſit the *Egyptian Pyramids*, of which he has given ſo good an Account, did, with a ſufficient Inſtrument, obſerve the Latitude of *Alexandria*, and found it 31° 4 or 6 Minutes more than it is reputed by *Ptolemy*, and before him by *Eratoſthenes*; ſo that in about 2000 Years, the Latitude of *Alexandria* has altered only a few Minutes; and ſo few, that the Accuracy of the Obſervations of the Ancients may well be queſtioned: But, both being granted, this Motion will amount to no more than a Degree in 20000 Years.

This is not ſaid with intent to invalidate what Mr. *Hook* hath from ſo good Grounds advanced, *viz.* That the Ball of the Earth, at leaſt the Fluids thereof, being neceſſarily of the Figure of a *Spheroides prolatus*, or flat Oval, whoſe ſhorteſt Diameter is the Axis, and greateſt Circle the Equinoctial; if the Poles be ſuppoſed changed, the Equinoctial will be ſo too; and conſequently the Water muſt riſe and cover thoſe Parts from which the Poles recede, and fall off and leave bare thoſe Places towards which the Poles approach. By this Means it may be accounted for, how ſuch ſtrange Marine things are found on the Tops of Hills, and ſo deep under Ground; and ſcarce any

any other Way. But from theſe, and the like Obſervations, it will follow, That if theſe Inundations are produced by any regular Motion of the Poles, it would require a prodigious number of Ages to effect the Changes we may be certain have been. Beſides, if the Acceſs and Receſs of the Sea were after ſuch a gradual manner, as when produced by ſuch an eaſy Tranſlation of the Poles, as can by Obſervation be admitted, thoſe Inundations could never be fatal to the Inhabitants; for that they would always give notice of their coming, ſo that the People might provide for their Safety. But the *Holy Scriptures*, and Pagan Tradition, do unanimouſly agree, That the laſt great *Deluge* was brought to paſs in a few Days, with no previous Notice; ſo that the Account we have thereof, could not, by this *Hypotheſis*, be made out, without the Suppoſition of a great and ſudden Alteration in the Poles of the Earth's Diurnal Revolution: For which, whether we ſhould have recourſe to the intelligent Powers, that firſt impreſs'd this whirling Motion on the Ball, or leave it to be performed naturally, by the caſual Shock of ſome tranſient Body, ſuch as a Comet, or the like, whereby the former Axis might be loſt, and a New Revolution produced, differing both in Time and Poſition from the Old; I ſhall not undertake to diſpute: Such a Suppoſition would include likewiſe a Change of the Length of the Year, and Eccentricity of the Earth's Orb; for which we have no ſort of Authority.

A ſuppoſed Alteration of the Meridian Line; by . . . . N. 255. p. 285. Jun. An. 1699.

1. As I was wondering how an ordinary Mathematician could miſs ſo eaſy a thing as the drawing a true Meridian, ſo far as in the inſtance of the old Meridian in the Church of St. *Potronio* in *Banonia*, which is found by M. *Caſſini* to vary 8 or 9 Degrees from the true Meridian of the Place; and in that of the Meridian of *Uraniburge*, which is found by M. *Picart*, and others, to vary 18′; I hit upon this Thought, that Meridians muſt needs vary. For you know, that (taking it for granted that the Earth moves, *&c.*) beſides the Diurnal and Annual Revolutions, there muſt be alſo a third to account for that ſlow Motion of the Fixed Stars upon the Pole of the Ecliptick, in about 25000 Years; which is ſolved by the Direction of the Earth's Axis from one Point to another of the polar Circle. And that Direction being nothing but a certain Wabble in the Earth's Motion, muſt needs make the Noon-ſhade of a Perpendicular not lie always in the ſame Line.

Conſidered by Dr. Wallis. *Ibid. p.* 289.

2. This being a new Suggeſtion, deſerves to be conſidered: For it is not probable that ſo careful a Man as *Tycho*, and thoſe concerned in the Church of St. *Petronio*, ſhould be ſo much miſtaken in the Meridian Line. But if there be ought of this Nature, it muſt ariſe from a Change of the Terreſtrial Poles (here on Earth) of the Earth's Diurnal Motion; (not of their pointing to this or that of the Fixed Stars:) For if the Poles of this Diurnal Motion remain fixed to the ſame Place on the Earth, the Meridians, (which paſs thro' theſe Poles) muſt remain the ſame.

The Parallax of the Sun; by Mr. Flamſteed. N 89. p. 1519. Nov. An. 1672. N. 96. p. 6100.

XVIII. I have had the good hap to meaſure the Diſtances of *Mars* from two Stars the ſame Night; whereby I find, that his Parallax was very ſmall, certainly not 30″: So that I believe the Sun's Parallax is not more than 10″.

To find the Sun's Ingress into the Tropical Signs; by Mr. Edmund Halley. N 215. p. 12. Feb. *An.* 1695.

XIX. It may perhaps paſs for a Paradox, if I ſhould aſſert, That it is an eaſier Matter to be aſſured of the Moments of the Tropicks, or of the Times of the Sun's Entrance into *Cancer* and *Capricorn*, than it is to obſerve the true Times of the Equinoctials or Ingreſs into *Aries* and *Libra*. But I here deſign to ſhew a Method to find the Moment of the *Tropicks*, capable of all the Exactneſs the moſt accurate can deſire; and that without any Conſideration of the Parallax of the Sun, of the Refractions of the Air, of the greateſt Obliquity of the Ecliptick, or Latitude of the Place; all which are required to aſcertain the Times of the Equinoctial, from Obſervation; and which, being faultily aſſumed, have occaſioned an Error of near three Hours in the Times of the Equinoctials deduced from the Tables of the Noble *Tycho Brahe* and *Kepler*, the Vernal being ſo much later, and the Autumnal ſo much earlier than by the *Calculus* of theſe famous Authors.

Now before we proceed, it will be neceſſary to premiſe the following *Lemmata*, ſerving to demonſtrate this Method; *viz.*

1. That the Motion of the Sun in the Ecliptick, about the Time of the *Tropicks*, is ſo nearly equable, that the Difference from Equality is not ſenſible, from 5 Days before the Tropick to 5 Days after, by reaſon of the nearneſs of the *Apogæon* of the Sun to the Tropick of *Cancer*.

2. That for 5 Deg. before and after the Tropicks, the Differences whereby the Sun falls ſhort of the Tropicks, are as the *Verſed Sines* of the Sun's Diſtance in Longitude from the Tropicks; which *Verſed Sines* in Arches under 5 Degrees, are beyond the utmoſt Nicety of Senſe, as the Squares of thoſe Arches. From theſe two follows a third;

3. That for 5 Days before and after the Tropicks, the Declination of the Sun falls ſhort of the utmoſt Tropical Declination, by Spaces which are in *Duplicate* Proportion, or as the Squares of the Times by which the Sun is wanting of, or paſt, the Moment of the Tropick.

Hence it is evident, That if the Shadows of the Sun, either in the Meridian, or any other Azimuth, be carefully obſerved about the time of the Tropicks, the Spaces whereby the tropical Shade falls ſhort of, or exceeds, thoſe at other times, are always proportionable to the Squares of the Intervals of Time between thoſe Obſervations and the true Time of the Tropick; and conſequently if the Line, on which the Limits of the Shade is taken, be made the Axis, and the correſpondent Times from the Tropick, *Expounded* by Lines, be erected on their reſpective Points in the Axis as Ordinates, the Extremities of thoſe Lines ſhall touch the Curve of a *Parabola*. Thus, *a*, *b*, *c*, *e*, being ſuppoſed Points obſerved, the Lines *a* B, *b* C, *c* A, *e* F, are reſpectively proportional to the Times of each Obſervation before or after the tropical Moment in *Cancer*. *Fig.* 124.

This premiſed, we ſhall be able to bring the Problem of finding the true Time of the Tropic by three Obſervations, to this Geometrical one: *Having three Points in a* Parabola, A, B, C, *or* A, F, C, *given, together with the Direction of the Axis; to find the Diſtance of thoſe Points from the Axis.*

Of

Of this there are two Cafes; the one, when the Time of the fecond Obfervation B is precifely in the Middle between A and C: In this Cafe, putting t for the whole Time between A and C, we fhall have Ac, the Interval of the remoteft Obfervation A, from the Tropick, by the following Analogy.

As $2ac - bc$ to $2ac - \frac{1}{2}bc$, fo is $\frac{1}{2}t$, or A E, to Ac, the Time of the remoteft Obfervation A, from the Tropick.

But the other Cafe, when the middle Obfervation is not exactly in the Middle between the other two Times, as at F, is fomething more operofe, and the whole Time from A to C, being put $= t$, and from A to F, $= s$, $ce = c$, and $bc = b$, the Theorem will ftand thus, $\frac{ttc - bss}{2tc - 2bs} = Ac$ the Time fought.

To illuftrate this Method of Calculation, it may, perhaps, be requifite to give you one or two Examples.

Ann 1500. *Bernard Walter*, in the Month of *June*, at *Nuremberg*, obferv'd the Chord of the Diftance of the Sun from the Zenith, by a large *Parallactick* Inftrument of *Ptolemy*, as follows;

June 2. 45467.	and	*June* 8. 44975.
June 9. 44934.		*June* 12. 44883.
June 16. 44990.		*June* 15. 44990.

In both thefe Cafes the middle Term is exactly in the middle between the Extremes, and therefore in the former three, $ac = 533$, $bc = 477$, and t, the Time between, being 14 Days, by the firft Rule, the Time of the Tropick will be found by this Proportion; as 589 to $827\frac{1}{2}$, fo $\frac{1}{2}t$, or 7 Days, to 9 Days, $20^h. 2'$. Whence the Tropick, *An.* 1500. is concluded to have fallen *June* 11. $20^h. 2'$. In the latter three ac is $= 107$, and $bc = 15$, and the whole Interval of Time is 8 Days $= t$; whence, as 199 to $206\frac{1}{2}$, fo is 4 Days to $4^d. 3^h. 37'$; which, taken from the 16th Day at Noon, leaves $11^d. 20^h. 23'$. for the Time of the Tropick, agreeing with the former to the third Part of an Hour.

Again; *Ann.* 1636. *Gaffendus* at *Marfeilles* obferved the Summer Solftice by a Gnomon of 55 Feet high, in order to determine the Proportion of the Gnomon to the Solftitial Shade, and he hath left us thefe Obfervations, which may ferve for an Example for the Second Rule.

June 19	*St.* N. Shadow	31766	Parts, whereof the Gnomon was 89428.
20		31753	
21		31751	
22		31759	

These being divided into two Setts, of three Observations, each, *viz.* The 19th, 20th, and 22d, and the 19th, 21st, and 22d, we shall have in the first three, $c = 13$, and $b = 7$, $t = 3$ Days, $s = 1$; and in the second, $c = 15$, and $b = 7$, $t = 3$, and $s = 2$. Whence, according to the Rule, the 19th Day at Noon the Sun wanted of the Tropick a Time proportionate to one Day, as $ttc - ssb$ to $2tc - 2bs$; that is, as 100 to 64 in the first Sett, or 105 to 62 in the second Sett; that is, $1^d. 17^h. 15'$. in the first, or $1^d. 17^h. 25'$. in the second Sett: So that we may conclude the Moment of the Tropick to have been *June* $10^d. 17^h. 20'$. in the Meridian of *Marseilles.*

Now that these two Tropical Times thus obtained, will be found to confirm each other's Exactness from their near Agreement, appears by the Interval of Time between them, *viz.* $1^d. 2^h. 30'$. less than 136 *Julian* Years, whereof $1^d. 1^h. 8'$. arises from the Defect of the Length of the Tropical Year from the *Julian*, and the rest from the Progression of the Sun's *Apogæon* in that Time; so that no two Observations made by the same Observer in the same Place can better answer each other, and that without any the least Artifice or Force in the Management of them.

What were the Methods used by the Ancients to conclude the Hour of the Tropicks, *Ptolemy* has no where deliver'd; but it were to have been wished that they had been aware of this, that so we might have been more certain of the Moments of the Tropicks we have received from them; which would have been of singular Use to determine the Question, Whether the Sun's *Apogæon* be fixed in the Starry Heaven; or, if it move, What is the true Motion thereof? It is certain, that if we take the Account of *Ptolemy*, the Tropick said to be observed by *Euctemon* and *Meton*, *Junii* 27 *Mane*, *Ann.* 432. *ante Christum*, can no ways be reconciled, without supposing the Observation made the next Day, or *June* 28 in the Morning. And *Ptolemy*'s own Tropick, observed in the 3d Year of *Antoninus*, *Ann. Christ.* 140. was certainly on the 23d, and not on the 24th Day of *June*, as will appear to those that shall duly consider and compare them with the Length of the Year deduced from the diligent and concordant Observations of those two great Astronomical Genii, *Hipparchus* and *Albatani*; established and confirmed by the Concurrence of all the Modern Accuracy. For the Observations give the Length of the Tropical Year, such as to anticipate the *Julian* Account only one Day in 300 Years; but we are now secure, that the said Period of the Sun's Revolution does anticipate very nearly 3 Days in 400 Years; so that the Tables of *Ptolemy*, founded on that Supposition, do err about a whole Day in the Sun's Place for every 240 Years. Which principal Error in so fundamental a Point, does vitiate the whole Superstructure of the *Almagest*, and serves to *convict its Author of want of Diligence, or Fidelity, or both.*

But to return to our Method: The great Advantage we have hereby, is, That any very high Building serves for an Instrument, or the Top of any high Tower or Steeple, or even any high Wall whatsoever, that may be sufficient to intercept the Sun, and caſt a true Shade, and make the Spaces large and fair; though the Heighth and Diſtance of the Building, and Poſition of the Plane upon which you receive the Shade, and of the Line on which you meaſure the Spaces, be not exactly known. But it is convenient that the Plane on which you take the Shade be not far from perpendicular to the Sun, at leaſt not very oblique, and that the Wall which caſts the Shade, be ſtreight and ſmooth at the Top, and its Direction nearly Eaſt and Weſt. The principal Objection is, That the *Penumbra*, or Partile Shade of the Sun, is, in its Extremes, very difficult to diſtinguiſh from the true Shade; which will render this Obſervation hard to determine nicely. But if the Sun be tranſmitted through a Teleſcope, after the Manner uſed to take his *Species* in a *Solar Eclipſe*, and the upper Half of the Object-Glaſs be cut off by a Paper paſted thereon, and the exact upper Limb of the Sun be ſeen juſt emerging out of it, or rather contingíng the Species of the Wall, (the Poſition of the Teleſcope being regulated by a fine Hair extended in the Focus of the Eye-Glaſs) I am aſſured, that the Limit of the Shade may be obtained to the utmoſt Exactneſs. I ſhall only further advertiſe, That the Winter Tropick by this Method may be more certainly obtained than the Summer's; by reaſon that the ſame Gnomon does afford a much larger Radius for this manner of Obſervation.

The Solar Numbers corrected; by M. J. Flamſteed. N. 110. *p.* 220. Jan. An. 1675.

XX. I have found it neceſſary to make new Solar Numbers, becauſe in my old I have neglected to apply Refractions in all the Altitudes above 30 Degrees; wherein yet Reaſon and ſome little Experience hath ſhewed me, they are not inſenſible. I found *S. Caſſini*'s Obſervations, which I took from *Ricciolus* his *Aſtronomia Reformata*, much more accurate than *Tycho*'s, and therefore ſought out Numbers that might anſwer them. The *Apogæum* I found it neceſſary to promote 44 Minutes; ſo that *Anno Ineunte* 1655, it might be in ♋ 7. 30. 00. and to make the greateſt Equation only 1°. 54′. 13″. whereby I found the *Phænomena* would be anſwered much more accurately than I expected, and as near, all things conſidered, as I could deſire.

But ſtill I was uncertain, whether the Refractions in the ſaid *Caſſini*'s Tables were juſt Meaſures or not, and I had no Conveniencies for making Trial. At laſt I thought on this Expedient, which fully ſatisfied me; *viz.*

I conſidered, That if ſome of thoſe Obſervations of the Diſtances of ♀ from the ☉ by Day, and from the Stars in the Night preceding or following, were ſkilfully examined, they might ſhew me the true Quantity of the Equations of the Sun's Orb, or rather the Difference of his Mean and Equal Motion. I turned over his *Progymnaſmata*, and pitched on two: The firſt made *Ann.* 1585, *March* 5. 4^h. 42′. and 7^h. 12′. *poſt Meridiem*: whereby I found the ☉ at 4^h. 42′. was 94°. 47′. in the Antecedence of the *Lucida Calcis* ♊; the ſecond made *Ann.* 1585, *September* 15. 5^h. 15′. and 6^h. 55′. *Mane.* Where-from (applying and conſidering the Refractions

fractions in both) I found the Sun at 6°. 35^h. to be 74°. 30′. in Consequence of the *Lower Head* of ♊. The Difference of Longitude betwixt these two Stars is 17°. 59′: And therefore, now the Sun, in Consequence of the *Lucida Calcis* ♊. 92°. 29′. So that the Sun's apparent Motion betwixt the Year 1582. *Mar.* 5. 4^h. 42′. and the Year 1585. *Septemb.* 15. 6^h. 55′. *Manè*, (besides the whole Revolutions) was 187°. 16′. but the Mean Motion is 191°. 2′. greater than the Apparent by 3°. 46′. which parted in proportion to the Equation of the Earth's Motion, collected for those Times from my New Tables, gives the greatest Equation of the Orb, 1°. 54′. 15″. consenting, to my wonder, without any wresting of the Observations, with that, which I deduced from *Cassini*'s correct Meridional Altitudes.

The Sun's Motion, by the Tables which I now use, grounded on this Equation, is less than *Tycho*'s by no less than 9. That great Equation made him commit no small Errors, and put him upon strange Shifts to hide and solve them. So that all his Observations of the Planets in their Oppositions to the Sun are to be corrected before we attempt to represent them by Numbers; for his Errors in the Sun's Place made him err sometimes 5 or 6 Hours in the Time of the Opposition; which must be reformed.

The Equality of Natural Days; by . . . . Professor of Mathematicks at Seville. N. 118. p. 426. Oct. An. 1676.

XXI. There is still no small Disagreement among Astronomers, how great the Prosthaphæresis is in equating Time; so that *Longomontanus* confesses, that he has found no greater difficulty in all his Astronomical Labours: Which when I took notice of, I considered in some Observations of the Heavens made by me, what might be the result. And having a very exact Pendulum Clock, with a Meridian Line artificially contrived, I observed the Sun's Transit over the Meridian every Day, with which my Clock agreed exactly, and if at any time it disagreed, it very seldom disagreed two Minutes, which I rectified when there was occasion. So that persisting for three Years, and duly observing the Sun in the Meridian, whenever it could be done, (which in this part of the World is very often,) I was satisfied at last, that no natural Day, at this or that Season of the Year, had a longer Revolution than another Day; whence I can boldly pronounce, that all natural Days are equal, and that if there should be any minute Difference among them, it is quite insensible. This I was willing to make known, that I might release Astronomers from this Scruple, which has perplexed so many, and still perplexes them every Day; though the Equation of *Tycho*, because of the Obliquity of the Ecliptick, must not be rejected.

Refuted; by Mr. Flamsteed. *ibid.* p. 430.

2. How Natural Days can be equal, and yet *Tycho*'s Equation be admitted, I confess I cannot comprehend. For because of the unequal Right Ascensions of equal Parts of the Ecliptick, one Equinoctial Day will be shorter than a Tropical Day, by 40 Seconds of an Hour; and 14 Tropical Days are longer than so many Equinoctial ones by the sixth Part of an Hour, or ten Minutes. But this Difference I think must be greater than that the Professor of *Seville* should not perceive it in his Observations; and therefore in examining them, I imagine he admitted *Tycho*'s Equation.

Now

Now if we ſuppoſe that the Revolutions of the Primum Mobile are all equal, (which was never denied by any that received the *Ptolemaick Hypotheſis*,) it will however neceſſary follow, that the Equation of Time is not to be rejected, which proceeds from the unequal Motion of the Sun in his Orbit; for whereas the Apogee advances daily only 57′. 10″. but the Perigee 61′. 15″; the Apogee will return ſooner by 16″ (or in the Time in which the Primum Mobile revolves 4′. 5″.) from Noon to the Noon of the Day following, than the Perigee can. Yet ſometimes the Equation proceeding from this Cauſe admits of a ſlower daily increaſe, that is, 8″ daily at moſt when it is ſwifteſt, and in 15 Days it hardly amounts to the Quantity of two Scruples, which I believe is taken away in his Clock, by that Correction of two Scruples which he mentions: Which therefore this learned Man ſhould conſider.

But laſtly, if he is more inclined to admit the *Copernican Hypotheſis* than the *Ptolemaick*, in that alſo the ſame Equations will follow, ſuppoſing the Revolutions of the Earth to be Iſochronal. Indeed I confeſs, that the Equation of Time proceding from the unequal Motion of the Sun in its Orbit, may be removed, and directed the contrary Way, if we ſuppoſe the Earth, or the Primum Mobile, to make unequal Revolutions: But if he will conſider the Nature of Time, he will eaſily underſtand, that it is impoſſible all its Inequality ſhould be removed.

XXII.
An Equation Table; by M. Cassini.
N. 214 p. 248.

A Table of the *Equation* of Days, to be entered with the Place of the Sun.

	♈		♉		♊		♋		♌		♍	
G.	'Sub.	"	'Add.	"	'Add.	"	'Sub.	"	'Sub.	"	'Sub.	"
0	7	45	1	11	4	3	0	59	5	43	2	8
1	7	26	1	24	4	0	1	15	5	45	1	53
2	7	7	1	37	3	56	1	29	5	46	1	37
3	6	48	1	49	3	51	1	42	5	47	1	21
4	6	29	2	1	3	45	1	54	5	48	1	5
5	6	10	2	12	3	39	2	6	5	48	0	48
6	5	51	2	23	3	32	2	19	5	48	0	30
7	5	31	2	33	3	25	2	32	5	46	0	12
8	5	11	2	43	3	17	2	44	5	44	0 Add	7
9	4	51	2	53	3	9	2	56	5	40	0	26
10	4	31	3	3	3	0	3	8	5	36	0	35
11	4	11	3	13	2	51	3	20	5	31	1	3
12	3	52	3	22	2	41	3	32	5	25	1	21
13	3	33	3	30	2	31	3	43	5	19	1	40
14	3	14	3	37	2	21	3	54	5	13	1	59
15	2	55	3	43	2	10	4	4	5	6	2	19
16	2	37	3	48	2	0	4	14	4	58	2	40
17	2	19	3	53	1	49	4	26	4	49	3	1
18	2	1	3	57	1	37	4	34	4	39	3	22
19	1	43	4	1	1	25	4	43	4	30	3	44
20	1	26	3	5	1	13	4	51	4	20	4	6
21	1	9	4	8	1	1	4	59	4	9	4	29
22	0	52	4	10	0	49	5	6	3	57	4	51
23	0	35	4	12	0	37	5	13	3	45	5	13
24	0	19	4	13	0	24	5	19	3	32	5	35
25	0	3	4	11	0	10	5	24	3	19	5	57
26	0 Ad	12	4	9	0 Sub.	3	5	29	3	5	6	19
27	0	27	4	8	0	16	5	33	2	51	6	41
28	0	42	4	6	0	29	5	37	2	37	7	2
29	0	57	4	5	0	44	5	40	2	23	7	23
30	1	11	4	3	0	59	5	43	2	8	7	44

Tabula

A Table of the *Equation* of Days, to be entered with the Place of the Sun.

	♎		♏		♐		♑		♒		♓	
G.	′Add.	″	′Add.	″	′Add.	″	′Add.	″	′Sub.	″	′Sub.	″
0	7	44	15	34	13	25	0	59	11	48	14	36
1	8	5	15	42	13	7	0	27	12	4	14	22
2	8	25	15	48	12	48	0	Sub. 5	12	19	14	21
3	8	45	15	53	12	29	0	35	12	35	14	13
4	9	5	15	57	12	10	1	4	12	50	14	4
5	9	25	16	1	11	50	1	33	13	5	13	55
6	9	44	16	5	11	30	2	3	13	19	13	46
7	10	3	16	7	11	10	2	32	13	32	13	37
8	10	22	16	8	10	49	3	1	13	44	13	27
9	10	41	16	9	10	28	3	29	13	55	13	17
10	11	00	16	9	10	6	3	57	14	5	13	7
11	11	19	16	9	9	42	4	25	14	14	12	56
12	11	38	16	8	9	17	4	53	14	22	12	44
13	11	57	16	7	8	51	5	20	14	29	12	32
14	12	15	16	5	8	25	5	48	14	35	12	19
15	12	33	16	1	7	58	6	15	14	40	12	6
16	12	50	15	56	7	31	6	42	14	45	11	52
17	13	7	15	50	7	5	7	9	14	50	11	37
18	13	22	15	44	6	38	7	34	14	54	11	21
19	13	36	15	37	6	12	7	58	14	56	11	4
20	13	49	15	30	5	45	8	21	14	58	10	46
21	14	2	15	22	5	19	8	45	14	59	10	28
22	14	14	15	13	4	52	9	8	15	00	10	10
23	14	26	15	3	4	26	9	31	15	00	9	52
24	14	37	14	52	3	58	9	53	15	00	9	34
25	14	47	14	40	3	30	10	13	14	58	9	16
26	14	57	14	27	3	1	10	32	14	55	8	58
27	15	7	14	13	2	31	10	51	14	51	8	40
28	15	16	13	58	2	1	11	10	14	47	8	22
29	15	25	13	42	1	30	11	29	14	42	8	4
30	15	34	13	25	0	59	11	48	14	26	7	45

Spots observed in the Sun; by Mr. Boyle. N. 74. *p.* 2216.

XXIII. *Ann.* 1660. *April* 27. About 8 of the Clock in the Morning there appear'd a Spot in the lower Limb of the Sun, a little towards the South of its Equator, which was entered about $\frac{1}{40}$ of the Diameter of the Sun itſelf, being about $\frac{1}{160}$ in its ſhorteſt Diameter, of that of the Sun; its longeſt, about $\frac{1}{40}$ of the ſame. It diſappeared upon Wedneſday Morning, *May* 9. though we ſaw it the Day before about 10 in the Morning, to be near about the ſame Diſtance from the Weſtward Limb, a little South alſo of its Equator, that it firſt appeared to be from the Eaſtward Limb, a little South alſo of its Equator. It ſeem'd to move faſter in the middle of the Sun than towards the Limb. It was a very dark Spot, almoſt of a Quadrangular Form, and was encloſed round with a kind of duſkiſh Cloud.

We firſt obſerved this very ſame Spot both for Figure, Colour, and Bulk, to be re-entered the Sun, *May* 25, when it appeared to be in a Part of the ſame Line it had formerly traced; and was entered about $\frac{4}{33}$ of its Diameter about 7 o' Clock in the Afternoon. At the ſame time there appear'd another Spot, which was juſt entered, and appear'd to be entered not above $\frac{1}{132}$ Part of the Sun's Diameter. It appeared to be longeſt towards the North and South, and ſhorteſt towards the Eaſt and Weſt. There ſeem'd to be diſpers'd about it divers ſmall Clouds here and there.

Spots observed in the Sun; by M. Picard. N. 74. *p.* 2238. N. 75. *p.* 2253. *By M.* Caſſini. N. 74. *p.* 2238. N. 75. *p.* 2250.

XXIV. 1. *Ann.* 1671. M. *Picard*, at Sea near the *Texel*, obſerved a Spot in the Sun from *Aug.* 3. *St. N.* to the 19th. It appear'd at firſt like the Tail of a *Scorpion*, but on the 19th Day reſembling a Melon-Seed.

2. *Aug.* 11. (*S. N.*) 1671. About 6 o' Clock at Night, M. *Caſſini*, with a three-foot Glaſs, remark'd in the Sun's Diſk, two Spots very dark, diſtant from its apparent Center about the third Part of his Semidiameter. They were in the Southern Part of the Sun, and their Elongation from the *Parallel of the Equator* paſſing through the Center of the Sun, was about $\frac{1}{60}$ part of his Diameter. The Time which lapſed between the Tranſit of the Sun's Center and that of the firſt of theſe Spots, was 22″. or 23″. the Semidiameter of the Sun then paſſing in 66″. The firſt of theſe Spots, being looked upon with a Teleſcope of 17 Feet long, appeared with a ſomewhat Oval Figure; the other was oblong and a little curved, like the *Hebrew* Letter *Jod*; and both together were ſurrounded by a *Corolla*, or Coronet, made up of little dark Points, which conformed itſelf to the Figure of the Spots, conſidered as they were join'd together.

Aug. 12. He perceived that they were nearer his Center. The Time between the Paſſage of the Sun's Center, and that of the interior Edge of the *Coronet* which encompaſſed them both, was then of 16″. At 7 o' Clock it was but of 15″. and the Southern Limb of the *Coronet* touched the Parallel paſſing through the Sun's Center. The firſt Spot was compoſed of two others almoſt round, and conjoined. The ſecond repreſented the Shape of a *Scorpion.* The third was round. And they were all three environed with a *Coronet*, which was compoſed, as we ſaid above, of abundance of little obſcure Pricks. This *Coronet* appear'd to be clearer than the reſt of the Sun, when looked

looked upon with the ſhort Glaſs, and darker when ſeen with the long. Without it there were other Points, but very black ones; *viz.* Five near the round Spot on the South-Side, and another near the *Scorpion*'s Tail on the North-ſide.

At 8 o'Clock 48′. the Figure of the *Scorpion* was ſeen divided into ſeveral Pieces, as if the Tail and Arms had been cut off. The Northern Point appear'd no more, there remaining none but thoſe on the South-Side; and the Length of the Incloſure of all the *Spots*, comprehended between the Extremities, was of 1′. 15″. and the Breadth of 30″.

The ſame 12th Day at 6 in the Evening, he found no great Change in the firſt *Spot*. The other two were ſevered into 5 diſtinct ones, compaſs'd about with a *Coronet*, together with 5 black Points, which ſtood in a ſtrait Row, and after another Manner than they did in the Morning. From 6 at Night unto 7, the Time when the Paſſage of the *Sun*'s Center, and that of the *Coronet*'s Limb, was found to be at one time of 8″. and another time of 7½, the Diſtance of the *Spots* unto the Parallel paſſing through the Sun's Center, was near the ſame on the North-ſide with what it had been obſerved to be in the Morning on the South-ſide.

Aug. 13. Between the Riſing of the Sun, and half an Hour paſt 6 in the Morning, the Edge of the *Coronet* was turned to a Point on the South-ſide, and was diſtant from the *Æquator* on the North-ſide, half a Minute; and there was but a Second of Time from the Paſſage of the Sun's Center unto the Paſſage of the ſame anterior Edge of the *Coronet*.

At 8 o'Clock 30′. the fore Edge was in the ſame Horary Circle with the Center of the Sun: So that in one Day and Half, theſe Spots have run thro' very near the third Part of the Sun's apparent Semidiameter, which giveth an Arch of 19 Degrees and a Half of the Circumference of the Sun's Body; and conſequently their *Diurnal* Motion about the Sun's Axe hath been of 13 Degrees; and the time of their *Periodical* Revolution, as far as we could conjecture in ſo little time, muſt be about 27 Days and a Half.

Aug. 14. At 6 in the Morning, there paſſed 15″. of Time between the Paſſage of the anterior Limb of the *Crown*, and the Paſſage of the *Sun*'s Center through the ſame Horary Circle: And then the Southern Limb of the *Crown* was a Minute and an half diſtant toward the North from the Parallel of the *Æquator*, paſſing through the ſame Center of the Sun. The Figure of the firſt Spot was almoſt the ſame with that of the Day before. The ſecond had taken the Form of an Heart, the Point of which was turned to the North-ſide, and its Baſe between the South and the Eaſt. Three other ſmall Spots, diſpoſed triangle-wiſe, ſtood over the ſaid Baſe, and were accompanied with two others upon a Line turned Southward. And they were all encompaſſed by a Crown running out into a Point on the South-ſide; and on the North-ſide, Eaſtward, it had an *Appendix*.

Aug. 15 At 6 in the Morning, there paſſed 27″. between the Paſſage of the anterior Limb of the Crown, and that of the Sun's Center through the ſame Horary Circle. The Southern Limb of the ſame Crown was two Minutes and an half diſtant from the Parallel of the *Æquator*, paſſing through the

the Center of the *Sun*, whofe Diameter paffed in 2′. 9″. through the fame Horary Circle. The firft *Spot* had a little changed the Figure; the fecond was quadrangular, longer from Eaft to Weft than from North to South: It appeared bigger than ordinary, and had withal on its fides, within the compafs of the *Crown*, three other fmall *Spots*. There were alfo feen four more without the faid *Crown* on the South-fide.

Aug. 16. At 6 in the Morning, there was 27″. between the Paffage of the *Sun*'s anterior Limb, and the Paffage of the anterior Limb of the *Crown* through the fame Horary Circle; and 38″. between the Paffage of the anterior Limb of the *Crown*, unto the Paffage of the *Sun*'s Center. The Southern Limb of the *Crown* was $3\frac{1}{2}'$ off from the Parallel of the *Æquator*, paffing thro' the Center of the *Sun* towards the North: And the Obfervation having been made yet more exactly at half an Hour paft 7 of the fame Morning, this Diftance was found of 3′ 33″. The Figure of the firft *Spot* in the Beginning of the Obfervation, differ'd not much from that of the precedent Day; but afterwards it was feen divided into two. The fecond, which likewife feemed to be the fame in the Beginning, was afterwards divided into three, accompanied with black and dark Points without the *Crown* on the South-fide. The fame Day at 6 o'Clock, and 15′. at Night, the Figures of thefe *Spots* were much changed. There were 5 *Spots* enclofed in the *Crown*; The two foremoft were Part of that which had been feen in the Morning as one; the two others following thofe two firft, were Part of the fecond in the Morning; and without there were 5 Points on the South-fide, and two more a little further to the North; which Points were ranged as in another Area made up of other Points, fo fmall that they could fcarely be perceived.

Aug. 17. in the Morning, immediately after the Rifing of the *Sun*, there appeared three very dark *Spots*, which form'd in a manner thefe Letters *F n J*, pofited from Eaft to Weft, and included in their wonted *Crown*, which ftretched out, as 'twere, two Arms, or two Handles, one to the South, and the other to the North. There paffed 18″. between the Paffage of the foremoft Limb of the *Sun*, and that of the foremoft Limb of the *Crown*, and $47\frac{1}{2}''$. between the Paffage of the anterior Limb of the *Crown*, unto the Paffage of the Sun's Center. The Southern Limb of the fame *Crown* was diftant 11′. 17″. from the *Parallel* that touched the *Sun* on the North-fide, and 4′. 38″. from the *Parallel* that pafs'd through the Center.

Aug. 18. at 7 in the Morning, the *Spots*, which appear'd through fome Clouds, had almoft the fame Shape with thofe of the Day before, only with this Difference, that they were a little clofer together, drawing from Eaft to Weft. There lapfed 13″. between the Paffage of the anterior Limb of the *Sun*, and that of the anterior Limb of the *Spot*, through the fame Horary Circle, and $52\frac{1}{2}''$. of the foremoft Limb of the *Spot* unto the Paffage of the Center. The Southern Limb of the *Spot* was 9′. 13″. diftant from the *Parallel* that touched the Northern Limb of the *Sun*, and 6′. 41″. from the *Parallel* that paffed through his Center. At 5 o'Clock and 55′. at Night of the fame Day, there lapfed 11″. between the Paffage of the anterior Limb of the *Sun* through the fame Horary Circle, and the Paffage of the anterior

Limb

Limb of the *Crown*; and from thence unto the Paſſage of the *Sun*'s Center $54\frac{1}{2}''$. The Limb of the *Crown* next the *Parallel* paſſing through the Center of the *Sun*, was diſtant from the ſame *Parallel* $7'. 40''$.

Aug. 19. from 4 to 5 in the Evening, the *Spot* appear'd oblong near the *Sun*'s Circumference, from which it was diſtant about the Breadth of the ſame *Spot*.

Aug. 20. in the Morning, which was not the full ſeventh from the Day that they were arriv'd to the middle of the Diſk, they diſappear'd.

The apparent Velocity nigh the Center was ſuch, that if it had continued the ſame, the *Spots* would have arrived almoſt in 4 Days to the Limb of the Diſk; but in this Hypotheſis, that the *Spots* were adherent to the *Sun*'s Surface, or at leaſt very nigh to it, this apparent Velocity was to leſſen according as they ſhould remove from the Center; as hath come to paſs in effect. The Diminution of the Length of the Miſty *Crown* was in a manner proportionable to the Diminution of the apparent Velocity; ſince that, when this Crown was in the Middle, and in a Situation wherein its true Figure could be beſt ſeen, it appear'd oblong, and of the Form of an human Ear, its greateſt Diameter reſpecting Eaſt and Weſt; but being nigh the Limb, the ſame Diameter ſeemed to ſhorten; and having appeared greateſt in its firſt Situation, it appear'd leaſt in this, becauſe it was almoſt in a Circle that paſs'd through the Center of the Sun, whoſe equal Arches are by ſo much the more oblique, by how much they approach more to the Limb of his Diſk, and conſequently appear leſs, according to the Rules of *Opticks*: mean time, the Diameter, that was turned from South to North, apparently kept the ſame Bigneſs it had near the Center, becauſe it was in a Circle almoſt Parallel to the Horizon of the *Sun*, which formed the Repreſentation of its Limb, and whoſe equal Arches (by the ſame *Optical* Reaſons) do not appear contracted.

3. Several curious Obſervers at *London*, have ſeen one of theſe *Spots* recurr'd to the Sun's Eaſtern Limb, about *Aug.* 25. *St. N.* as M. *Caſſini* predicted they ſhould return. *By ſeveral at* London. N. 75, *p.* 5253.

4. *Aug.* 30. 1671. I ſaw a large *Spot* in the Center of the *Sun*'s Face about Noon. *By Dr.* Hook. N. 77. *p.* 2295.

Sept. 1. At 3 o'Clock, I ſaw the ſame *Spot* moved about a Quarter of the Diameter of the *Sun* Weſtward; it conſiſted of one greater and two leſſer black *Spots*, with a *duſky Cloud* encompaſſing them: The Diameter of the whole Phænomenon was about $\frac{1}{70}$. of the Diameter of the *Sun*, and it was diſtant from the next adjoining Limb $\frac{18}{72}$ (that is, exactly one Quarter) of the Diameter of the *Sun*.

5. The ſolar *Spots* have been obſerved by us at *Hamburg*, from *Aug.* 26, Old Style, (almoſt the firſt Day on which they began again to appear) as far as *Sept.* 5. on which they approached very near to the Limb. *By Mr.* Hen. Siferus. N. 78. *p.* 3033.

XXV. *An.* 1676. *Jun.* 26. *St. N.* we have in the Sun a pretty large *Spot*, which was in the middle of the *Sun* at Four in the Afternoon, with South Latitude $4\frac{1}{4}'$. Its Diſtance from the ſouthern Pole of the *Sun* by many Obſervations I determined to be $78\frac{1}{4}$ Degrees. If it is of a ſufficient Conſiſtence to compleat its Circle, its Reſtitution may be expected at the Middle, in the Evening of *July* 25, with greater South Latitude. *Spots obſerved in the Sun; by* M. Caſſini. N. 127. *p.* 665.

XXVI.

XXVI. 1.

Spots observed in the Sun; by Mr. Flamsteed, *and Mr.* Halley. N. 128. *p.* 687.

	At Greenwich, A. D. 1676.			At Oxford, A. D. 1676.		
Jul. O. S.	*Times of Observations.*	*Longit. from the Sun's Center.*	*South. Lat.*	*Times of Observations.*	*Long.*	*South. Lat.*
	h. ′	′ ″	′ ″	h. ′	′ ″	′ ″
25				6 46 p. m. Con.	13 40	2 8
27	10 3 a. m. Con.	9 34	3 25			
28	4 51 ------	5 40	2 50			
29	10 31 a. m. --	3 05	3 27	6 21 a. m. ---	3 55	3 22
	2 54 p. m. --	2 25	3 10			
30	9 15 a. m. Ant.	0 37	3 33	7 20 a. m. ---	0 00	3 30
31				7 40 a. m. ---	3 36	3 28
Aug. 1.	9 25$\frac{5}{6}$ a. m. ---	6 48	4 09	7 3 a. m. ---	6 54	3 50
				5 6 p. m. ---	8 7	3 53
2	8 8 a. m. ---	9 49	3 55	7 16 a. m. ---	9 57	3 40
3	9 36 a. m. ---	82 28	3 27	5 9 p. m. ---	13 15	3 56
	4 16$\frac{2}{3}$ p. m. --	12 55	3 58	6 2 p. m. ---	13 25	3 26
4	7 38 a. m. ---	14 02	4 4	7 33 a. m. ---	14 7	3 14
				4 54 p. m. ---	14 43	3 23

Mr. *Halley* saith, That he saw a Spot again on the fifth Day, 8^h. 20′. *mane*, very near the Limb of the Sun, so that it appeared only as a fine Line; but by reason of its Fineness and the too great Height of the Sun, he could not take any Measures to determine its Place and Latitude by; and that while the Spot continued one, as it was *July* 25. he measured to the middle of it; as also when the Pieces were divided, but not far disjoined: Afterwards, when they were separated considerably, he observed the middle of the bigger Spot, which was to the South, apparently I suppose, but really North: for so only his Observations will agree with those of Mr. *Flamsteed* exactly.

Hence it seems very evident, (saith Mr. *Flamsteed*) that the Spot's Way was not inclined to the *Ecliptick* six or seven Degrees, as *Scheiner* and some others make it, but much less, by the joint Consent of the Observations of both our Observers. Mr. *Halley* adds, That considering the Motion of the Spot cross the Sun's Disk, as both their Observations give it, it appears that the Latitude was not so great at its Entrance into the Sun as in the middle of him. And by Mr. *Flamsteed*'s Observation, it was greatest on the first of *August*, and then again inclining towards the Ecliptick. If you grant this, it will follow, (infers Mr. *Flamsteed*) that the Sun's Axis was inclined to the Plane of the *Orbis magnus*; but the quantity of this Inclination must not be very great.

great. The *Nodes* of the Sun's Equinox and Ecliptick he gueſſes to be not far from the beginning of *Cancer* and *Capricorn*; and that from *Cancer* to *Capricorn* the Earth is North of the Sun's *Æquator*; from *Capricorn* to *Cancer*, South of the ſame: And the Period of the Sun's Revolution in reſpect of the fixed Stars 25 Days $9\frac{1}{2}$ Hours, ſufficiently exact. Of which things theſe two Obſervators ſay they might have been more certain, had not the *Spot* in its Paſſage broken into ſo many Parts, and thoſe often varied their Poſitions to each other.

2. We here obſerved the Solar Spot, from *Aug.* 6. to 14. and by comparing our Obſervations we have found, that it was in the middle of its courſe in the apparent Diſk of the Sun about Midnight after the 8th Day of *Auguſt*, at the apparent Diſtance of 3 Minutes from the Center towards the South. It is ſeparated into ſeveral Parts, which are disjoin'd from one another at a conſiderable Diſtance, daily towards the North and South; ſo that beſides their common Motion about the Sun's Axis, each of the Parts have a direct Motion of their own among one another. I think this Spot to be different from that which we obſerved in the preceding Month of *June*. For ſince that had the middle of its Courſe in the apparent Diſk of the Sun on the 28th Day of the ſame Month, it muſt have return'd nearly to the ſame Situation, if it had been ſtill in Being, in the Night following the 25 of *July*; as is deduced both from its Velocity, the obſerved Time of its Appearance, and alſo from the Courſe of the other Spots which we ſaw to finiſh their Period about the Sun in the Space of $27\frac{1}{3}$ Days, or $27\frac{1}{2}$. Beſides its Path is different from the foregoing; for the firſt was ſomething more remote from the Equator of the Spots than the latter. And this, if it had Conſiſtence enough, return'd to the middle of the Sun on *Sept.* 5. in the Morning. *By Mr.* Caſſini, Ibid. *p.* 689.

XXVII. *Ann.* 1684. *Apr.* 25. About an Hour before Noon I diſcover'd a large Spot entred within the Sun's Diſk, a little diſtant from his following Limb. Theſe Appearances, however frequent in the Days of *Scheiner* and *Galileo*, have been ſo rare of late, that this is the only one I have ſeen in his Face ſince *December* 1676. By the obſerved Meridional Diſtances of it, and the Sun's Southern Limb from the *Vertex* at Noon, I found it to have 3′. 40″. more North Declination than the Sun's Center; and at 3^h. 35′. after Noon, I meaſured its Diſtance from his next Limb 40″. *Spots obſerved in the Sun; by Mr.* Flamſteed. N. 157. *p.* 535.

Next Morning, *April* 26. I ſaw it more remote from his Limb, and by the Obſervations then made (at 8^h. *mane*) determined its Longitude from the Sun's Axis $66\frac{3}{4}$ Deg. and its Declination from the Solar Æquator $9\frac{2}{3}$ Deg. South. Whence, ſuppoſing the Revolution of any Point of the Sun to the ſame fixed Star to be performed in 25 Days, 6 Hours, the Angle of his *Equator* and our *Ecliptick* 7 Deg. and the Longitude of his Northern Pole ♍ 16 Deg. I deſigned the Line of its Way or Trace over the Sun, and the Points in it where the Spot would appear every Morning after at the ſame Hour, till its Egreſs on the 8th of *May*; which I found altogether confirmed by ſuch Obſervationsas I made till then; ſo that I had no reaſon to doubt of the Theory.

When

When the *Spot* was near the Middle of the Sun, it appear'd very broad, and almoſt Square, the *Nucleus* of the ſame Figure about 40″ Diameter; but when it was near the Limb, much narrower, and almoſt oval: It ſeemed to have Conſiſtence enough to endure a ſecond Return; if it ſhall, it will enter the viſible Diſk of the *Sun* on the 21ſt of *May* in the Evening, and in its Paſſage over him deſcribe a Line nearly ſtreight, with greater Latitude from the *Ecliptick*.

To find in what Proportion the Planets are enlightned by the Sun; by M. Auzout. *N. 4. p. 68.*

XXVIII. One of the Means uſed by M. *Auzout* to enlighten an Object in what Proportion one pleaſeth, is by ſome great Object-Glaſs, by him called a *Planetary* one, becauſe that by it he ſhews the Difference of Light, which all the Planets receive from the *Sun*, by making uſe of ſeveral Apertures, proportionate to their Diſtances from the Sun, provided that for every 9 Feet Draught, or thereabout, an Inch of Aperture be given for the Earth. Doing this, one ſees (ſaith he) that the Light which *Mercury* receives, is far enough from being able to burn Bodies, and yet that the ſame Light is great enough in *Saturn* to ſee clear there, ſeeing that (to him) it appears greater in *Saturn* than it doth upon the Earth, when it is over-caſt with Clouds; which (he adds) would ſcarce be believed, if, by means of the Glaſs, it did not ſenſibly appear ſo.

The Æquinoxes; by M. Wortzelbaur. *N. 265. p. 623.*

XXIX. The *Æquinoxes* of this Year, 1699, according to the Obſervations of M. *Wortzelbaur* at *Nurenberg*, happened *March* 9. 20ʰ. 35′. 27″. and *Sept.* 12. 10ʰ. 22′. 42″. which, by his Tables, ought to have been *March* 9. 20ʰ. 40′. 30″. and *Sept.* 12. 10ʰ. 32′. 52″.

To obſerve Solar Eclipſes; by Mr. Flamſteed. *N. 55. p. 1104.*

XXX. For the well obſerving of Solar Eclipſes, caſt the Species of the Sun through a good Teleſcope of a competent Length, on an extended Paper, placed behind the Eye-Glaſs ſo far, as that the ſaid Species may appear at leaſt 6 Inches over; then divide both his *Periphery* into 360 Degrees for the better obſerving the Inclination of the *Cuſps* of each Phaſis, and his Diameter into Digits, and their Parts, by concentrick Circles, for meaſuring the Quantities of the obſcured Parts.

An Eclipſe of the Sun, An. 1666. June 22. at London; *by Mr.* Willoughby, *Dr.* Pope, *Dr.* Hook, *and Mr.* Phillips. *N. 15. p. 295.*

XXXI. 1. The *Eclipſe* began at 5ʰ. 43′.

		h.	′		h.	′
It was darkned	$\frac{3}{11}$ Diam. - - at	6	00	5 Dig. - - - at	7	6
	4 Digit. - - at	6	7	4 Dig. - - - at	7	13
	5 Dig. - - - at	6	13	3 Dig. - - - at	7	20
	6 Dig. - - - at	6	21	2 Dig. - - - at	7	26
	7 Dig. - - - at	6	39	1 Dig. - - - at	7	32
	6 Dig. - - - at	6	57	0 Dig. - - - at	7	37

Its *Duration* hence appears to have been one Hour and 54′. Its greateſt *Obſcurity* ſomewhat more than 7 Digits. About the middle, between the Perpendicular and Weſtward Horizontal Radius of the Sun, viewing it thro' Mr. *Boyle*'s

Mr. *Boyle*'s 60 Foot Telefcope, there was perceived a little of the Limb of the Moon without the Difk of the Sun; which feemed to fome of the Obfervers to come from fome fhining Atmofphere about the Body either of the Sun or Moon. They affirm to have obferved the Figure of this Eclipfe, and meafured the Digits, by cafting the Figure through a 5 Foot Telefcope on an extended Paper, fix'd at a certain Diftance from the Eye-Glafs, and having a round Figure; all whofe Diameters were divided by 6 concentrick Circles, into 12 Digits.

2. The *Eclipfe* began at $5^h. 44'. 52''.$ *mane*. It ended at $7^h. 43'. 6''.$ So that its whole Duration was $1^h. 58'. 14''.$ The greateft Obfcuration was 7 *Dig.* 50'. but it feemed to have been greater by 3'. which Mr. *Payen* imputes to a particular Motion or Libration of the Sun's Globe, which entertained that Luminary in the fame Phafis for the fpace of 8'. and fome Seconds, as if it had been ftopped in the midft of its Courfe, rather than to a tremulous Motion of the Atmofphere, as *Scheiner* would have it. The apparent Diameters were almoft equal; for in the Phafis of 6 *Digits*, the Circumference of the Moon's Difk paffed through the Center of that of the Sun, fo as that two Lines drawn through the two Horns of the Sun, made, with the common Semidiameter, two Equilateral Triangles. *At* Paris, *M.* Payen. *Ibid. p.* 296.

The Beginning and Middle of the Eclipfe happened to be in the North-Eaftern Hemifphere, and the End in the South-Eaftern. The firft Contact (as 'twere) of the two Difks, was obferved in the fuperior Limb of the Sun's Difk, in refpect to the Vertical Line; and in the inferior, in refpect to the Ecliptick. But the Middle and the End were feen in the fuperior Limb, in refpect both to the Vertical and the Ecliptick: And, what to M. *Payen* feems extraordinary, both the Beginning and the End of this Eclipfe happen'd to be in the Oriental Part of the Sun's Difk.

3. The *Eclipfe* began about 5 o'Clock in the Morning, at $5^h. 15'.$ The Sun's Altitude was $6°. 55'.$ *At* Madrid; *by the Earl of* Sandwich. *Ibid. p.* 296.

The Middle of it was at $6^h. 2'.$ The Sun's Altitude $15°. 5'.$

The End was exactly at $7^h. 5'.$ The Sun's Altitude $25°. 24'.$

The Duration $2^h. 4'.$

Thirty-feven Parts of the Sun's Diameter remained light, and 63 were darken'd.

4. In this *Eclipfe* it is chiefly obfervable, That the Semidiameter of the Moon, from the very Beginning to about 5 or 6 Digits of the increafing Phafis, was almoft equal to the Semidiameter of the Sun; but, after the greateft Obfcuration, when I again contemplated the Moon's Semidiameter, I found it 8''. or 9''. bigger than that of the Sun; fo that the Semidiameter of the Moon was not always, during the *Eclipfe*, conftant to itfelf. Of this Variation the excellent *Ifmael Bullialdus* hath alfo obferv'd fomething at *Paris*: For he hath written to me, That in this fame *Eclipfe*, the Semidiameter of the Sun to the Semidiameter of the Moon was, as 16'. 9''. to 16'. 22''. but that in another Phafis of 6 Digits, the Semidiameters appeared equal. *At* Dantzick *by M.* Hevelius. N. 19. *p.* 1347.

Ibid. p. 349.
N. 21. p. 370.

Order of the Phases.	Quantity of the Phases.	Time estimated by a Watch.	Time by a Sun-dial.	Altit. of the Sun.	Time corrected.	Observations.
		h. ′ ″	h. ′ ″	° ′	h. ′ ″	
		5 51 11	5 51 00	17 45	5 53 12	That the Sun-dial does not intirely agree with the corrected Time, is to be imputed only to the Meridian Line.
		5 57 05	5 57 00	18 37	5 59 28	
		6 00 00	6 00 00	18 55	6 1 28	
	Beginning.	6 55 30			6 57 30	The Beginning happen'd about 79 Degrees from the Zenith towards the West
1	$0\frac{3}{8}$ Dig.	8 57 30			6 59 30	
2	$0\frac{3}{4}$	7 0 23	7 0 0		7 2 23	
3	$1\frac{1}{8}$	7 2 30	7 2 0		7 4 30	
4	$1\frac{1}{2}$ Dig.	7 4 50	7 5 near.		7 6 50	
5	$1\frac{3}{8}$ nearly	7 10 57	7 10		7 12 57	
6	$3\frac{3}{8}$	7 14 59	7 15		7 16 59	
7	$3\frac{3}{4}$	7 17 50	7 18 near.		7 19 50	
8	4 Digits.	7 21 35	7 21		7 23 35	
9	$4\frac{2}{3}$	7 23 43	7 23 near.		7 25 43	
10	$5\frac{1}{4}$	7 27 53	7 28		7 29 53	Hitherto the Semi-diameter of the Moon was equal to that of the Sun.
11	6	7 31 50	7 32		7 33 50	
12	$6\frac{3}{4}$	7 36 55	7 37		7 38 55	
13	$6\frac{7}{8}$ somet.mo.	7 38 5	7 38		7 40 0	
14	$7\frac{1}{8}$	5 39 45	7 39		7 41 45	
15	$7\frac{1}{4}$ somet.mo.	7 42 30	7 42		7 44 30	
16	$7\frac{1}{2}$	7 44 6	7 44		7 46 6	
17	$7\frac{2}{3}$	7 46 0	7 46		7 48 0	
18	8 nearly.	7 48 25	7 48 near.		7 50 25	
19	$8\frac{1}{5}$	7 51 15	7 51		7 53 15	
20	$8\frac{1}{4}$ somet.mo.	7 53 37	7 52		7 55 37	The greatest Obscuration was Dig. 8. 25′. The Hour 8. 2′.
21	$8\frac{3}{4}$	7 55 45	7 56 near.		7 57 45	
22	$8\frac{3}{8}$ somet. less	7 59 5	7 59		8 1 5	
23	$8\frac{1}{5}$	8 6 30	8 6		8 8 30	

Ord. of the Phas.	*Quantity of the Phases.*	*Time estimated by a Watch.*	*Time by a Sun-dial.*	*Altit. of the Sun.*	*Time corrected.*	*Observations.*
		h. ′ ″	h. ′ ″	° ′	h. ′ ″	
24	7¼	8 11 25	8 12		8 13 25	Here the Semidiameter of the Moon appeared greater by 8″ or 9″.
25	7¼ nearly	8 17 30	8 18		8 19 30	
26	7 nearly	8 19 41	8 19		8 21 40	
27	5⅞	8 28 8	8 28		8 30 8	
28	5½ nearly	8 30 14	8 30		8 22 14	
29	4¾	8 36 25	8 36		8 38 25	
30	3⅝	8 43 19	8 43		8 45 19	
31	3¼	8 46 12	8 46 near.		8 48 12	
32	3	8 47 32	8 47		8 49 32	
33	2¾	8 50 57	8 50		8 52 57	
34	2½ nearly	8 54 15	8 54		8 56 15	
35	1⅜	8 58 24	8 58		9 0 24	
36	1⅛	8 59 35	8 59		9 1 35	
37	0⅙	9 1 38	9 1		9 3 38	
38	0½	9 3 20	9 3		9 5 20	
39	The End.	9 6 53	9 6		9 8 53	The Point of the End was distant from the Vertical 143° to the East.
		9 23 6		47 33	9 25 28	
		9 24 16		47 42	9 26 45	
		9 28 29		48 10	9 30 42	
		9 30 36		48 28	9 33 12	

XXXII. *An Eclipse of the Sun, June 23. (St. N.) 1675. at Dantzick; by M. Hevelius.* N. 127. p. 660.

Order of the Phas.	Observations.	Alt. of the S. h. ′ ″	Time cor. h. ′ ″
	The Sun's Center in the Horizon - - - -		3 21 30
	Nothing yet in the Sun - - - - - - - -		4 42 0
	The Beginning - - - - - - - - - -		4 44 0
1	Almost $6\frac{1}{2}$ Digits were obscured - - - -		5 32 0
2	$6\frac{3}{4}$ Digits - - - - - - - - - - -		5 34 0
3	The greatest Obscuration was nearly 6 Dig. 42′.		5 38 50
4	$6\frac{1}{2}$ Digits - - - - - - - - - - -		5 43 30
5	$6\frac{1}{4}$ Digits - - - - - - - - - - -		5 47 30
6	6 Digits - - - - - - - - - - - -		5 49 30
7	$5\frac{1}{2}$ Digits. { The Diameter of the Moon was 14′. 37″. the Semidiameter of the Sun being suppos'd 15′.		5 55 0
8	$5\frac{1}{4}$ Digits - - - - - - - - - - -		5 57 0
9	5 Digits nearly - - - - - - - - -		5 59 30
10	$4\frac{5}{8}$ Digits - - - - - - - - - - -		6 2 0
11	$4\frac{1}{2}$ Digits - - - - - - - - - - -		6 4 15
12	4 Digits - - - - - - - - - - - -		6 6 30
13	$3\frac{5}{8}$ Digits - - - - - - - - - - -		6 9 15
14	$3\frac{1}{4}$ Digits - - - - - - - - - - -		6 14 35
15	$2\frac{5}{8}$ Digits - - - - - - - - - - -		6 18 10
16	$2\frac{3}{8}$ Digits - - - - - - - - - - -		6 20 0
17	2 Digits - - - - - - - - - - - -		6 22 0
18	$1\frac{1}{2}$ Digit - - - - - - - - - - -		6 24 0
19	$1\frac{1}{4}$ Digit - - - - - - - - - - -		6 25 25
20	1 Digit - - - - - - - - - - - -		6 27 10
21	$\frac{1}{2}$ Digit - - - - - - - - - - - -		6 30 30
	The End. - - - - - - - - - - -	° ′	6 33 30
	Altitude of the Sun - - - - - - - - -	25 20	6 41 22
	Altitude of the Sun - - - - - - - - -	28 5	7 0 14

An Eclipse of the Sun; June 1. 1676. at Westminster; by Mr. Francis Smethwick. N. 126. p. 637.

XXXIII. 1. The Beginning of Obscuration - - - - - 7^h. 50′.
The End - - - - - - - - - - - - - 9 $54\frac{3}{4}$.
The Duration of the whole Eclipse - - 2 $4\frac{3}{4}$.

The Time was observed by a Pendulum Clock, corrected by Observations. The Telescope made use of was a very good one, of $7\frac{1}{2}$ Feet.

Time

2.
At Wapping; *by M.* Colson. *Ibid.*

The Time according to a Pendulum Clock.			*The Phases.*	*The Suns Altitude*		*The Time corrected by the Altitude.*			
h.	′	″		°	′	h.	′	″	
7	34	50		22	46	7	36	0	
7	37	14		33	10	7	38	40	
7	39	10		33	30	7	40	48	
7	50	40	$0\frac{1}{2}$ Digit.			7	51	51	Eſtimated by a Teleſcope.
8	8	34	$1\frac{1}{4}$ Digit.			8	9	45	
8	17	25	$2\frac{5}{8}$ Digits.			8	18	36	Meaſured by a Teleſcope.
8	27	10	$3\frac{1}{10}$ Digits.			8	28	21	
9	39		$1\frac{1}{2}$ Digits.			9	40		Eſtimated by a Tube.
9	43		$1\frac{1}{4}$ Digits.			9	44		
9	48		$0\frac{3}{4}$ Digit.			9	49		
9	54	25	Not ended.			9	55	36	
9	55	55	Ended.			9	57	6	
4	26	5		32	10	4	26	56	
4	28	58		31	53	4	29	52	
4	31	2		31	31	4	32	16	

3.
At Greenwich; *by Mr.* Flamſteed.
N. 127. *p.* 662.

For performing theſe Obſervations I had the Aſſiſtance of my Friend Mr. *Halley*. We had prepared two Tubes, one was $196\frac{1}{2}$ Inches long, which had one of *Townley*'s Micrometers. I took myſelf the Meaſures of the eight firſt Phaſes. The other was only $103\frac{1}{2}$ Inches long, with which, and with my Micrometer, Mr. *Halley* took the Meaſures aſſigned to them. But in the laſt two Obſervations, with the leſſer Tube and my Micrometer, (fitter for this Uſe than the other,) I took the Diſtance of the Azimuths falling by the lucid Limb of the Sun, and the neareſt Cuſpid of the Eclipſe; while Mr. *Halley* in the mean time meaſured the lucid Parts, and the Diſtance of the Cuſpids with the greater Tube. A little before the Beginning came the moſt noble Lord Viſcount *Brouncker*, Preſident of the *Royal Society*, who proved by his own Judgment the Meaſure of the Sun's Diameter taken with the longer Tube. At the Hour 7. 45′. the Sun firſt appeared through the Clouds. The Obſervations were thus.

Order

Fig. 152.

Ord. of the Phases.	Hour by the Pen. Clock.	Corrected.	With the longer Telescope.	With the shorter.
	h. ′ ″	h. ′ ″		
	7 46 00	7 45 00	No Eclipse as yet.	
1	7 54 50	7 53 50	The right Side of the Sun appeared Eclipsed, having got clear of the Clouds.	
2	7 58 24	7 57 24	I C —— 2040 = 10 10	
3	8 04 12	8 03 12	I C —— 2779 = 13 56	
4	8 13 40	8 12 40	I C —— 3580 = 17 52	P L — 3198 = 26 18
5	8 18 37	8 17 37	P L —— 4975 = 24 50	I C — 2334 = 29 13
6	1 21 06	8 21 06		P L — 2989 = 24 35
			The Sun's Dia. 6360 = 31 43	3850 = 31 40
7	8 28 01	8 27 01		P L — 2888 = 23 57
8	8 29 01	8 28 01	P L —— 4565 = 21 46	
9	8 35 12	8 34 12	P L —— 4478 = 22 18	AZ — 2310 = 19 00
10	8 40 20	8 39 20	I C —— 4417 = 22 00	AZ — 2070 = 17 02
	10 02 00	10 01 00	Afterwards the Sun got behind the Clouds, until the Limb emerging through the Clouds, appeared free from the Eclipse. It came out clearer, and nothing	
	10 04 00	10 03 00	was found wanting in the Limb.	

For correcting the Clock, I had taken the Day before the Eclipse, *May* 31. Morn.				
The Hour of the Clock.		*The Sun's Altitude*	*The Time computed from thence.*	*The Error.*
h. ′ ″		° ′	h. ′ ″	′ ″
7 07 12	The Altitude of the inferior Limb.	27 47	7 06 09	1 03
7 10 16	Of the same Limb.	28 16	7 09 19	0 57
	Again *Jun.* 1. Afternoon.			
5 32 00	Altitude of the inferior Limb, &c.	22 06	5 31 06	3 56
5 35 23	Of the upper Limb.	22 06	5 34 34	0 49
5 45 17	Of the Lower.	20 6	5 44 18	0 59
	Lastly, *June* 2. Morn.			
8 9 44	Altitude of the inferior Limb, &c.	37 34	8 08 45	0 59
8 13 36	——————	38 09	8 12 34	1 02
8 15 44	——————	38 28		
8 17 51	——————	38 47		
8 20 1	——————	39 07	8 18 49	1 11

Whence it appears, that the Clock kept an even Motion, and was duly corrected in the Eclipse.

The

The Hour of the Pend. Clock.	*Corrected by a Merid. Line.*	*Measures.*		*Phases.*
h. ′ ″	h. ′ ″			′ ″ ′ ″
8 06 45	8 8 27	I C	1190	10 09 perhaps 1109 = 14 50
8 11 00	8 12 42	P L	1935	26 15
8 18 00	8 19 42	I C	1405	19 04
8 21 00	8 22 42	P L	1805	24 30
8 26 14	8 27 56	I C	1504	20 47
8 34 00	8 35 42	P L	1711	23 13
8 42 15	8 43 57	I C	1551	21 03 exactly.
8 46 30	8 48 12	P L	1702	23 20 or - - - 1720 = 23 15
8 51 45	8 53 27	I C	1553	20 04 precisely.
9 00 00	9 01 42	P L	1801	24 33
9 12 34	9 14 16	I C	1357	18 25
9 30 55	9 32 37	I C	872	11 50

4. *At* Townley; *by Mr.* Rich. Townley. *Ibid.* 633.

Fig. 125.

9 41 15 9 42 57 The Eclipse was ended, as near as I could perceive, because of the Air's tremulous Motion. The Place of the Exit was so near the Vertex, that I could not well determine which way it inclined from it; though at $9^h. 29'$. by the Clock, the Cuspids appear'd parallel to the Horizon.

At $9^h. 10'$. the Sun's Diameter was 2334, exactly enough as I thought.

Afterwards when the Sun came to the Meridian, by a long Meridian Line, the Clock was found too slow by $1'. 42''$. But by a great Equinoctial Dial, by which I could distinguish to half Minutes or less, the Clock was too slow all this Morning only $45''$. Yet I rather trust to that Correction by the Meridian Line, than by the Sun-dial.

5. *At* Wingfield, *near* Derby; *by M.* Imman. Halton. *Ibid. p.* 664.

$7^h. 50'$. Nothing under the Sun.
7 $50\frac{1}{2}$ The beginning exactly.
7 52 The Defect was observable.
9 00 Digits $3\frac{1}{2}$.
9 11 Digits $3\frac{1}{10}$.
9 21 Digits $2\frac{15}{100}$.
9 $47\frac{1}{2}$ Not finish'd, but the End just approaching.

At Paris *by M.* Cassini.

6. When the Sun appear'd out of the Clouds, approaching to an Altitude of 48 Degrees, I directed my Quadrant to him, and held it immoveable at this Altitude. From the Time that the upper Limb of the Sun *a*, touched the horizontal Thread *c d* in the Focus of the Telescope, to the coming of the Center *b*, there pass'd $104'' = ab$ or *b r*. From the Passage of the Center *b*, to that of the upper Limb of the Moon *o*, were $11'' = bs$. From the Transit of the Center *b* to that of the upper Western Horn *e*, were $25''\frac{1}{2} = eh$. From the Transit of the Center *b* to that of the lower Eastern Horn *i*, were $93'' = ik$. Hence is determin'd the Line of the Horns *i e*, (setting aside the Variation) and its Inclination to the Horizon *l k*; and the Point of Concourse *p* of a Tangent to the Moon with the Secant *i e p*, and the Tangent it self *p o*, being a mean Proportional between *p i* and *p e*. Also the Angles *n o e*, *t o i*; and hence the Angle *i o e*, and the Triangle *i o e* inscribed in the Circumference of the Moon.

Ibid. Fig. 126.

From these and other Astronomical Principles I have deduced, that the beginning at *Paris* ought to be $7^h. 55'$. The End about $10^h. 12'$.

The

7.
At Dantzick; by M. Hevelius. Ibid. p. 666.

The Time according to a Sun-dial and Pendulum Clock.			Altitudes of the Sun.			The Time corrected by the Sun's Altitudes.			The Order of the Phases.	Their Magnitudes.	Observations.
h.	′	″	h.	′	″	h.	′	″			
7	58	10	36	17	0	7	58	18			
8	1	30	36	41	0	8	1	6			
8	3	30	37	3	0	8	3	39			
8	50	30				8	50	0			The Sun appear'd quite clear.
9	21	30				9	21	0			Nothing yet in the Sun.
9	22	30				9	22	0	1	Digit.	The Beginning of the Eclipse.
9	24	10				9	23	40	2	$\frac{1}{2}$ almost.	
9	24	55				9	24	25	3	$\frac{1}{2}$ Digit.	
9	27	28				9	27	0	4	$\frac{3}{4}$ Digit.	
9	29	40				9	29	10	5	1 Digit.	
9	33	25				9	33	0	6	$1\frac{1}{4}$ Digit.	
9	36	30				9	36	5	7	$1\frac{5}{8}$ almost.	
9	39	35				9	39	10	8	2 Digits.	
9	45	49				9	45	25	9	$2\frac{1}{2}$ Digits.	
9	54	22				9	54	0	10	$3\frac{1}{8}$ Digits.	
10	3	44				10	3	22	11	$4\frac{1}{2}$ Digits.	
10	8	30				10	8	10	12	$4\frac{3}{4}$ Digits.	
10	18	17				10	18	0	13	$4\frac{1}{5}$ almost.	
10	22	42				10	22	22	14	$4\frac{1}{2}$ somet. mo.	
10	26	19				10	26	0	15	$4\frac{1}{3}$ almost.	
10	35	24				10	35	6	16	4. 22′.	At the Hour 10^h. 31′. 0″. was the greatest Obscuration.
10	38	53				10	38	38	17	$4\frac{1}{4}$ almost.	
10	47	34				10	47	20	18	4 Dig. almost.	
10	53	49				10	53	30	19	$3\frac{5}{8}$ Digits.	
10	58	17				10	58	8	20	$3\frac{2}{8}$ Digits.	
11	5	27				11	5	20	21	$2\frac{7}{8}$ Digits.	
11	8	50				11	8	44	22	$2\frac{1}{4}$ Digits.	
11	22	13				11	22	8	23	$1\frac{3}{4}$ almost.	
11	29	14				11	29	10	24	$1\frac{1}{00}$	
11	35	25				11	35	20	25	$\frac{1}{2}$	
11	36	59				11	36	55	26	$\frac{1}{4}$ somet. mo.	
11	39	15				11	39	15			The S. not yet clear of the Ecli.
11	39	40				11	39	40			The End of the Eclipse.
4	18	10	33	13	0	11	18	19			
4	20	0	32	25	0	11	20	36			

	By Calc. from the Rudolphine Tables.	*By Obſervation.*	*Diff.*	*Time.*
	° ′ ″	° ′ ″	′ ″	h. ′ ″
Semid. ☉	0 15 0			
Semid. ☾	0 15 3	0 13 53	1 10	10 0 0
		0 14 0	1 3	10 24 0
		0 14 50	0 13	11 0 0
		0 15 0	0 0	The laſt
	h. ′ ″	h. ′ ″		
Duration.	1 50 58	2 17 40		

8. On the preceding Days we choſe a very fit Place, in which we enjoy'd a clear open Air; which was at the Convent of the *Barefoot Carmelites*, which in reſpect of the City of *Avignon* inclines to the Eaſt, and being cloſe to the Walls enjoys a good Air, free from the Smoak and Vapours of the City. In the middle of the Garden we erected an Apartment, which we made dark with Tapeſtry Hangings, and in this we fixt our Inſtruments neceſſary for Obſervation. *At* Avignon; *by M.* Gallet. N. 141. *p.* 1020.

We fitted our Teleſcope with a concave ocular Lens, and convex Object-glaſs, having a double Motion with a firm Support, that is, vertical and horizontal, carrying about with it a little Board made immovable by ſtrong Skrews, cover'd over with a white Paper that was always parallel to the Eye-glaſs, on which we deſcribed the ſolar Image determin'd by the Diſtance of the Teleſcope. The Diameter of this we divided into twelve Digits by concentric Circles, and every Digit into 60 Parts.

Inſtead of a Quadrant, which requires much Caution, and is liable to wavering, we placed a Gnomon very well divided into 100 Parts, for taking the Sun's Shadow; ſo that it might freely move, and yet keep its vertical Situation by means of a Perpendicular. Laſtly, we prepared a Clock that ſhew'd Minutes and Seconds, and went with a Pendulum vibrating in a Cycloid.

On the 11th of *June*, which was the Day of the Eclipſe, at about an Hour after Sun riſing, to the beginning and end of the Eclipſe, we received his bright Image upon the Paper without Intermiſſion; and every one of us watch'd it with an Inſtrument appointed for him. M. *de Beauchamps*, the great Mæcenas of the Muſes at *Avignon*, and my ſelf were at the Teleſcope; the quick-ſighted M. *de St. Florent* was at the Gnomon; M. *Moutonier* was at the Clock, along with M. *Marin*, a Prieſt, who was very converſant in Mathematicks, but particularly in Clock-work.

Preſently and ſenſibly the Shadow began to enter the Diſk; over againſt the firſt Phaſis I put down the Quantity of the Parts obſcured, the Shadow in the Parts of the Gnomon, and the Hour told by the Clock; and thus I collected 39 Phaſes, which are contain'd in the following Tables.

Num. Phases.	Digits obscur.	The Shadow of the Gnomon in such Parts as the Gnomon contains 400	The Sun's apparent Altitude.	The Sun's true Altitude.	The Hour by the Pendulum Clock	The Hour corrected by the Sun's Altitude.	
	D. ′		° ′ ″	′ ′	h. ′ ″	h. ′ ″	
1	0 27	561	35 29 23	35 28 48	7 50 31	7 50 34	
2	1 0	536	36 44 0	39 43 28	7 57 25	7 57 28	
3	1 30	520	37 34 7	37 33 37	8 2 3	8 2 7	
4	3 0	478	39 55 23	39 54 57	8 15 14	8 15 13	
5	3 25	466	40 38 30	48 38 6	8 19 0	8 19 14	
6	4 30	438	42 24 14	42 23 53	8 29 19	8 29 6	
7	4 40	434	42 39 58	42 39 37	8 30 59	8 30 34	
8	5 0	424	43 19 53	43 19 32	8 34 34	8 34 18	
9	5 30	412	44 9 12	44 8 52	8 39 19	8 38 56	
10	6 0	394	45 10 57	45 10 39	8 44 54	8 44 44	The Horns were vertical.
11	6 40	375	46 35 50	46 35 33	8 53 19	8 52 45	
12	6 50	371	46 54 15	46 54 0	8 54 54	8 54 31	
13	7 0	466	47 17 30	47 17 14	8 56 44	8 56 44	
14	7 20	350	48 30 37	48 30 23	9 3 44	9 3 44	The greatest Obscuration.
15	7 8	339	49 29 10	49 28 58	9 9 14	9 9 15	
16	7 0				9 11 0		
17	6 35	325	50 39 22	50 39 10	9 15 54	9 16 12	
18	6 25	321	51 0 12	51 0 0	9 18 14	9 18 11	
19	5 25	296	53 10 29	53 10 19	9 31 5	9 31 1	
20	5 0	286	53 55 14	53 55 5	9 35 44	9 35 30	
21	4 40	283	54 27 6	54 26 57	9 38 39	9 38 43	
22	4 35				9 42 3		Horns were parallel to the Horizon.
23	4 0				9 47 19		
24	3 53	266	56 3 35	56 03 27	9 48 45	9 48 36	
25	3 35	262	56 28 29	56 28 22	9 51 29	9 51 11	
26	3 30	262	56 37 32	56 37 25	9 52 11	9 51 59	
27	3 26	260	56 43 34	56 43 27	9 52 34	9 52 45	
28	3 6	254	57 15 59	57 15 53	9 56 5	9 56 10	
29	3 0				9 57 40		
30	2 48	249	57 50 48	57 50 42	9 59 34	9 59 53	
31	2 35	246	58 9 32	58 9 26	10 1 34	10 1 53	
32	2 25	243	58 26 11	58 26 5	10 3 0	10 3 41	
33	2 0				10 6 46		
34	1 50	236	59 12 33	59 12 28	10 8 56	10 8 47	
35	1 0	226	60 16 59	60 16 55	10 15 51	10 16 0	
36	0 40	220	60 56 21	60 56 16	10 20 57	10 20 31	
37	0 30	217	61 16 11	61 16 6	10 22 54	10 22 50	
38	0 20	214	61 36 12	61 36 8	10 25 0	10 25 12	Western Horn was vertical with the Center of the Sun.
39	Finis	209	62 6 23	62 6 19	10 28 41	10 28 50	

The Proportion of the Diameters appear'd equal, in the Eclipſe of ſix Digits; for then the vertical Horns of the Sun were diſtant on each Side from the Sun's Vertical about 30 Degrees. Whence it appears the Center of the Moon was then found in the Sun's Periphery, and that the Line through the Center was equal to the Sun's Semidiameter. But after the middle of the Eclipſe we found ſome Change in the Diameter of the Shadow; for the Shadow appear'd a little more convex, and therefore the Diameter was ſhorter, but almoſt inſenſibly.

XXXIV. *An Eclipſe of the Sun, July 2d. 1684. at Greenwich; by M. Flamſteed.* N. 162. p. 691.

Time by the Pendulum Clock.	*Time corrected by Obſervation.*	*Obſervations.*	*Parts obſcured, of which 32 were equal to the Sun's Diam.*	*Parts free in the Micrometer.*
h. ′ ″	h. ′ ″			′ ″
2 12 30	2 03 45	The Sun was perfect; then Clouds.		
2 21 2	2 12 17	The S. eclipſed very lit. at low. Limb		
2 21 25	2 12 40	Parts obſcured above the Shadow - -	0½	
2 32 20	2 23 35	- - - - - - - - - - - - - -	4	22 19
2 46 40	2 37 55	- - - - - - - - - - - - - -		
2 51 37	2 42 52	- - - - - - - - - - - - - -	11	
3 5 23	2 56 38	- - - - - - - - - - - - - -	15	
3 9 5	3 00 20	The Center.	16	
3 10 4	3 1 19	- - - - - - - - - - - - - -		15 07
3 11 47	3 3 2	- - - - - - - - - - - - - -		14 36
3 12 15	3 3 30	- - - - - - - - - - - - - -	17	
3 13 23	3 4 38	The Horns were horizontal.		
3 17 43	3 8 58	- - - - - - - - - - - - - -	18	
3 21 48	3 13 3	- - - - - - - - - - - - - -		12 30
3 23 0	3 14 15	- - - - - - - - - - - - - -	19	
3 25 40	3 16 55	- - - - - - - - - - - - - -		12 11
3 29 51	3 20 6	- - - - - - - - - - - - - -	19½	
3 33 54	3 25 9	- - - - - - - - - - - - - -	19½	
3 40 8	3 31 23	- - - - - - - - - - - - - -	19	
3 43 16	3 34 31	- - - - - - - - - - - - - -	18½	
3 45 35	3 36 50	- - - - - - - - - - - - - -	18	
3 49 15	3 40 30	The low. Cuſp. was at the S.'s Nadir		
3 50 2	3 41 17	- - - - - - - - - - - - - -	17	
3 54 20	3 45 35	The Center.	16	
3 56 45	3 48 00	- - - - - - - - - - - - - -	15	
4 2 58	3 54 13	- - - - - - - - - - - - - -	13	
4 6 0	3 57 15	- - - - - - - - - - almoſt	12	
4 8 45	4 00 00	- - - - - - - - - - - - - -	11	
4 16 32	4 7 47	- - - - - - - - - - - - - -	8	
4 17 44	4 9 00	Vertical Cuſpids were diſtant 84°.		
4 24 8	4 15 23	Between the Cuſpids - - - - -		17 32
4 24 20	4 15 35	- - - - - - - - - - - - - -	5	
4 27 14	4 18 29	Between the Cuſpids - - - -		15 35
4 29 36	4 20 51	- - - - - - - - - - - - - -	2½	
4 30 32	4 21 47	Between the Cuſpids - - - -		12 22
4 33 06	4 24 21	- - - - - - - - - - - - - -	1	
4 36 22	4 27 37	The End exactly - - - - -		

Then

Then to find the Error of the Clock.

Hour by the Clock.			*Distances from the Vertex.*				*The H. thence computed.*			*The horary Error.*	
h.	′	″		°	′	″	h.	′	″	′	″
4	43	38	Of the lower	60	11	00	4	34	56	8	42
4	45	48	Limb of the	60	31	20	4	37	7	8	41
4	46	56	Sun.	60	41	50	4	38	15	8	43
4	49	3		61	1	40	4	40	22	8	41

At Paris; *by M.* Bullialdus. N. 162. *p.* 693.

2. The Altitude of the Sun was 50°. The beginning was elapsed, the Sun being cover'd with Clouds, and about a Digit was eclipsed.

The Sun's Altitude was 41°. 15′. a little more than 7 Digits. It reached 8 Digits.

The Altitude of the Sun was 29°. 30′. The End.

At the Observatory; *by M.* Cassini N. 162. *p* 693. N. 163. *p.* 715.

3. The Beginning of the Eclipse could not be seen, but was deduced from the following Phases. The apparent Diameter of the Moon appeared less than that of the Sun. It was judged that the Dilatation of the Sun's Light, might make the Moon's Diameter seem less.

Phases.	*Time.*			*Phases.*	*Time.*		
	h.	′	″		h.	′	″
Begin.	2	25	30	$7\frac{7}{8}$ Digits	3	35	00
or	2	25	55	7 Digits	3	55	50
1 Digit	2	32	50	6 Digits	4	4	10
2 Digits	2	40	00	5 Digits	4	12	25
3 Digits	2	47	40	4 Digits	4	19	15
4 Digits	2	54	10	3 Digits	4	25	50
5 Digits	3	2	00	2 Digits	4	32	15
6 Digits	3	10	5	1 Digit	4	37	40
7 Digits	3	20	10	End.	4	43	23

4. By *M.* de la Hire *and* Pothenot. *Ibid. p.* 716.

Phases.	*Time.*			*Phases.*	*Time.*		
Beginning.	h.	′	″		h.	′	″
	2	25	24	7 Digits	3	53	34
1 Digit	2	33	2	6 Digits	4	3	53
2 Digits	2	40	30	5 Digits	4	11	3
3 Digits	2	47	47	4 Digits	4	17	42
4 Digits	2	54	41	3 Digits	4	25	14
5 Digits	3	2	41	2 Digits	4	31	56
6 Digits	3	12	6	1 Digit	4	38	11
7 Digits	3	20	54	End.	4	43	27
7 Dig. 5′	3	36	27				

 The

The Beginning was deduced from many Obſervations made ſoon after it: The Moon's Diameter appear'd then not to be more than about 30′; though by the Obſervations of her Diameter ſome Days before and after, it was judged to be 31′. 30″. But the Extremities of the Horns, on which depended the Exactneſs of the Determination, appear'd a little blunted.

5. *At the College of* Lewis the Great; *by* R. P. Fontenay. *Ib. p.* 717.

Phaſes.	*Time.*			*Phaſes.*	*Time.*		
Leſs than	h.	′	″		h.	′	″
½ Digit	2	29	30	7 Digits	3	51	20
1½ Digit	2	37	40	6 Digits	4	2	25
2 Digits	2	40	25	5 Digits	4	10	50
3 Digits	2	48	34	3 Digits	4	24	31
4 Digits	2	54	30	2 Digits	4	29	54
5 Digits	3	3	00	0⅓ almoſt.	4	41	00
6 Digits	3	12	40				
7 Digits	3	22	18				
7¾ Digits	3	38	4				

6. The Beginning was at 2^h. 54′. 30″. The End at 5^h. 9′. 9″. The Greatneſs of the Eclipſe 8½ Digits. *At* Aix; *by* M. Gautier. *Ib. p.* 718.

7. *At* Lyons; *by* R. P. Paul Hoſte. *Ib.*

Phaſes.	*Time.*					
	By Fix'd Stars.			*By the Sun.*		
	h.	′	″	h.	′	″
1 Digit	2	45	3	2	50	3
8½ Digits	3	53	52	3	58	52
1 Digit	4	59	20	5	4	20

At ^{h}. 26′. 14″. (by the *Stars*) the Diameter of the Sun and Moon 30′. 58″. But at 4^h. 20′. 34″. the Diameter of the Sun 30′. 58″. of the Moon 30′. 5″.

8. *At the Bay de* Roſes; *by M.* Chaſſelles. *Ib. p.* 719.

Phaſes.	*Times.*		
	h.	′	″
The Beginning of the Eclipſe	2	40	00
The Edge of the Moon at the Sun's Center	3	25	00
The Horns Horizontal	3	40	00
The Horns Vertical	4	15	00
The End of the Eclipſe	5	1	30

The Greatneſs of the Eclipſe about ¾ of the Sun's Diameter, at which Time *Venus* might be ſeen without Pain.

9. The

At Honfleur ; *by M.* de Glos. *ibid.*

9. The Beginning was at $2^h. 15'. 2''$; the End, at $4^h. 34'. 35''$. Th Greatneſs more than 8 Digits, but leſs than 9.

At Pau ; *by* R. P. Richaud. *ib.*

10. At $1\frac{3}{4}^h$. the Eclipſe was not begun : At $3\frac{1}{4}^h$. at 10 Digits : The En at $4\frac{3}{4}^h$.

11.

At Avignon ; *by* R. P. Bonfa. *ibid.*

Phaſes.	*Time.*	*Phaſes.*	*Time.*
	h. ′ ″		h. ′ ″
TheBeginning	2 43 27	HornsVert.	4 24 32
1 Digit	2 51 58	$1\frac{1}{2}$ Dig.	5 1 16
9Digits	4 2 00	The End.	5 4 37

The Sun's Diameter 31′. 38″ : The Moon's 30′. 6″.

At Oxford ; by Dr. Ed. Bernard. N. 164. *p.* 747.

12. The careful Hand of Dr. *Wallis* determined the 40 Phaſes of this Eclipſe. Alſo the learned Mr. *Caſwell*, and Dr. *Rooke* obſerved the true Time of the ſame, by taking ſome Altitudes of the Sun, where our Clocks and Pendulums were deficient.

Obſcure Digits & their Tenths.	*Time by the Clock corr-rect. by the Heavens.*	
	h ′ ″	
	2 03 00	The beginning of the Eclipſe.
0 6	2 07 44	
1 0	2 10 44	
1 3	2 13 19	
1 9	2 15 4-	
2 2	2 21 34	
2 6	2 23 44	
2 9	2 25 39	
3 5	2 29 54	
4 0	2 33 04	
4 4	2 36 34	
4 6	2 40 04	
5 0	2 43 14	
5 3	2 48 19	
5 6	2 50 09	The middle of the Sun obſcure.
6 5	2 57 30	
6 7	2 59 14	
7 4	3 08 24	The greateſt Obſcurity.
7 1	3 11 09	
6 8	3 29 19	
6 7	3 31 39	Darkneſs again at the Cent. of the Sun
6 0	3 37 24	
5 7	3 39 29	

		h. ′ ″	
5	5	3 44 29	
5	0	3 47 59	
4	4	3 50 34	
3	9	3 53 54	
2	9	4 2 49	
2	5	4 4 39	
2	2	4 6 19	
2	0	4 7 54	
1	4	4 13 9	
1	0	4 15 4	
0	7	4 16 49	
0	3	4 19 39	
		4 21 14	The End of the Eclipse.

13. Mr. *Jacobs* at *Lisbon* noted *At* Lisbon. *ib.* *p.* 749.

The Beginning of the Eclipse at 1^h. 30′ exactly.

The Ending at - - - - - - 4 12.

14. Mr. *Ash* and *Molyneux*, toward the middle of the Eclipse, having a *In* Ireland. *ib.* short View of the Sun, they judged that about 8 Digits were covered; at the Ending also having a faint View thereof, they assigned its End at 3^h. 56′. p. m.

The same Eclipse was observed by one Mr. *Osburn*, nigh *Tredagh*. The Beginning 1^h. 37′. 30″. The End 3^h. 56′. 20″.

15. *Jo. Ludovicus Donellus*, and *Nic. Ign. Joanettus*, measured the Sun's *At* Bononia; *by S.* Domin. Gulielmini. N. 203. *p.* 858. Distances from the Zenith; we were three of us employ'd in determining the Phases, D. *Jo. Galeatius Manzius*, *Hercules Vanottus*, and myself. The Observations were wrote down by D. *Greg. Malisardus*. And the Time was observ'd at the Clock by D. *Bart. Ferrarius*.

Time by the Clock	*Corrected by the observed Distances.*	*Dist. of the Cent. of the S. from the Zenith.*	*The Phases.*
h. ′ ″	h. ′ ″	′ ″	′
3 34			Dig. 2 30
3 37 30			Dig. 3
3 48 14	3 47 47	51 31	Dig. 4 20 altogeth. doubtf.
3 52 00			Dig. 5 Very good.
3 57 00	3 56 2	52 58	Dig. 5 30
4 2 00	4 2 29	54 10	Dig. 6
4 4 45	4 5 59	54 44	Dig. 6 30 Very good.
4 9 20	4 9 1	55 17	Dig. 7 exact.
4 14 40	4 15 43	56 28	Dig. 7
4 19 00			Dig. 7 20 doubtful.

h.	′	″	h.	′	″	′	″			′	
4	27	44	4	28	42	58	39	Dig.	7	20	
4	32	35						Dig.	7		exact enough
4	34	20						Dig.	6	45	
4	44	30						Dig.	6	30	
4	47	15						Dig.	6	30	
4	51	30						Dig.	6		Very good
4	54	38	4	53	53	63	16	Dig.	5	30	exact
4	58	2	4	57	38	63	56	Dig.	5		exact
5	1	55	5	1	2	64	32	Dig.	4	30	exact enough
5	4	40	5	5	28	65	19	Dig.	4		altoge. diligent
5	7	0	5	6	23	65	28	Dig.	3	30	exact
5	10	30	5	9	9	65	58	Dig.	3		exact
5	12	35	5	13	28	66	43	Dig.	2	30	exact enough
5	16	15	5	16	14	67	13	Dig.	2		exact
5	19	50	5	20	24	67	57	Dig.	1	30	exact
5	22	30	5	23	21	68	28	Dig.	1		exact
5	25	0	5	25	14	68	48	Dig.	0	30	diligent
5	27	40	5	28	7	69	18	Dig.	0		exactly

It was to be obſerved, when the Quantity of the Eclipſe was Dig. 7. 20′. which ought to have brought on no ſmall Obfuſcation of the Air, (as hath been often obſerved in ſuch Eclipſes,) yet the State of the Air was not ſenſibly changed from what it uſed to be when the Sun is at Liberty. When many that did not view the Sun had a Suſpicion, either that the Sun was not at all eclipſed, or but very little. Of this it ſeems to me that no other Cauſe can be aſſigned, than the great Quantity of Clouds illuminated by the Sun, which were not very far from him. For the Rays of the Sun being multiply'd by the Reflexion and Refraction of theſe, and thereby become more intenſe, might eaſily make amends for the Light that was intercepted.

An Eclipſe of the Sun, May 1. 1687. at Oxford. N. 187. p. 329.
In divers other Places. N. 189. p. 370.

XXXV. 1. Dr. *Wallis* writes from *Oxford*, that this Eclipſe of the Sun was obſerv'd there about ½ a Digit, between one and two o'Clock after Noon.

2. This Eclipſe, tho' it was but a ſmall one, and could not be perceived by the naked Eye, yet ſeems to be very convenient for the accurate Determination of the Parallax, and Latitude of the Moon.

At *London*, by the ſeparate Obſervations of Meſſ. *Hook* and *Halley*, tho' the Heavens were very clear, yet becauſe of the oblique Incidence of the Moon, the Moment of the beginning could not be rightly determined: But at 1^h. 16′. the Eclipſe had begun very remarkably. The middle of the Eclipſe was about 1^h. 40′. The Chord of the Part eclipſed, or that between the Horns, was found to be 9′. 30″. to which anſwers an Arch of 36°; but in the Diameter only 1′. 30″. By the Agreement of both Obſervators the End happen'd exactly at 2^h. 3′. 0″.

At *Greenwich*, at the Royal Obſervatory, Mr. *Flamſteed*, for the ſame Reaſon, did not ſee the beginning. But he determined the End at 2^h. 4′. 15″. In the middle of the Eclipſe, or at the greateſt Obſcuration, the Chord of the eclipſed Part was 9′. 54″.

At *Totteridge* near *London*, Weſtwardly, Mr. *Haines*, F. R. S. ſaw the End at 2^h. 2′. And the greateſt Quantity was half a Digit from the South.

In the Island of *Barbados*, at *Bridg-town*, Mr. *Frank* found the End at 1'. 30". before the Sun's height was 31°. 47'. to the East; that is, 7^h. 56'. 45". By Estimation he judged the greatest Quantity to be two Digits from the South.

At *Nuremberg J. P. Wurtzelbaur* observed the same Eclipse. The Beginning was exactly 1^h. 58½'. About the Middle, that is at 2^h. 36½'. he saw the greatest Quantity to be two Digits exactly. The End was at 3^h. 13'. 33".

At *Ulm* in *Suevia*, the Beginning was observed by *Honoldus* at 1^h. 48'. The greatest Quantity 2⅓ Dig. The End at 3^h. 16'.

At *Leipsic* by *Kirchius*, the Eclipse was observable at 2^h. 20'. 10". At 2^h. 47½'. the Digits were about 1⅓. The End exactly at 3^h. 15'.

At *Wratislaw* in *Silesia*, *D. G. Schultzius* observed the greatest Obscuration to have been something sooner than 3^h. 12': 1½ Dig. Eclip. The End was 3^h. 17'.

XXXVI. 1. I did not see the Beginning of the late Eclipse, but the End happen'd here, precisely 24'. 9". after 10 o'clock in the Morning, apparent Time: The greatest Obscuration, which was 10 Digits and a Quarter, was about 7 Min. after 9.

An Eclipse of the Sun, Sept. 3. 1699. at Oxford; by Dr. D. Gregory. N. 256. *p.* 336.

2. *At* Nuremberg; *by M.* Wurtzelbaur. N. 265. *p.* 619.

Phases.	*Quant. eclipsed.*		*Times by a Pendulum.*			*Phases.*	*Quant. eclipsed.*		*Times by a Pendulum.*		
	Dig.	'	h.	'	"		Dig.	'	h.	'	"
Begin.			8	57	14	20	9	49	10	30	10
1	0	52	9	3	26	21	9	21	10	33	11
2	1	32	9	8	23	22	8	52	10	35	53
3	2	28	9	14	14	23	8	30	10	38	46
4	3	19	9	19	40	24	7	38	10	42	42
5	4	8	9	35	57	25	7	14	10	46	7
6	5	15	9	38	57	26	6	33	10	49	42
7	5	50	9	24	2	27	6	6	10	53	22
8	6	26	9	31	43	28	5	27	10	56	37
9	6	53	9	40	36	29	5	9	11	0	00
10	7	20	9	43	47	30	4	33	11	4	24
11	7	56	9	50	39	31	3	57	11	8	16
12	8	30	9	55	9	32	3	13	11	13	3
13	9	23	10	1	44	33	2	41	11	18	3
14	9	53	10	5	46	34	2	11	11	21	37
15	10	24	10	10	34	35	1	32	11	25	38
16	10	38	10	14	37	36	1	2	11	28	27
17	10	45	10	17	54	End.	0	00	11	33	56
18	10	45	10	22	29						
19	10	12	10	27	31						

From

From the 8th to the 12th Phasis, the opake Limb of the Moon on the South-side was a little rough; but about the Northern Horn, to near a 4th part of the Segment, it was more smooth: But when the Horns of the Eclipse were almost parallel to the Horizon, before and after the 15th Phasis, the Extremity of the gibbous Limb of the Moon looking downward, was somewhat enlightned, and of a kind of Saffron Colour; but though the Sky was free from Clouds, yet no Stars were visible. Nor was even *Venus* itself visible in the open Air, unless by some more sharp-sighted than ordinary.

Amongst many round Plates cut out of thick Paper of divers Magnitudes, differing from one another 5″. about the first Phasis, and after, none agreed to the Limb of the Moon but that which was cut to a Radius or Semidiameter of 15′. 30″. (taking the Radius or Semidiameter of that of the Sun to be 16′. 4″.) and that gradually so swelled or augmented, that larger Plates were necessary to be made use of; and about the 36th Phasis, none less than one described of a Radius of 16′. 5″. would agree with, or equal the Appearance; and consequently, that the Diameter of the Moon, about the End of the Eclipse, did equalize, if not exceed, that of the Sun. Besides, in the 27th Phasis (when the obscure Part was 6 Dig. 6′.) the Body of the Moon did obscure more than two 3ds of the Sun's Limb; which is an Argument that its Semidiameter at that time was equal to that of the Sun.

By others, ib. p. 623.

3. This Eclipse, by the Observations of Mr. *Godfred Tuber* at *Ciza*, began at 9^{h}. and ended at 11^{h}. 35′. and increas'd to 11 Dig. By the Observations of Mr. *Jacob Honold* at *Harvelsing* near *Ulm* of *Suevia*, it began at 8^{h}. 55′. and ended at 11^{h}. 31′. and its greatest Defect was 10 Dig. And by Observations at *Leipsick*, it began at 9^{h}. 11′. and ended at 12^{h} 38′. 30″. The greatest Obscurity was 11 Dig. 20′. which lasted from 10^{h}. 16′. 45″. for 6′. Ten Digits being obscured, the Sky (being otherwise very clear) began to appear of a more livid or wan Complexion, and more sad than it usually looks with a clear Sky when the Sun is set, or below the Horizon. The Cocks also, which had hitherto crowed very frequently, as if silenc'd, going to Roost, left off crowing, and did not renew it, till, by the Recovery of the Sun's Light, they had recover'd their former Gaiety and Mirth: However, we cannot learn that any Star, besides that of *Venus*, was discover'd by those who were Spectators of it in the open Air.

Changes likely to be discovered in the Moon, by M. Auzout. N. 7. p. 120. Dec. Ann. 1665.

XXXVII. I sometimes think that the Earth must appear, to the supposed Inhabitants of the Moon, to have a different Face in the several Seasons of the Year; and to have another Appearance in Winter, when there is almost nothing green in a very great Part of the Earth; when there are Countries all cover'd with Snow, others all cover'd with Water, others all obscur'd with Clouds, and that for many Weeks together; another in Spring, when the Forests and Fields are green; another in Summer, when the whole Fields are Yellow, *&c.* Methinks, I say, that these Changes are considerable enough in the Force of the Reflections of Light to be observ'd, since we see so many Differences of Lights in the Moon. We have Rivers considerable enough to be seen, and they enter far enough into the Land, and have Breadth capable to be observed. There are Fluxes in certain Places that reach into large Countries, enough to make there some apparent Change; and in some of our Seas there float sometimes ſuch bulky Maſſes of Ice, as are far greater than the Objects which we are aſſured we can ſee in the Moon. Again; we cut down whole Foreſts, and drain Marſhes, of an Extent large enough to cauſe a notable Alteration; and Men have made ſuch Works as have produced Changes great enough to be perceived. In many Places alſo are *Vulcano's* that ſeem big enough to be diſtinguiſh'd, eſpecially in the Shadow. And when Fire lights upon Foreſts of great Extent, or upon Towns, it can hardly be doubted, but theſe luminous Objects would appear either in an Eclipſe of the Earth, or when ſuch Parts of the Earth are not illuminated by the Sun: But yet, I know no Man, who hath yet obſerved ſuch things in the Moon; and one may be rationally aſſured, that no *Vulcano's* are there, or that none of them burn at this time. This it is which all curious Men that have good Teleſcopes ought well to attend; and I doubt not, but if we had a very particular Map of the Moon, as I had deſigned to make one, with a *Topography*, as it were, of all the conſiderable Places therein, that we or our Poſterity would find ſome Change in her. And if the Maps of the Moon of *Hevelius*, *Divini*, and *Riccioli*, are exact, I can ſay that I have ſeen there ſome Places conſiderable enough, where they put Parts that are clear, whereas I there ſee dark ones. 'Tis true, that if there be Seas in the Moon, it can hardly fall out otherwiſe than it doth upon our Earth, where Alluviums are made in ſome Places, and the Sea gains upon the Land in others; I ſay, if thoſe Spots we ſee in the Moon are Seas, as moſt believe them to be, whereas I have many Reaſons that make me doubt whether they be ſo. And I have ſometimes thought, whether it might not be, that all the Seas of the Moon, if there muſt be Seas, were on the Side of the other Hemiſphere, and that for this Cauſe it might be, that the Moon turns not upon its Axis, as our Earth, wherein the Lands and Seas are as it were balanced: That thence alſo may proceed the Non-appearance of any Clouds rais'd there, or of any Vapours conſiderable enough to be ſeen, as there are rais'd upon this Earth; and that this Abſence of Vapours is, perhaps, the Cauſe that no Crepuſcle is there, as it ſeems there is none, my ſelf, at leaſt, not having been hitherto able to diſcern any Mark thereof: For, methinks, it is not to be doubted but that the reputed Citizens of the Moon might ſee our Crepuſcle, ſince we ſee that the ſame is without Compariſon ſtronger than the Light afforded us by the Moon, even when ſhe is full; for a little after Sun-ſet, when we receive no more the firſt Light of the Sun, the Sky is far clearer than it is in the faireſt Night of the Full-Moon. Mean while, ſince we ſee in the Moon, when ſhe is increaſing or decreaſing, the Light ſhe receives from the Earth; we cannot doubt but that the People of the Moon ſhould likewiſe ſee in the Earth that Light wherewith the Moon illuminates it, with, perhaps, the Difference there is betwixt their Bigneſs. Much rather therefore ſhould they ſee the Light of the Crepuſcle, being, as we have ſaid, incomparably greater. In the mean time, we ſee not any faint Light beyond the Section of the Light, which is every where almoſt equally ſtrong, and we there diſtinguiſh nothing at all, not ſo much as that cleareſt Part which is call'd *Ariſtarchus* or *Porphyrites*, as I have often tried; although one may there ſee the Light which the Earth ſends thither, which is ſometimes ſo ſtrong, that in the Moon's Decreaſe, I have often diſtinctly ſeen all the Parts of the Moon that were not enlighten'd by the Sun, together with the Difference of the clear Parts and the Spots, ſo far as to be able to diſcern them all. The Shadows alſo of all the Cavities of the Moon ſeem to be ſtronger than they would be, if there were a ſecond Light. For although afar off the Shadows of our Bodies, environed with Light, ſeem to us almoſt dark, yet they do not ſo appear ſo much as the Shadows of the Moon do; and thoſe that are upon the Edge of the Section, ſhould not appear in the like manner. But I will determine nothing of any of theſe Things.

To find the Parallax of the Moon; by . . . . *N. 1 p. 151. Feb An. 1666.*

XXXVIII. At certain Times agreed on by two Obſervers, making uſe of Teleſcopes, large, good, and well-fitted for this Purpoſe, by a Meaſuring-Rod placed within the Eye-Glaſs at a convenient Diſtance, that it may be diſtinctly ſeen, and ſerve for meaſuring ſmall Diſtances by Minutes and Seconds, (which is eaſy enough in large Teleſcopes). Let each of ſuch Obſervers, thus furniſhed, obſerve the viſible Way of the Moon among the fix'd Stars (by taking her exact Diſtance from any fix'd Star that lies in or very near her Way, together with the exact Time of her ſo appearing) and the then apparent Diameter of her Diſk; continuing theſe Obſervations, every time for two or three Hours; that ſo, if poſſible, two exact Obſervations of her apparent Place among the fix'd Stars being made at two Places thus diſtant in Latitude, and, as near as may be, under the ſame Meridian, by theſe Obſervations concurring at the ſame time, her true and exact Diſtance may be hence collected, not only for that time, but at all other times, by any ſingle Obſervator's viewing her with a Teleſcope, and meaſuring exactly her apparent Diameter. It were likewiſe deſirable, that as often as there happens any conſiderable Eclipſe of the Sun, that this alſo might be obſerv'd by them, noting therein the exact Meaſure of the greateſt Obſcuration compared with the then apparent Diameter of his Diſk. For by this means, after the Diſtance of the Moon hath been exactly found, the Diſtance of the Sun will eaſily be deduced.

As for the Time fitteſt for making Obſervations of the Moon, that will be when ſhe is about a Quarter, or ſomewhat leſs illuminated; becauſe then her Light is not ſo bright but that with a good Teleſcope ſhe may be obſerv'd to paſs cloſe by, and ſometimes over ſeveral fix'd Stars, which is about four or five Days before or after the Change: Or elſe at any other time, when the Moon paſſes near or over ſome of the bigger ſort of fix'd Stars, ſuch as of the firſt and ſecond Magnitude; which may be eaſily calculated and foreſeen: Or, beſt of all, when there is any total Eclipſe of the Moon; for then the ſmalleſt Teleſcopical Stars may be ſeen cloſe adjoining to the very Body of the Moon.

A Method for obſerving Lunar Eclipſes; by Mr. Rook. *N. 22. p. 388. Feb. An. 1666.*

XXXIX. 1. Eclipſes of the Moon are obſerved for two principal Ends: One Aſtronomical, that by comparing Obſervations with Calculations, the Theory of the Moon's Motion may be perfected, and the Tables thereof reformed; the other Geographical, that by comparing among themſelves the Obſervations of the ſame Ecliptick Phaſes, made in divers Places, the Difference of the Meridians or Longitudes of thoſe Places may be diſcerned.

The Knowledge of the Eclipſes Quantity and Duration, the Shadow's Curvity and Inclination, *&c.* conduce only to the former of theſe Ends. The exact Time of the Beginning, Middle, and End of the Eclipſes, as alſo in total Ones, the Beginning and End of total Darkneſs, is uſeful for both of them.

 But

But becauſe in Obſervations made by the bare Eye theſe Times conſiderably differ from thoſe with a Teleſcope; and becauſe the Beginning of Eclipſes, and the End of total Darkneſs, are ſcarce to be obſerved exactly, even with Glaſſes (none being able clearly to diſtinguiſh between the true Shadow and Penumbra, unleſs he hath ſeen, for ſome time before, the Line ſeparating them paſs along upon the Surface of the Moon); and laſtly, becauſe in ſmall partial Eclipſes, the Beginning and End, and in total ones of ſmall Continuance in the Shadow, the Beginning and End of total Darkneſs are unfit for nice Obſervations, by reaſon of the ſlow Change of Appearances, which the oblique Motion of the Shadow then cauſeth: For theſe Reaſons I ſhall propound a Method peculiarly deſign'd for the Accompliſhment of the Geographical End in obſerving Lunar Eclipſes, free (as far as is poſſible) from all the mention'd Inconveniencies.

For, *Firſt*, It ſhall not be practicable without a Teleſcope. *Secondly*, The Obſerver ſhall always have Opportunity, before his principal Obſervation, to note the Diſtinction between the true Shadow and the Penumbra. And, *Thirdly*, It ſhall be applicable to thoſe Seaſons of the Eclipſe when there is the ſuddeneſt Alteration in the Appearances. To ſatisfy all which Intents,

Let there be of the eminenteſt Spots, diſpers'd over all Quarters of the Moon's Surface, a ſelect Number generally agreed on, to be conſtantly made uſe of to this purpoſe, in all Parts of the World. As for Example, thoſe which M. *Hevelius* calleth *M. Sinai*, *M. Ætna*, *M. Porphyrites*, *M. Serorum*, *Inſ. Beſbicus*, *Inſ. Creta*, *Palus Mæotis*, *Palus Marœotis*, *Lacus Niger Major*.

Let in each Eclipſe, not all, but (for Inſtance) three of theſe Spots, which then lie neareſt to the Ecliptick, be exactly obſerv'd when they are firſt touch'd by the true Shadow; and again, when they are juſt compleatly entred into it; and (if you pleaſe) alſo in the Decreaſe of the Eclipſe, when they are firſt fully clear from the true Shadow. For the accurate Determinations of which Moments of Time (that being in this Buſineſs of main Importance) let there be taken Altitudes of remarkable fix'd Stars; on this Side of the Line, of ſuch as lie between the *Æquator* and *Tropick* of *Cancer*; but beyond the Line, of ſuch as are ſituate towards the other Tropick; and in all Places, of ſuch as at the Time of Obſervation are about four Hours diſtant from the Meridian.

2. The Eclipſe of the Moon, *Octob.* 29. *An.* 1697, was obſerved at *Roterdam* with a Teleſcope of almoſt four *Paris* Feet, with a convex Eye-Glaſs, in whoſe Focus were four Threads croſſing in the Axis at right Angles and half right Angles, for meaſuring the Phaſes, and determining the ſituation of the Lunar Spots. This Teleſcope was ſupported by a Fulcrum having its Axis in a parallel Situation to the Axis of the World, that after it was directed to the Moon for the Obſervation of one Phaſis, for obſerving other Phaſes it might turn about to the Weſt along the Path of the Moon. So it was firſt directed to the Moon, that continuing immoveable the Northern Limb of the Moon, by its Motion to the Weſt, might touch one of theſe Threads, which therefore we ſaid was parallel; tho' becauſe of the Motion of the Moon in Declination, blended with the much ſwifter Motion of the Moon to the Weſt, it declined ſomething from the Equator, whilſt the Diſk of the Moon fell ſucceſſively upon the three other Threads. The middle one of theſe

By M. Ja. Caſſini. N. 236. p. 15.

these three Threads, making right Angles with the Parallel, we may call the ſtrait, perpendicular, and vertical Thread; the other two oblique ones, of which we call that the firſt, upon which the Moon falls firſt, the ſecond oblique one upon which the Moon falls afterwards. At the beginning of the Eclipſe, when the moſt Northerly Point of the Moon was not yet immerſed in the Shadow, we adapted it to the parallel Thread. Then after this Point was immerſed in the Shadow, we adapted the moſt Southern Point of the
Fig. 127. Moon to the ſame Thread. Whence it is that the Thread which at the beginning was firſt, in the determining the other Phaſes was laſt, and that became the firſt which before was laſt. Now when the Limb of the Moon deſcribed the parallel Thread, the Center of the Moon muſt be ſuppoſed to deſcribe the Lunar Path parallel to this Thread, which was cut by the other three Threads. And the Portions of this Path are ſuppoſed proportional to the times in which the Center of the Moon paſſes over them; for the inequality of the proper Motion blended with the univerſal Motion in a ſmall time is not perceivable. Therefore when the Limb of the Moon deſcribed the Parallel, by the help of a Pendulum-Clock which beforehand had been ſet to the Sun, the Time of the approach of ſome of the Lunar Spots was obſerved, and alſo of the Lunar Horns, to any of theſe three Threads; and it was found, that at the time of the ſaid Eclipſe the Moon's Diſk paſſed through the upright Thread in 2′. 24″. and through the oblique Threads in 3′. 24″. and therefore the Semidiameter of the Moon paſſed through the upright Thread in 1′. 12″. but through the oblique in 1′. 42″; the difference of each
Fig. 128. Tranſit being 30″. Hence one Appulſe of the Moon being obſerved to any of theſe Threads, or one Egreſs, all the others are given to the other Threads. The Semediameter of the Moon AB, lying in the Lunar Path ABCDEF, paſſes through any one of its Points while the Center A runs over a Space AB equal to it; as another Semidiameter AK, making a right Angle with another Line NCK at the Point K, in which therefore it will touch the Moon in K, declining from its Path by the Angle KCA, paſſes through the Thread CK, while the Center of the Moon paſſes through the Line AC, which is the Hypothenuſe of the right-angled Triangle AKC. And the time of the Tranſit of the Semidiameter AB through the Perpendicular Thread that touches the Moon in B, to the Tranſit of the Semidiamer AK through the oblique Thread NCK, as AB or AK, the Sine of the Angle ACK, to AC the Sine of the right Angle or Radius. Therefore the Thread NCK making half a right Angle KCA with the Path of the Moon, alſo the Angle KAC in the right-angled Triangle will be half a right Angle, and therefore the Sides CK and KA will be equal; the right Tranſit according to AB will be to the Tranſit of the Semidiameter AK, through the oblique Thread NK, as the Sine of half a right Angle to the Sine of a right Angle, as 707 to 1000, or as 72″ to 102″, or 1′. 42″ nearly, as was obſerved. The Path of the Center of the Moon being AH, to the Semidiameter of the Moon perpendicular to AM, MNO being drawn parallel to AH, it will be congruous to the Thread which the Limb of the Moon touches by its Motion to the Weſt, which will be cut by the oblique Threads NCK and NGI, and by the upright

right Thread NEP in the Point N, where the Axis of the Teleſcope paſſes. And with theſe Threads the Lunar Orbit will make two right-angled Triangles NEC, NEG, which are ſuppoſed to have half right Angles at the Points N, C, G; they are therefore like and equal, and have their Sides CE, EG, EN, equal to the Semidiater of the Moon AM. If on each ſide of the Interſections C and G, be taken in the Threads CK, CS, GI, GR, equal to the Semidiameter, and CA, CF, GD, GH, in the Orbit equal to CN, and AK, FS, DR, HI, are joined; theſe will all be equal to one another, and at the Threads will make right Angles, at K, S, R, I. Wherefore the Center of the Moon being in A, the Moon will touch the firſt oblique Thread in K, and after the Center of the Moon comes from A to C, its Semidiameter will coincide with the Line CE, and therefore the Moon will touch the upright Thread in E. But after the Center of the Moon ſhall come from A to D, it will touch the ſecond oblique Thread in R. But AD is equal to the Moon's Diameter; for ſince GD is equal to CA, adding DC we ſhall have AD equal to GC, which is equal to the Moon's Diameter. And ſince GD is equal to CF, if from theſe are taken Equals, GE and EC, then FE will be equal to ED, and will be the double of DF; and will be only from the firſt Contact of the ſecond oblique Thread in R, to the laſt Contact of the firſt oblique Thread in S; and after the Center of the Moon has gone on to G, at the diſtance of one Semidiameter EG, the Moon will finally touch the upright Thread in E. The Center going on from G to H, the Moon herſelf will finally touch the ſecond oblique Thread in I. Suppoſing therefore the upright Tranſit of the Moon to be 2′. 24″. as it is obſerved to be; and,

	′	″	*Diff. Contact.* ′	″
Suppoſing the Center at A, and the Contact of the firſt oblique Thread at K - - - - - - - - - - - - - -	0	0	1	42
The Center of the Moon will be at C, and will touch (firſt) the upright Thread at E - - - - - - - - - - - - -	1	42	0	42
The Center will arrive at D, and will touch (firſt) the ſecond oblique Thread at R - - - - - - - - - - -	2	24	0	30
The Center of the Moon will be at E, the intermediate perpendicular Thread - - - - - - - - - - - - - -	2	54	0	30
The Center will arrive at F, and will touch (laſtly) the firſt oblique Thread at S - - - - - - - - - - - - - -	3	24	0	42
The Center will be at G, and will touch (laſtly) the upright Thread at E - - - - - - - - - - - - - - - -	4	6	1	42
Finally it will be at H, and will touch (laſtly) the ſecond upright Thread at I - - - - - - - - - - - - - -	5	48		

Hence the Obſervations in this Eclipſe generally correſponded with the Calculation within one Second. Therefore it was ſufficient in one Phaſis to obſerve two of theſe Tranſits, in the reſt one, that all the reſt might be known. As to the Lunar Spots, the Tranſit of the preceding Limb of the Moon and of the Spot through the upright Thread, is compared, to have what *Fig.* 129.

is

is called the Difference of the Longitudes of the Spot from the preceding Limb. And the upright Tranſit of the Spot is compared with the Oblique, to have the Difference which is equal to the Diſtance of the Way of the Spot from the Path of the moſt Northern or Southern Point touching the parallel Thread. For ſince the Way of the Spot ABC is parallel to the Way of

Fig. 130. the Limb D E F, it makes the ſame half right Angles at A and C with the ſame Threads, and right Angles at B; whence the Angle at A is equal to the Angle at C, and the Side B A equal to the Side B E, which is the Latitude of the Spot B from the Thread F E D. But the Longitude and Latitude of the Spot being given, its Situation in the Moon is given alſo. For a Square being deſcribed about it whoſe Side is A B, let it be ſuppoſed to become congruous to the parallel Thread, and let it be divided into ſo many equal Parts, as the Moon paſſes through the upright Thread in Seconds; and let the Sides A C, B D, perpendicular to the Thread, be divided in like manner into as many equal Parts. The Longitude A E, C F, being taken in the Parallels, and F E being drawn, and in the Perpendiculars the Latitude A G, B H, which we ſay is equal to the way intercepted between the upright and oblique Threads; the Situation of the Spot M is determin'd by the common Interſection of theſe right Lines.

As to what concerns the Horns of the Moon in the Eclipſe, they may be determin'd by their Longitude alone, if it be but known in what Semicircle North or South they are. As the Horn I by the Longitude A E or C F. For the right Line F E cuts the Moon's Limb in two Points L and I, one of which is in the Northern Semicircle, the other in the Southern. It may alſo be determin'd by the Latitude alone A K or B M, if it be but known in what Semicircle Eaſtern or Weſtern the Point I is ſituate. But of the Lines of Longitude and Latitude, that will determine the Situation of the Horn more exactly, which is nearer to the Center; as there the Point I is more exactly de-

Fig. 131. termin'd by the Longitude than by the Latitude. And on the contrary, the Point O is more exactly determin'd by the Latitude than by the Longitude; and that becauſe of the leſſer Obliquity of the right Line to the Circumference, by which it is brought about, that a ſmall Variation of Diſtance is more ſenſible in the Circumference. In another manner the Situation of the Spots and Horns of the Moon may be determin'd by the oblique Tranſits, if the Line A D, parallel to the Moon's Path P Q touching its Limb, be made the Diameter of a Square circumſcribed about the Moon, which is divided into ſo many equal Parts as the Moon paſſes through the oblique Thread in Seconds; as in this Eclipſe into 204. Of this Square the two Sides A C, B D, will repreſent the firſt oblique Thread, as being parallel to it; the others A B, C D, will repreſent the ſecond oblique Thread. Now the Difference being taken between the Tranſit of the preceding Limb of the Moon and Spot M through the oblique Thread, in horary Seconds from the preceding Angle from A to T, and through T the right Line E F being drawn parallel to the Side A C; and in like manner from the ſame Angle A taking the Difference between the Tranſit of the preceding Limb K and the Spot M, through the

ſecond

ſecond oblique Thread A B, as A V; through the Point V let the right Line G V H be drawn parallel to the Side A B; it will repreſent the ſecond oblique Thread cutting the former in the Point M, and will there determine the Situation of the Spot. In the ſame manner will be determin'd the Situation of the Horn E, by the Difference of its Tranſit and of the Limb, through the firſt oblique Thread, taken in the Diagonal as A T; the Situation of the Horn H, by the Difference of its Tranſit along the ſecond oblique Thread A B, as A V, and drawing through V a right Line G H parallel to the Side A D; if it be known whether the Horn be in the precedent or ſubſequent Semicircle.

XL. The Tables did not indicate an *Eclipſe* of the *Moon*, *July* 27. (*N. S.*) 1665. but tho' the Sky here was very clear, yet the Moon was not at all obſcured by the true Shadow, but entred only a little into the Penumbra, wherein it continued 50′. The Beginning of its touching the Penumbra did then almoſt happen, when *Aquila* was elevated 36°. 18′. *An Eclipſe of the Moon, 1665, obſerved at* Dantzick; *by M.* Hevelius. N. 19. *p.* 348.

XLI. In the *Eclipſe* of *June* 16, (*N.S.*) 1666, the firſt *Phaſis* of 1 *Dig.* 45′. appear'd in the Moon's Altitude of 2°. 30′. when the greateſt Obſcuration was already paſt. The End fell out 9ʰ. 27′. about 120°. from the Zenith Weſtward. *An Eclipſe of the Moon,* June 6. *A.* 1666. *by M.* Hevelius. *Ibid. p.* 348. N. 21. *p.* 371.

XLII. On the 29th of *September* new Style, An. 1670. in the Morning, the Beginning of this Eclipſe happened at 2ʰ. 22′. tho' this could hardly be obſerved very accurately, becauſe of the very thin Shadow of the Earth. For during the Eclipſe the Shadow of the Earth was ſo very thin and dilute, that I could ſee very well through it all the principal Spots, with my twenty-foot Tube, and even with ſhorter. *An Eclipſe of the Moon,* Sept. 19. *A* 1670. *by M.* Hevelius. N. 61. *p.* 2023.

The greateſt Obſcuration fell at 3ʰ. 50′. The End at 5ʰ. 21′. So that the whole Duration was 2ʰ. 59′, and the Quantity hardly more than 9 Digits. About the Middle of this Eclipſe, at 3ʰ. 40′. I ſaw very plainly a certain unknown little Star, which could be ſeen only with the Tube, covered by the Moon near the greater black Lake; but I could not ſee it come out again. When the Eclipſe was ended it was a very pleaſant Sight to ſee the two Luminaries both above the Horizon together: For the Sun aroſe before the Moon was ſet. The other Things that were remarkable may be found in the following Table.

Order of the Phases.	Phases of the Moon observed with a Telescope.	The observed Altitudes.	Times corrected by the Altitudes. h. ′ ″	Things observable.
		Swan's Tail 50°. 54′.	12 8 34	
		Swan's Tail 50 25	12 11 32	
		Of *Pollux* Ⅱ 26 39	1 28 56	
		Of *Pollux* Ⅱ 27 16	1 33 17	
	Beg. Penum.		2 10 0	
	Beg. Eclipse.		2 22 0	Eclipse began in upper Parts of the M. about Sin. *Hyper.*
1	1$\frac{3}{8}$ Dig.		2 31 0	Shadow skim'd by Sin. *Apol.* and Mar. *Porphyr.*
2	2$\frac{1}{4}$		2 36 0	*Lac.Nig.Maj.* beg. to be cov.
3	3$\frac{1}{4}$		2 41 40	Shadow reach'd the Isle of
4	3$\frac{3}{4}$ som.more		2 45 50	*Corsica.*
5	4$\frac{3}{8}$		2 49 0	*Palus Mæotis* and M. *Ætna*
6	5 Dig. nearly		2 53 0	plainly cover'd.
7	5$\frac{3}{4}$		2 57 0	*Insul. Besbic.* and *Ins. Macra*
8	6 Dig.		3 3 0	cover'd.
9	6$\frac{1}{4}$		3 5 0	
10	6$\frac{3}{4}$		3 8 30	*Ins. Melos* beg. to be cover'd.
11	7$\frac{1}{8}$		3 11 0	
12	7$\frac{5}{8}$		3 16 0	*Insul. Rhodus* cover'd.
13	7$\frac{7}{8}$		3 20 0	
14	8$\frac{1}{4}$		3 25 30	
15	8$\frac{1}{2}$		3 29 0	*Insul. Maj. Casp.* was cover'd
16	8$\frac{3}{4}$		3 33 40	
17	8$\frac{7}{8}$		3 37 50	
			3 40 0	

18	9 Dig.		3 47 0	Greatest Obscurat. extended itself thro' *J. Let.* & *M. Aber.*
19	9 somet. less		3 51 10	*Pal. Maræotis* under the Section of the Shadow.
20	8 $\frac{3}{4}$		2 57 0	
21	8 $\frac{1}{2}$		4 1 40	
22	8 $\frac{1}{4}$ nearly.		4 6 0	
		Of *Pollux* ♊ 49°. 50′.	4 10 28	
23	8 some. more		4 11 0	Islands *Melos* and *Rhodes* came out of the Shadow.
24	7 $\frac{3}{4}$		4 17 20	
25	7 $\frac{3}{8}$		4 22 25	*Mar. Porphyrites* began to be illuminated.
26	6 $\frac{3}{4}$		4 27 35	The Shadow had now left Mount *Ætna*.
27	6 $\frac{1}{4}$ nearly		4 33 40	
28	5 $\frac{3}{4}$		4 37 37	
29	4 $\frac{3}{4}$		4 44 46	*M. Argentor.* and *Ins. Besbic.* were illuminated.
30	4 Dig.		4 50 56	
31	3 $\frac{3}{8}$		4 54 0	
32	2 $\frac{3}{4}$		4 57 0	
33	2 $\frac{1}{4}$ nearly.		5 1 23	Shadow had almost pass'd the whole Island *Casp.* Maj.
34	1 $\frac{5}{8}$		5 4 45	
35	1 $\frac{1}{4}$ Dig.		5 7 43	
		Lion's Heart 25° 48′	5 10 50	
	End Eclipse.		5 21 25	The end happen'd about the *Riphean* Mountains.
	End *Penumb.*		5 24 0	
		Sirius 18°. 54′.	5 28 32	

XLIII. 1. On *Sept.* 8. 1671. about six in the Evening, the Moon rose totally obscured at *Ecton* in *Northamptonshire*. *An Eclipse of the Moon, Sept 8. 1671. at Ecton; by Mr. Palmer. N. 76. p. 2272.*

It began to emerge out of the Shadow, the Center of the Moon being 9°. 35′ high, or at 7^h. 18′.

At the End *Arcturus* was 16°. 30′. high, or at 8^h. 16′. 20″. Whence the middle of the Eclipse is computed to be at 6^h. 28′. 16″.

	°	′	h.	′
2. The Emersion: Alt. of the upper Edge of the Moon	10	30	7	21
The End of the Eclipse: Alt. of *Arcturus*	16	20	8	16 $\frac{1}{3}$

At London; by Mr. Street. ib.

3. 7^h. 27½′, I first observed the Moon eclipsed when it began to be enlightned, the total Darkness being already past. The Shadow passed through the middle of the Spot called by *Hevelius*, *M. Porphyrius*. *By Dr. Hook. N. 77. p. 2296.*

 7^h 49′

7^h. 49′. The Shadow paſſed through the middle of *M. Sinai*, through the middle of the Eaſtermoſt of the three Lakes called *Mare Adriaticum*, and juſt touched the Ridge of the *Apennine* Mountains.

7^h. 54′. It paſſed the middle of the *I. Beſbicus* in the *Propontis*.

8^h. 0½. It paſſed through the *Streights* of the *Pontus Euxinus*, at the Promontories *Acheruſia* and *Ariſtes*.

8^h. 6½′. It touched the *Palus Mæotis*, which *Palus Mæotis* was then diſtant from the Limb of the Moon, next adjacent, one third part of its ſhorter Diameter or Breadth.

8^h. 17′. The Shadow went off the Body of the Moon upon the innermoſt Limb-line of *Hevelius*'s large Chart of the Moon at the 29th Diviſion, juſt without the *I. Major* of the *Caſpian* Sea. The duſkiſh *Penumbra* left not the Limb of the Moon quite without ſome kind of Darkneſs till 8^h. 29′; at which time I found that that ſide of the Moon which the Shadow laſt left, was full as light and clear as the other.

About four or five Minutes after the Shadow was gone off, I perceived a faint Repreſentation of Colours upon that Part of the Body of the Moon which was moſt affected with the *Penumbra*, ſomewhat reſembling the Colours of a faint *Halo* about the Moon; this grew fainter and fainter, and after a few Minutes was no more viſible. It did not ſeem to be cauſed by any Clouds or Exhalations in the Air, the Sky near the Moon being very clear, and the ſaid Colours not appearing any where but upon the duſky part of its Phaſis. Poſſibly it might be cauſed by the Refraction of the Light of the Sun through the Atmoſphere about the Earth.

At Paris; *by M.* Bullialdus. N. 75. *p.* 2273.

	h. ′ ″	° ′ ″
4. the End was obſerved, when the Altitude of *Arcturus* to the Weſt was - - - - - - - - - - -		13 41
Subtracting the Refraction, his Height was - -		13 37 45
Hence is given the End obſerved - - - - - - -	8 29 16	
The End of the *Penumbra*, the Height of *Arcturus* being - - - - - - - - - - - - - - - -		13 0
Corrected - - - - - - - - - - - - - -		12 56
Whence is given - - - - - - - - - - -	8 33 40	
Mæotis was obſerved wholly out of the Shadow	8 24 16	
The Altitude of *Arcturus* was - - - - - - -		14 26 0
Corrected - - - - - - - - - - - - - -		14 23 55

The Moon came out of the Shadow over againſt *Petra Sogdiana*, by *Hevelius*'s Map.

At Dantzick; *by M.* Hevelius. N. 78. *p.* 3028. 5. At 8^h. 30′. a-Clock, through the opening Clouds, which were pretty thick, we perceived the Moon ſomething obſcurely, and ſo much enlightned, that one would have thought the Eclipſe had been over already. Thence it was certain, that the total Obſcuration was then paſs'd at leaſt, or rather ſomething ſooner. For that the Moon was come again, we could all perceive plainly enough through the Clouds. So that the Eclipſe muſt have appear'd in the Heavens above half an Hour ſooner, than *Kepler*'s Calculation made it. At 8^h. 34′. I obſerved the Moon had freed herſelf from the Shadow a whole Digit at leaſt; and again at 9^h. 41′. the Light of the Moon had increaſed to 1½ Digit, as near as we could judge.

6. We

6. We found here, as Mr. *Hevelius* had done at *Dantzick*, that the *Rudolphine* Tables were out in the late Eclipse. We found here also, that the Moon emerged out of the Shadow of the Earth before nine a-Clock. *At* Hamburg; *by Dr.* Fogelius. *Ibid. p.* 3033.

	h.	′
XLIV. 1. The beginning of the true Shadow	5	22
The Immersion	6	19
The Emersion	7	58
The End of the true Shadow	8	58

An Eclipse of the Moon, Jan. 1. 1674-5. *at* London; *by Dr.* Hook. N. 111. *p.* 237.

The Penumbra was seen to continue near half an Hour before it wholly quitted the Body of the Moon.

2. Mr. *Flamsteed* observed the Beginning of the Entrance of the true Shadow h. 5. and 19′. *At* Derby; *by M.* Flamsteed. *Ibid.*

	°	′	h.	′	″
3. The beginning of the true Shadow, Height of *Capella* - - - - - - -	52	26	5	32	29
The Immersion, Height of *Capella*	62	8	6	33	3
The Emersion, Height of Cap. *Polluc.*	43	46	8	9	30
End of the true Shadow, Height of *Sirius*	20	47	9	10	0

At Paris; *by M.* Bullialdus. *Ibid. p.* 238.

4. At 5^h^. 12′. in the Evening, in the *Royal Observatory*, they began to perceive that the Oriental Part of the Moon, by little and little lost its Light; so that at 5^h^. 25′ they saw a manifest *Penumbra:* Then at 5^h^. 32′. 50″. the Limb over-against the Spot called *Hevelius* grew so dark that they all agreed that this was the true *Beginning* of the *Eclipse.* At 8^h^. 7′. one of the Observers believed the *Emersion*, another at 8^h^. 8′. and the third at 8^h^. 9′. 30″. but afterwards considering the *Emersion* of the first Spots, they all esteemed it at 8^h^. 8′. At 7^h^. 21′. the Southern Limb of the Moon was come close to a Telescopick Star: At 8^h^. 9′. 20″. another Star yet less than the former, came out of the darkest Side, almost over-against the Spot *Langrenus.* At 9^h^. 9′. 40″. all the three Observers agreed, that the Moon then came out of the Shadow. The Diameter of the Moon, being measured before the Eclipse, was of 32′. 15″. *At* Paris; *by M.* Cassini, *M.* Picard, *and M.* Roemer. *Ibid p.* 238. N. 112. *p.* 257.

The Times were noted by great *Pendulum Watches* that had been adjusted by the Sun the same Day, and that were afterwards verified the next Day: Besides that, before the Eclipse, at 4^h^. 45′. 1″. by the Watches, the Star *Capella* was 45 Degrees high towards the East.

Time.

Time.	Phases.
h. ′ ″	
5 32 50	*Beginning* over-againſt the Spot *Hevelius.*
5 36 00	The firſt Spot of *Grimaldi. Palus Maræotis.*
5 36 30	The ſecond Limb of *Grimaldi.*
5 45 00	The middle of *Ariſtarchus. Mons Porphyrites.*
5 46 00	*Merſennus.*
5 48 30	*Herigone.*
5 53 00	*Heraclides.*
5 53 15	The firſt Limb of *Copernicus. Ætna.*
5 54 15	The middle of *Copernicus.*
5 54 40	*Pitheas*, or *Hiera Inſula.*
5 55 05	The ſecond Limb of *Copernicus.*
5 57 40	The firſt Limb of *Timocharis. Corſica.*
5 59 35	The firſt Limb of the *Sinus Medius Æſtuum. Adriatick Sea.*
6 01 30	The middle of the *Sinus Medius.*
6 02 40	The firſt Limb of *Tycho*, or *Sinai:* and the firſt Limb of *Plato*, or the *Lacus Niger Major.*
6 03 50	The ſecond Limb of *Plato*, and the middle of *Tycho.*
6 04 30	The *Center* of the Diſk.
6 09 00	The middle of *Manilius*, or *Mons Beſbicus.*
6 12 00	The middle of *Menelaus*, or *Byſantium.*
6 13 45	*Dionyſius Areop.* or *Mons Amanus.*
6 14 30	*Plinius.*
6 15 45	*Vitruvius.*
6 20 35	*Endymion*, or *Lac. Hyperbor. ſuperior.*
6 21 00	*Promont. Heraclium.*
6 24 50	Betwixt *Alcuin* and *Taruntius.*
6 26 00	The firſt Limb of the *Caſpain Sea. Mare Criſium. Palus Mæotis.*
6 28 15	The middle of the *Caſpian Sea.*
6 29 40	The other Limb of the *Caſpian Sea.*
6 30 5	The firſt Limb of *Langrenus*, or *Inſula Maj.*
6 3 5	The middle of *Langrenus.*
6 35 46	*Total Immerſion*, betwixt *Langrenus* and the *Caſpain Sea.*
8 8 00	Firſt *Emerſion*, towards *Grimaldus.*
8 12 35	The firſt Limb of *Grimaldus.*
8 14 00	The ſecond Limb of *Grimaldus.*
8 20 20	*Merſennus.*
8 24 5	*Herigone.*
8 24 35	The middle of *Ariſtarchus*, and the middle betwixt *Herigone* and *Morin*
8 26 30	The middle of *Kepler*, or *Loca Paludoſa.*
8 28 30	The firſt Limb of *Tycho.*
8 29 50	The ſecond Limb of *Tycho.*

Time.			Phases.
h.	′	″	
8	34	5	The middle of *Copercnius.*
8	35	35	The second Limb of *Copernicus.*
8	36	10	*Pitheas.*
8	36	30	*Heraclides.*
8	40	0	The first Limb of *Timocharis.*
8	42	35	The first Limb of *Plato.*
8	43	45	The second Limb of *Plato.*
8	49	30	The middle of *Manilius.*
8	52	10	*Menelaus* and *Dionys. Areopag.*
8	55	0	*Possidonius.*
8	56	6	*Vitruvius.*
8	59	30	*Endymion.*
9	6	20	The first Limb of the *Caspian Sea.*
9	7	10	The middle of the *Caspian Sea.*
9	8	40	The other Limb of the *Caspian Sea.*
9	9	40	The *End*, between the *Caspian Sea* and *Langrenus.*

5. Through the whole Duration of the Eclipse, with a Tube of 20 Feet, and others better than that, I directed my watchful Eyes to four fixt Stars, neglecting others that were less, (which however I saw very well,) among which the Moon was at that Time. It was distant from the little Star *a* hardly 4 Minuutes, with its lower Limb in Conjunction with it: And the three other Stars *b*, *c*, *d*, the Moon cover'd entirely with her Body. Now of all these four remarkable little Stars, only one of them *e* has been hitherto taken notice of by Astronomers, and inscribed upon the Globes; it is call'd the uppermost of the unform'd Stars between ♊ and ♋, at the Back of *Pollux:* whose Course with its Ingress, Progress, and Egress, is chiefly to be well observed. For from this kind of Observations especially it may be easier to perfect the Theory of the Moon's Motion, and to fix its Nodes and Latitude, than in my Judgment can be done from mere Solar Eclipses. The little Star *b* was cover'd nearly at Mount *Eous*, and *d* at the inferior Limb of the Moon itself. This pass'd through the *Sinus Sirbonis*, the Isle of *Rhodes*, and S. *Atheniensis*, the other through the Desert of *Mingui.*

At Dantzick; *by M.* Hevelius. N. 113. p. 289.

Time.

The Time according to Pend. Clock, correct. by Alt.	*Order Phases*	*The Altitudes of the fixed Stars, with things worthy to be noted.*	*Through what Spots the Sections of the Shadow passed.*
h. ′ ″			
6 22 18		The height of the *Swan*'s Tail 39°. 3′. 0″	
6 25 4		The height of the ſame 41′. 0″.	
6 35 0		Moon enter'd the *Penum.*	
6 41 50		Beginning of the Eclipſe.	It began about 50° from the *Nadir*, towards the Eaſt.
6 43 45	1	It reach'd the *Palus Maræotis.*	Juſt at the Beginning *Sinus Sigaricus*, the Iſlands of *Beſbica* and *Melos* were in one right Line.
6 44 55	2	*Palus Maræotis* quite obſcured.	
6 49 0	3		The Section of the Shadow paſs'd by Mounts *Pentadact.* and *Eous.*
6 52 30	4	*Mons Porphyrites* cover'd.	By the *Loca Paludoſa* and M. *Cataract.*
6 57 35	5		To *M. Baronius*, thro' *M. Petri*, *Athor*, and *M. Troicus.*
7 2 15	6	It began to cover Mount *Ætna.*	To the Bay of *Apollo*, the Iſland *Ficaria*, to the bot. of M. *Ætna*, the Iſl. *Didyma*, and the S. Lake.
7 2 55	7	Mount *Ætna* quite cover'd.	To the Iſle of *Sardinia*, by the Iſles *Hiera* and *Crete.*
7 7 40	8		By the greater *Atlantic* Mountains, the Iſle *Vulcania*, *Rhodes*, and Mount *Ann.*
7 10 40	9	Mount *Sinai* cover'd.	By the Iſles *Ophiuſa*, *Cyprus*, and Mount *Sinai.*
7 14 0	10	The greater black Lake cover'd.	By greater black lake, by the M. *Sipylus*, *Libanus*, and *Seir.*
7 16 40	11		By leſſ. black lake, the Iſle *Beſbica*, Mounts *Olympus* and *Didymus.*

7 20 20	12	The Star *c* was diſtant from the Limb of the Moon towards the Eaſt almoſt 30′.	The Section of the Shadow paſs'd by M. *Carpathus*, *Byzantius*, and *Taurus*.
7 25 0	13		By the Lake *Boryſthenes*, the Iſle *Apollonia*, Mount *Moſchus*, and *Sogdianus*.
7 28 30	14		By the Mountains *Macrocemnios*, *Promontory* of *Aries*, of *Hercules*, by the utmoſt Bay of *Pontus*, and Mount *Parapæmiſus*.
7 32 0	15		By the *Palud. Hyperboreæ*, the Iſle *Corocondametis*, and M. *Caucaſus*.
7 34 10	16		By the *Riphæan* Mountains, the *Palus Mæotis*, and the lower Bay of the *Caſpian* Sea.
7 42 44		The total Immerſion happen'd about 50°. of the Limb from the Zenith towards the Weſt.	
7 55 30		The little Star *a*, in its Conjunction with the Moon, was diſtant from its lower Limb about 4 Minutes.	
8 0 50		The little Star *b* cover'd at Mount *Eous*.	
8 35 20		The little Star *c* enter'd at the Southern Lake.	
8 51 20		The little Star *d* was hid at the lower Limb.	
9 9 10		The little Star *c* emerged again under Mount *Nevoſus*; ſo that it enter'd the Moon at 3′. 20″. It was truly a very pleaſant Sight, to find all theſe very bright, even almoſt under the greateſt Obſcuration, and the M's Conjunction.	
9 12 13		Emerſion of the Moon out of the Shadow happen'd almoſt at 30°. of the M's Limb, from the Nadir towards the Eaſt.	
9 20 20	17		Shadow paſs'd by *Pal. Maræotis*, *Fontes Amari*, and Mount *Eous*.
9 25 0	18		By Mount *Audus*, *Ajax*, and *Troicus*.
9 30 20	19		By M. *Pentadactylus*, *Carpathus*, S. *Sirbonis*, and Mount *Lion*.

9 32 40	20	Mount *Porphyrites* came out of the Shadow.	By Mount *Porphyrites*, *Cassius*, and *Didymus*.
9 36 5	21	Mount *Sinai* began to be illuminated.	By M. *Baron*. at the Isle of *Sicily*, by *Crete*, at the bottom of *Sinai*.
9 42 15	22	Mount *Ætna* under the very Section of the Shadow.	By the Promontory of *Apollo*, M. *Ætna*, by *Rhodes*, and the Mountains of *Seir*.
9 47 10	23		By the Isle *Vulcania*, M. *Masicytus*, *Cragus*, and *Antilibanus*.
9 51 0	24		By the greater black Lake, Bay of *Pastanum*, Mount *Didymus*, and Mount *Coibacaroni*.
9 56 50	25	The Isle *Besbica* came out again into the Light.	By the lesser black Lake, at the Isle *Besbica*, by the Mount^s *Uxerii*.
9 59 35	26		By the Lake *Salmidersa*, M. *Hormi-nium*, *Moschus*, and lake *Thospitis*.
10 5 0	27		By *Pontus*, Isle *Cyanea*, Bay of *Athens*, and Mount *Caucasus*.
10 7 0	28		By Lake *Borysthenes*, at the Isle *Apollonia*, by *Heracleum*, and M. *Tancon*.
10 19 35		The Shadow was not yet quite gone.	
10 20 0		The End of the Eclipse.	
10 23 0		The *Penumbra*.	
10 52 58		Alt. of *Mars*. 37°. 12′	
10 58 35		Alt. Star *Aries*. 28 52	
11 11 33		Alt. of *Capella*. 70 11	

At Seville; *by* S. . . . , *Professor of Mathematicks.* N. 118. *p.* 428.

6. The Observation of this Eclipse was very exact; for the Sun being near the Horizon, by the Latitude of this Place the Minutes were easily found. I observed the rest by my Clock, which that Day did not differ so much as a Minute; so that there is no Room for Doubt in the Observation.

	h.	′	
The Beginning of the true Shadow	4	56	
The Immersion	6	1	
The Emersion	7	33	
The End	8	39	or something longer.

XLV.

XLV. 1. *An Eclipse of the Moon*, June 27. 1675. *at* London; *by Mr.* Flamsteed, *and Mr.* Halley. N. 116. *p.* 371. N. 118. *p.* 432.

	Hour of the Pend. Clock.			*The Phases.*
	h.	′	″	
1	1	1	00	Moon's Diam. 3190 = 31′ 40″.
3	1	11	00	Moon's Diam. 3191 = 31 46 — The Measures were often repeated, both by my self, and my Assistant Mr. *Halley*.
5	1	37	50	No Appearance of the Penumbra; and now the Moon went under some flying Clouds, under which she still lay hid.
6	1	46	40	Till a dense Penumbra appear'd through their Openings, or perhaps the Beginning itself; but I could not be sure.
7	1	51	40	The Moon's Limb being now raised out of the Clouds, was seen to labour under a very notable Defect, a sixth Part, or at least an eighth Part of her Circumference being obscured.
8	1	55	15	*Pentadactylus* was cover'd.
9	2	2	20	*Porphyrites* was cover'd.
10	2	5	30	The first Limb of *Sinai*.
11	2	6	00	The next Limb of *Ætna*.
12	2	8	40	The remaining Parts illuminated were 2071 = 20′. 38″.
13	2	12	00	A small Telescope Star, that was not visible with the lesser Tube, in the greater appear'd to be of almost half the Capacity of the same, or distant 15′ apparently from the lower Limb.
14	2	17	45	The remaining Parts illuminated 1655 = 16′. 27″.
15	2	23	5	The first Limb of *Besbicus*.
16	2	26	3	*Horminius* cover'd.
17	2	29	00	*Æmus* cover'd.
18	2	30	45	The remaining Parts illustrated 1047 = 10′. 24″.
19	2	35	00	The remaining bright Parts 865 = 8′. 38″. And now in the longer Tube another small fixt Star appear'd, being distant from the Limb of the Moon the Long. of the *Casp.* Spot, its Lat. from the line drawn thro' the Cuspids towards the right Hand.
20	2	37	15	The Shadow cover'd the Western Shore of *Pontus*.
21	2	39	30	It touched the first Limb of *Corocondometis*.
22	2	45	00	It touched the *Palus Mæotis*.
23	2	50	45	*Mæotis* was wholly cover'd.
24	2	56	10	Doubtful whether any true Light remain'd.
25	2	56	55	Immersion: For surely the primary Light had intirely left the Moon, for over against, or a little above the *Riphean* Mountains, and about a Deg. of the Limb of *Hevelius* 330, 2ʰ. 57′. 30″. the Limb appear'd thro' the Tube of a kind of Ash-colour.

The Air was very serene from the seventh Observation to the Immersion. And a certain faint whitish Light seem'd to take Possession of the Cuspids of the

the darkned Moon through the whole Time of the Eclipſe, which made the Moon conſpicuous after the Immerſion, on that Side which fell laſt into the Shadow. The Penumbra of this Eclipſe was very thin, nor was its breadth greater than that of *Sinai* or *Ætna*. The *Palus Mæotis* appear'd very broad, and removed as far as it could be from the Limb of the Moon. On the contrary, *Maræotis* was very much contracted, nor farther diſtant from the Moon's Limb than half its Length.

At Paris; *by M.* Bullialdus. *Ibid. p.* 372.

	°	′	h.	′
2. Beginning of true Shadow, *Capella*'s height to Eaſt	18	45	1	55
Shadow reach'd *Palus Mæot. Lyra*'s Alt. to Weſt	50	51	2	55
Total Immerſion, *Lyra*'s Alt. to the Weſt	48	50	3	6

3. *By M.* Caſſini, *M.* Picart, *and M.* Roemer. N. 117. *p.* 388.

Time.			*Tranſit of the Shadow.*
h.	′	″	
1	56	45	The Beginning below *Grimaldus.*
1	57	20	Through the firſt Limb of *Grimaldus.*
1	58	50	The ſecond Limb of *Grimaldus.*
2	1	45	*Galilæus.*
2	2	15	The firſt Limb of *Merſennus.*
2	4	15	The Beginning of *Gaſſendus.*
2	4	40	The middle of *Gaſſendus.*
2	5	30	The other Limb of *Gaſſendus.*
2	6	15	*Herigon* and *Seleucus.*
2	7	45	*Morinus.*
2	8	18	The middle of *Kepler.*
2	11	35	*Ariſtarchus* and *Bullialdus.*
2	12	40	*Ariſtarchus* diſappears.
2	16	25	The Beginning of *Tycho.*
2	16	40	The Beginning of *Copernicus.*
2	17	25	The middle of *Tycho* and *Copernicus.*
2	18	12	The other Limb of *Tycho.*
2	21	45	*Pythea*, and the firſt of the three *Sin. Medii.*
2	24	0	The middle of the ſecond *Sinus Medii.*
2	24	53	*Heraclides* or *Virgo.*
2	26	10	The firſt Limb of *Timocharis.*
2	26	40	The middle of *Timocharis.*
2	31	40	The Promontory between *Virgo* and *Plato.*
2	32	20	*Abulfeda.*
2	34	15	The Beginning of *Manilius.*
2	36	15	*Dionyſius* the *Areopagite.*
2	38	10	The Shore of the Sea of Tranquillity.
2	38	45	The firſt Limb of *Menelaus* and *Plato.*
2	39	20	*Fracaſtor.*
2	39	53	The middle of *Plato.*

2 41

Time.			Tranfit of the Shadow.
h.	′	″	
2	41	15	Through the other Limb of *Plato.*
2	44	15	Promontory between *Conforinus* and *Beda.*
2	50	20	The firft Limb of *Palus Somnii.*
2	50	45	The Horns were vertical.
2	53	55	The beginning of *Langrenus.*
2	55	20	The firft Limb of *Mare Cafpium.*
3	1	10	The other Limb of *Mare Cafpium.*
3	1	45	*Endymion.*
3	3	15	*Mefhala.*
3	7	45	End, or tot. Immerf. above *Mare Cafpium.*

The *Cafpian* Sea was then diftant from the Weftern Limb about $\frac{3}{4}$ of its Breadth. After the total Immerfion the whole Body of the Moon was ftill diftinguifhable.

XLVI. 1. *An Eclipfe of the Moon,* Decemb. 22. 1675. *at* Greenwich ; *by Mr.* Flamfteed. N. 121. *p.*435.

Correct. H. of the Clock			Phafes.
h.	′	″	
2	29	30	Between the Cufpids 2085 = 17′. 16″.
2	55	45	The Shadow almoft touch'd *Hæmus.*
3	0	30	It had certainly touch'd *Hæmus.*
3	11	30	The right Cufpid from *Maræotis* 1235 = 10′. 14″.
3	35	0	The lucid Parts were about 2800 = 23°. 11″. or perhaps fomething more ; for it was very difficult to diftinguifh the Limits of the true Shadow, becaufe the Air was foul with Vapours.
3	42	30	The Shadow near *Macra.*
3	52	45	Between the Cufpids about 2288 = 18′. 57″.
4	7	15	The End : For the Limb appear'd, and there feem'd nothing to be wanting in the Roundnefs of the Moon.
4	8	0	The Limb very plainly feen through the Tube.
4	15	30	The Penumbra, which to the naked Eye refembled an Eclipfe.
4	19	30	The Diameter of the Moon taken 3757 = 31′. 5″. but not much confided in, tho' I think it not far from Truth.
4	23	0	Still and afterwards, the Limb forfaken by the Eclipfe feem'd fomething obfcure, and as it were another Eclipfe.

The Diftance of *Corfica* from the remote Limb of the Moon 2732=22′. 37″.
Its neareft Limb from the neareft of the Moon 1045 = 8′. 39″.
The remoter Limb of *Sinai* from the neareft of the Moon 599=4′. 58″. good.
The Middle of the greater black Lake from the neareft Limb 452=3′. 45″.

I took notice besides, that the Shadow always appear'd far more distinct at the Horns than elsewhere, in the Face of the Moon. In the first Observation, or a little before, the Horns were parallel to the Horizon.

Then also *Porphyrites*, and the greater black Lake, were equally out of the Shadow, about the Length of *Marœotis*.

Yet it never went beyond *Porphyrites* in this Eclipse, yet I saw it deeply immersed in the Penumbra.

In the Height of the Eclipse the Shadow almost reached *Corsica*; yet I never saw it extinct, but immersed so deeply in the Penumbra, that I could hardly perceive it.

Neither did the true Shadow ever go over the Isle *Macra*, but only a dense Penumbra, through which it was difficult to see it.

At $4^h. 5\frac{1}{2}'$. I could not see the Limb, nor at $4^h. 6\frac{1}{2}'$. But at $4^h. 7'$ I thought I saw the Light of the Limb very faint, but with much Difficulty. At $4^h. 7'. 15''$. I was sure it had emerged out of the Shadow, nor was any thing wanting to its Roundness. Therefore there I placed the End.

The Shadow went out near the upper *Lacus Hyperboreus*, the Penumbra remaining, which exhibited the Eclipse to the naked Eye as far as $4^h. 15\frac{1}{2}'$. But the Limb left by the Eclipse recover'd the Brightness of the other Limb not till $4^h. 28'$. or later.

The Times of the Phases were corrected by the Altitudes of *Arcturus*, and the bright Star of the Crown, taken by a Telescopic Quadrant of above three Feet Radius. To the taking of which Altitudes I apply'd my self, whenever the Clouds came over the Moon, Those Stars sometimes shone out very bright in the other Quarter of the Heavens.

At London; *by Mr.* Edm. Halley. *Ibid. p.* 493.

2. The Eclipse was begun before I came to my Instruments. But this was observed at *London* in *Winchester-street* by Mr. *Halley*, when the upper Limb of the Moon was distant from the Vertex.

	° ′		h. ′
	39 51	whence he reckon'd the Hour	2 16
from the same	41 1	The Horns parallel to the Horizon	2 25
	54 12		3 58

By Mr. Colson. *Ibid.*

3. *John Colson* at *Wapping*, near the *Hermitage*, saw the Limb of the Moon something deficient at $2^h. 17\frac{3}{4}'$. But at $4^h. 9'. 25''$. he found it had come out of the true Shadow, and that there was only a dense Penumbra remaining.

At Paris; *by M.* Cassini. N. 123. *p.* 561.

4. In this Eclipse two of the chief things have been exactly determin'd by us, that is, the middle Time of the Eclipse, and its Magnitude. The middle is deduced not only from a Comparison of the Beginning and End, but also of two equal Phases, which are very easily determin'd, that is, when the Distance of the Horns was equal to the Semidiameter of the Moon, taken before the Eclipse, $15' 28''$. That is, when the beginning of the Eclipse was estimated at $2^h. 24'. 35''$.

	h. ′ ″
End of the total Eclipse, a like Penumbra being left as was in the Determination of the Beginning	4 15 25
The Duration of the whole Eclipse comes out	1 50 50
The Half	0 55 25
And the middle of the Eclipse	3 20 0
A sixth Part of the Circumference is cut off	2 38 5

	h. ′ ″
And again	4 2 25
The Interval	1 24 20
The Half	42 10
Hence the middle of the Eclipse	3 10 15

Agreeing to the former Determination within a fourth part of a Minute.

We agree entirely with Mr. *Flamsteed* in the Situation of the Shadow, and the Magnitude of the Eclipse. For it is observed by both of us, the Shadow never went beyond *Porphyrites*, tho' it was deeply immersed in the Penumbra.

Next to *Porphyrites* is a little whitish Mountain, which we then call'd the *Companion of Aristarchus*, because it is hardly distant from *Porphyrites* its own Diameter. That little Mountain was immersed in the Shadow at $2^h. 51'. 15''$. And it emerged at $3^h. 8'. 25''$, and all the Time between was in the Shadow next to *Porphyrites*.

We both of us observed also, that in the Height of the Eclipse the Shadow almost reached to *Corsica*, yet it was never cover'd by it, but a small Distance was left; the Distance of which Limit being taken from the nearest Limb of the Moon was $8'. 17''$. Whereas *Flamsteed* found the Distance of the Island itself a little more remote from the same Limb, to be $8'. 39''$. We also observed the Island *Macra*, or rather *Peninsula*, to be very long adjacent to both the Shadows. We took notice this begun at $3^h. 28'. 15''$. and that it continued at the same Distance for a quarter of an Hour.

5. By *M.* Bullialdus. N. 125. p. 610.

Capella *dist. from the Vert.*		*Phases.*	*Mean Time.*		
°	″		h.	′	″
39	36	The Penumbra thin.	2	6	12
40	42	The Penumbra more dense.	2	12	7
42	30	Sensible Begin. over against *Sinus Hyperb.* about 70°.	2	23	32
42	50	Almost $\frac{1}{8}$ of a Digit.	2	25	48
44	25	The Shadow touch'd the lesser *Atlas.*	2	36	11
47	28	The Shadow a little above *Baronius*, above *Ligustinus*, it had seized *M. Macr.*	2	56	27
48	56	The Shadow had almost reached *Catena Mundi.*	3	6	22
49	54	The Shadow touch'd *Montunial.*	3	12	54
50	30	Touch'd *Sin. Peront.* M. *Pyra*, and middle of *Pal. Hyper.*	3	17	41
52	7	It seiz'd *Sinus Sagaricus*, and *Peronticus*, and the Promontory of the Moon.	3	29	1
54	52	*Leucopetra* was out of the Shadow.	3	48	2

55 40

55	40	*Sinus Peronticus* out of the Shadow	3 54 6
55	48	*Sinus Sagaricus* out of the Shadow.	3 55 12
56	17	*Sinus Cercinites* was almoſt emerged.	3 58 29
57	16	Part under Shad. equal almoſt to breadth of *Pal. Mæot.*	4 5 38
58	30	The End over againſt Mont. *Macr.* about g. 355.	4 13 59
59	6	Penumbra.	

The Shadow did not reach *Corſica*, nor *Lacus Thraſymenus*; wherefore the Eclipſe did not exceed 3 dig. 30′. or rather leſs. The Beginning was ſooner by a Minute or 45″ than what is ſet down, ſo that it may be fixt more exactly at 2^h. 22′. 30″. Hence the whole Duration exactly enough was 1^h. 51′. 24″. So that the greateſt Obſcuration happen'd at 3^h. 18′. 14″.

6. *At* Strasburg; *by M.* Richelt. *Ibid.*

Alt. of Arctur.		*Mean Time.*			*Phaſes.*
°	′	h.	′	″	
30	30	2	48	48	Beginning.
36	0	3	20	8	Shad. thro' *M. Porphyrites*, and Promont. of the Moon.
39	50	3	45	44	The Shadow ſkim'd by *Lacus Thraſymenus*, Mount *Baronius*, and *Sinus Cercinites.*
44	15	4	13	20	Shadow paſs'd by Promont. of the Moon, and *M. Cimmerius.*
46	25	4	27	36	Shadow touch'd the leſſer black Lake, and M. *Carparthus.*
48	30	4	41	44	It ended in the middle Region of *Sinus Hyperboreus.*

Therefore the whole Duration was 1^h. 52′. 56″.

At Dantzick; *by M.* Hevelius. N. 124. *p.* 589.

7. In this Eclipſe it is to be well obſerved, that all the Sections never intirely cover'd Mount *Porphyrites*, but it remain'd perſpicuous in the very Limit of the Shadow, even in the greateſt Obſcuration.

Time

Time correct. by Alt.	Altitudes of the fixed Stars.		Order of Phaſes.	Through what Spots the Sections of the Shadow paſs'd.
h. ′ ″	° ′			
2 28 38	26 12	Right Should. *Orion.*		
2 33 20	25 35	The ſame.		
2 36 40		Begin. of the *Penum.*		At Mount *Baronius.*
3 8 10				The *Penumbra* more denſe.
3 16 35				The *Penumbra* denſe.
3 24 20				The *Penumbra* very denſe.
3 30 0		Begin. of Eclipſe.	1	At the Bay of *Apollo.*
3 36 25			2	By M. *Alabaſt.* and *Sin. Hyperb.*
3 42 5			3	At *Apollo*'s Bay.
3 46 30			4	By M. *Baronius* and the greater black Lake.
3 52 10			5	By the Iſle *Ophiuſa.*
3 59 15			6	At M. *Porphyr.* & leſſ. blac lake
4 7 45		Star diſtant from the Limb 36′ or 40′.	7	By M. *Porph.* and M. *Serr.*
4 11 45			8	By M. *Porph.* Promont of the Moon, and M. *Carpath.*
4 18 5			9	By the Iſle of *Corſica*, M. *Arg.* and Mount *Macroceran.*
4 26 0			10	By M. *Porphyrit.* and *Lac. Threſim.*
4 56 20			11	At *Apollo*'s Bay, *Mons Chriſti*, and *Inſul. Macra.*
5 55 28	32 33	Brt. Star of the harp.		
5 57 33	32 50	The ſame.		
5 59 0				The Penumbra.
6 8 0				Penumbra vaniſh'd, as well as we could gueſs by the Clouds.

XLVII. *An Eclipſe of the Moon, Oct. 29. (St. N.) 1678. At Paris; by M. Caſſini.* N. 141. p. 1015.

The Phaſes of the Moon, and of the Spots, as determined by Ricciolus.	*In the Royal Obſervatory.* Below.	*In the Royal Obſervatory.* Above.	*In the College of Clarmont.*
	h. ′ ″	h. ′ ″	h. ′ ″
The Shadow begins.	6 43 30	6 43 40	6 43 54
The ſubſequent Limb of *Grimaldus.*	6 45 0		6 45 29
Galilæus.	6 46 0	6 46 0	
The End of *Galilæus.*	6 47 0		

	h.	′	″	h.	′	″	h.	′	″
Mersennus.	6	48	20						
The Chord of the Eclipse was 6 dig.				6	49	00			
The Beginning of *Gassendus.*	6	50	50	6	50	50			
The middle of *Gassendus.*				6	51	30	6	51	37
The Beginning of *Schikard.*	6	51	43						
11 Dig. Eclip.				6	52	00			
The Beginning of *Aristarchus.*	6	52	50						
The middle of *Aristarchus.*				6	53	10	3	56	7
The End of *Aristarchus* and *Morinus.*	6	54	00						
Capuanus, or the Dragon's Eye.	6	56	00						
III. Digits.				6	56	30			
A Chord of 9 Digits.				6	57	00			
The Begin. of *Terra Pruina* and *Copernicus*	6	58	54						
The Beginning of *Copernicus.*				6	59	10			
The middle of *Copernicus.*	7	00	00	7	00	00	6	59	30
The end of *Copernicus.*	7	00	55	7	00	55			
The beginning of *Pitheas.*	7	1	50	7	1	40			
The end of *Pitheas.*	7	2	30						
The Virgin's Head.	7	2	45	7	2	40	7	3	18
Harpalus.	7	2	55						
The beginning of *Tycho.*	7	4	20	7	4	20			
The middle of *Tycho.*	7	5	00				7	5	48
The end of *Tycho.*	7	5	55						
Eratosthenes.	7	6	20						
V. Digits.				7	6	50			
The Promont. between the Virgin and *Plato.*	7	7	00						
The Island in the farthest of the *Sinus Medii.*	7	7	30						
A bright Spot following *Tycho.*	7	8	31						
VI. Digits.				7	11	20			
Tymocharis.	7	11	48						
The beginning of *Plato.*				7	13	20	7	13	29
The middle of *Plato.*				7	13	40			
The end of *Plato*, and the begin. of *Manilius.*	7	14	00						
The end of *Plato.*				7	14	40			
Manilius.				7	14	50	7	15	4
The end of *Manilius.*	7	15	12						
The beginning of *Dionysius.*	7	17	15						
Dionysius.				7	17	25			
Menelaus.				7	18	10	7	17	59
The end of *Dionysius*, and begin. of *Menelaus.*	7	18	28				7	18	11
Pliny begins.	7	20	56						
Pliny.				7	21	10	7	21	51
Picolomineus, or the bri^t Spot above the Ring.	7	21	30						
The beginning of *Fracastoreus* or the Ring.	7	23	00	7	23	5			
The beginning of *Possidonius.*	7	23	55				7	24	38
The end of *Fracastoreus.*	7	24	25						

The

	h. ′ ″	h. ′ ″	h. ′ ″
Bright Spot before the Angle of the acute Promontory		7 24 35	
The Angle of the acute Promontory	7 25 10		
IX Digits		7 26 10	
Palus Somni	7 28 00		
The beginning of *Endymion*	7 29 20		
The beginning of *Taurentius*	7 30 30		
Angle of the horns with the Parallel 77° 15′.		7 30 40	7 31 16
The beginning of *Hermes*	7 31 5		
End of *Taurentius*, or of the Serpent's Head	7 31 40		
The end of *Hermes*	7 32 00		
Proclus	7 32 20		
The Limb of *Mare Caspium*	7 32 29	7 33 3	7 33 10
The lower Spot	7 33 5		
The beginning of *Langrenus*	7 34 24		
Messala	7 34 40		
The end of *Langrenus*	7 35 40		
The *Peninsula* in *Caspia*	7 37 50		
The end of *Caspia*	7 37 50	7 37 50	7 38 18
An oblong Spot	7 39 16		
The end	7 40 41	7 41 00	7 41 28
The beginning of the Emersion	9 21 30	9 21 30	9 21 5
Grimaldus	9 22 44		9 22 10
The end of *Grimaldus*	9 23 40	9 23 40	
Galilæus	9 24 35		
The Sea of *Humours*	9 28 15		
The middle of *Schikard*	9 29 00		
The beginning of *Aristarchus*	9 29 44		9 29 41
The middle of *Aristarchus*		9 30 20	
The whole of *Aristarchus*	9 30 25		
The whole of *Gassendus*	9 31 00		
The beginning of *Kepler*		9 31 40	9 31 6
The whole of *Kepler*	9 32 24		
Morinus	9 30 00		
The end of the Island of *Kepler*	9 34 22		
The whole of *Capuanus*	9 34 40		
The beginning of *Terra Pruina*	9 35 43		
Virgo	9 37 00		
Golden Spot between *Pitheas* and *Kepler*		9 37 20	
Harpalus, & the bright spot before *Copernicus*	9 37 34		
III Digits		9 37 40	
Bullialdus	9 38 30		
The beginning of *Copernicus*		9 39 00	9 38 36
The beginning of *Tycho*	9 40 00		9 40 22
The whole of *Copernicus*	9 40 18		
Pitheas		9 40 30	

Tt 2 The

	h. ′ ″	h. ′ ″	h. ′ ″
The middle of *Tycho*	9 41 00	9 41 10	
The end of *Tycho*		9 42 20	
IV Digits		9 42 40	
The whole of *Timocharis*	9 45 30		
Plato begins		9 45 30	9 45 00
V Digits		9 47 00	
The whole of *Plato*	9 45 00	9 47 30	
The Iſland under *Sinus Medius*	9 50 00		
The end of *Sinus Medius*	9 50 50		
Archimedes	9 51 37		
VI Digits		9 52 00	
Manilius		9 54 00	9 53 52
Fretum	9 54 22		
The beginning of *Abifeldea*	9 54 40		
The end of *Abifeldea*	9 55 30		
The whole of *Ariſtotle* and *Eudoxus*	9 56 00		
VII Digits		9 56 20	
The beginning of *Dionyſius*	9 57 12		
Menelaus	9 57 50	9 57 40	9 57 16
The middle of *Dionyſius*		9 58 30	
The whole of *Menelaus*	9 59 00		
The whole of *Dionyſius*	10 00 00		
VIII Digits	10 1 30		
The Mouth of *Lacus Mortis*		10 2 00	
Pliny.		10 2 15	10 1 28
The Promontory above *Dionyſius*	10 3 00		
The end of *Pliny*	10 3 40		
Poſſidonius		10 5 30	
The Acute Promontory	10 6 00		
Hermes		10 6 15	
IX Digits		10 9 30	
The Chord of the Shade of 8 Digits	10 11 00		
Meſſala	10 13 30	10 12 10	10 11 30
The beginning of the *Caſpian Sea*	10 16 00		
The whole of *Langrenus*		10 14 00	
A Chord of 6 Digits		10 16 50	10 16 44
The firſt end of the *Caſpian*	10 17 33	10 17 25	
The other end of the *Caſpian*	10 18 15		
The Whiteneſs in the *Caſpian Sea*	10 20 00	10 20 10	10 20 42
The total End			

XLVIII. 1. *An Eclipse of the Moon, Aug. 19. m. 1681. at* Greenwich; *by Mr.* Flamsteed. *Ph. Coll. N.* 3. *p.* 67.

Time by the Pendulum Clock.	*Time corrected by Observat.*	*Observations.*
h. ′ ″	h. ′ ″	
1 5 00	1 00 00	The Moon's Diameter 6191 = 30′. 53″.
1 46 30	1 41 30	The Penumbra obſervable.
1 53 40	1 48 40	The Penumbra denſe.
1 55 40	1 50 40	The beginning.
1 58 00	1 53 00	The Shadow at Mount *Climax.*
2 3 20	1 58 20	*Sinus Sirbonis* begins.
2 5 50	2 00 50	*Lacus Maræotis* begins.
2 7 30	2 2 30	*Mons Cataractes* begins.
2 8 16	2 3 16	*Maræotis* wholly cover'd.
2 10 50	2 5 50	*Sinai* begins.
2 12 56	2 7 56	*Sinai* wholly cover'd.
2 18 00	2 13 00	*Audus.*
2 27 24	2 22 24	*Circinna.*
2 31 00	2 26 00	*Abulfeda* according to *Ricciolus.*
2 32 30	2 27 30	*Pentadactylus* begins.
2 33 32	2 28 32	The firſt Limb of *Ætna.*
2 34 26	2 29 26	The whole of *Pentadactylus.*
2 35 6	2 30 6	The middle of *Ætna.*
2 36 00	2 31 00	*Ætna* wholly cover'd.
2 40 00	2 35 00	The Shadow thro' the middle of *Porphyrites.*
2 44 50	2 39 50	Iſle *Hiera* and *Ficaria* together at the Shadow.
2 46 10	2 41 10	The Shadow at *Horminius.*
2 50 10	2 45 10	*Mons Hercules* begins.
2 51 10	2 46 10	*Mons Hercules* within the Shadow.
2 52 10	2 47 10	The Shadow through the middle of *Besbicus.*
2 54 00	2 49 00	Through the middle of *Inſula Major.*
2 55 30	2 50 30	Through the middle of *Bizantium.*
2 57 40	2 52 40	Through the middle of the Iſle *Cyanea.*
3 1 50	2 56 50	At the firſt Limb of *Corocondometes.*
3 4 30	2 59 30	At the firſt Limb of *Mæotis.*
3 13 00	3 8 00	*Macra* begins to be obſcured : Doubtful.
3 14 00	3 9 00	*Mæotis* wholly cover'd.
3 19 12	3 14 12	The remaining lucid parts were 1092=5′. 27″.

2.
At Paris *; by M.* Cassini. *Ibid. p.* 66.

Digits eclipsed.	*Phases.*	*Time.*
d. ′ ″		h. ′ ″
	The *Beginning* at	1 58 30
	The Arrival of the Shadow at *Grimaldus*	2 1 30
	At *Tycho*	2 8 00
	At the Center of the *Moon*	2 37 30
	At the middle of *Copernicus*	2 39 30
	At *Aristarchus*	2 40 00
8 16 00	At the middle of *Manilius*	2 54 30
	At *Plinius*	3 1 00
9 2 00	At the lower part of the *Caspian Sea*	3 7 30
9 31 20	At the upper side of the *Caspian Sea*	3 18 30
10 1 00	The *greatest Obscurity*	3 55 45
4 46 00	The *Return* of the Shadow to *Aristarchus*	3 47 00
	To the Center of the *Moon*	4 29 00
	To *Tycho*	4 41 30
	The *End* of the *Eclipse*	5 13 00
	The *Whole Duration*	3 14 30

At 5h. 13′ 56″. the *Apparent Altitude* of the upper edge of the *Sun*, was 17′. 10″. and that of the *Moon*, 1°. 11′. 30″.

3.
At Dantzick *; by M.* Hevelius. N. 5. *p.* 160.

Time by the Clock.	*Phases.*	*Altitudes.*	*Time corrected.*
h. ′ ″		° ′	h. ′ ″
1 1 03	The Altitude of the Bull's Eye	24 14	1 4 48
2 4 30	The same Altitude	32 58	2 6 32
2 9 00	Taken again	33 30	2 10 32
2 45 00	The Track of the Penumbra		2 46 30
2 53 00	Penumbra something denser		2 54 00
2 59 00	Still more dense		3 00 00
3 1 00	Now very dense		3 2 00
3 2 00	The beginning of the Eclipse		3 3 00
3 6 00	The first Phasis		3 6 30
3 12 00	The second Phasis		3 12 30
3 14 00	The third Phasis		3 14 30
3 20 00	The fourth Phasis		3 21 00
3 22 30	Mount *Sinai* wholly cover'd		3 23 00
3 29 00	The sixth Phasis		3 30 00
3 43 00	The Altitude of *Pollux*	30 00	3 43 00
5 2 00	The Center of the Sun arises		

The Colour of this Eclipſe was Aſh-colour, or duſky. At the Time of Obſervation *Mons Porphyrites*, and Mount *Ætna* were nearly in the ſame Perpendicular.

Phaſes I. The Shadow paſs'd over Mount *Eous.*

II. It came to the Lakes of *Arabia.*

III. It touch'd the lower Bank of *Palus Maræotis*, and the Extremity of *Sinus Sirbonis.*

IV. It paſs'd over the Iſland *Letoa* as far as M. *Sinai*, but the whole Mountain was yet viſible and uncover'd.

V. It ſeem'd to paſs over *Sinus Syrticus*, ſo that the Shadow now cover'd all Mount *Sinai.*

VI. It went above *Sinus Syrticus*, beyond the Iſland *Crete*, and over *Mare Mortuum.*

An Eclipſe of the Moon, Feb. 11. 1682. *by Mr.* Flamſteed. N. 145. *p.* 89.

XLIX. 1. *An.* 168½. *Feb.* 11. Hour 8. 1′. with a Tube of 16 Feet I took the Moon's Diameter 6702 = 33′. 25″. Then the Diſtance of its neareſt Limb from the neareſt Limb of *Maræotis* 145 = 0′. 43″. But the Diſtance of the Limb of the ſame Spot from the remoter Limb of the Moon was 6575 = 32′. 48″. Alſo by the Help of the ſame Tube I obtain'd the Times, when the Obſcuration reach'd the Center of the Moon, and when the Radius ſubtended its Arches in the Periphery that were either deficient or after they were reſtored: From whence the middle may be derived, perhaps not leſs accurately, than from the compared Obſervations of the Beginning and End, the Immerſion and Emerſion.

Phaſes.

Phases.	The Times of the Phases corrected by Pendulum Clocks.		
	Observat. in Greenwich		At London
	By myself.	By Halley.	By Haines.
	h. ′ ″	h. ′ ″	h. ′ ″
Famus at the lower Limb; by our naked Eyes	8 48 38		
The Shadow - - - - - - - - - -	9 4 8		
A dense Penumbra - - - - - - - -	9 11 44		
The Beginning - - - - - - - - - -	9 12 32	9 13 04	9 12 18
The middle of *Palus Marœotis* cover'd	9 14 02		perh.soon.
The whole of *Marœotis* cover'd - -		9 14 39	9 13 48
A sixth part of the Periphery was obscured	9 18 10		
Circinna within the Shadow - - - - - -	9 20 10		
The middle of *Porphyrites* - - - - -		9 21 1	
The Shadow skims by *Syrbo* - - - - -		9 21 9	
First Limb of *Mons Cataractes*, or of *Gassendus*	9 21 32		
The Eye of the Dragon - - - - - - -	9 27 58		
It skim'd by the nearer limbs of *Crete* and *Ætna*	9 28 22	9 28 44	9 28 19
Mount *Ætna* wholly cover'd; *Hiera* begins	9 29 48	9 30 16	9 30 12
Hiera wholly cover'd - - - - - - - -		9 30 44	
The Beginning of *Corsica* - - - - - -	9 33 46		
The middle of *Corsica* - - - - - - - -		9 34 48	
Mount *Sinai* begins - - - - - - - -	9 36 38	9 37 10	9 36 20
The middle of *Sinai* - - - - - - -	9 37 22		
All *Sinai* cover'd - - - - - - - - -	9 38 04	9 38 10	9 38 20
The Center of the Moon, or 6 Digits	9 38 48		
The greater black Lake begins - - -	9 39 58	9 40 36	
The middle of the greater black Lake			9 40 48
The whole is cover'd - - - - - - -		9 41 40	
The beginning of *Besbicus* - - - - - -		9 43 48	
The middle of *Besbicus* - - - - - - -	9 43 42		9 44 13
Whole of *Besbicus*, it glides by the *Euxine* Sea		9 44 36	
Byzantium begins - - - - - - - - -	9 46 58		
Horminius begins - - - - - - - - -	9 47 22		
Carpathes - - - - - -	9 47 50		
Mons Serrorum - - - - -	9 48 30		
Apollonia - - - - - -	9 50 24	9 51 21	
Macra - - - - - -	9 52 44	9 53 33	
Mount of *Hercules* - - - - - -	9 54 26		
All *Macra* cover'd - - - - - -		9 54 53	
All Mount *Hercules* cover'd - - -		9 55 33	
Corocondometes Palus - - - - -	9 59 10		
Thro' the middle of the upper *Lacus Hyperbor.*		9 59 53	
Corocondometes wholly cover'd - - - -	10 00 38		
The Shadow over Mount *Corax* - - - - -		10 1 17	
It glides by *Mæotis* - - - - - -	10 2 20	10 2 38	

Through

	h.	′	″	h.	′	″	h.	′	″
Through the lower *Lacus Hyperboreus*				10	3	53			
Through the middle of *Inſula Major*	10	5	14						
Lacus Mæotis almoſt wholly cover'd	10	6	54	10	8	00	10	6	48
A ſixth part of the Periphery, the reſt bright	10	7	28						
Immerſion	10	10	14	10	10	11	10	9	48
Emerſion	11	47	38	11	47	9	11	47	48
A ſixth part of the Periphery illuminated, with the firſt Limb of *Maræotis*	11	50	02	11	50	7			
The middle of *Maræotis*	11	50	42				11	50	48
All *Maræotis* illuminated	11	51	6	11	50	58			
The Shadow thro' the middle of *Porphyrites*	11	52	50						
All *Porphyrites* cover'd	11	53	34				11	52	54
All *Circinna*	11	58	18						
It glides by the *Sinus Sirbonis*				11	58	59			
Cataractes Sirbonis, or all *Gaſſendus*	12	1	00						
Hiera begins				12	3	14			
Ætna begins to emerge	12	3	20						
Thro' the middle of the greater black Lake							12	3	48
Through the middle of *Ætna*				12	4	19			
Ætna wholly uncover'd	12	5	18	12	5	4	12	5	45
Crete is illuminated	12	7	34						
Sinai begins	12	13	38				12	13	43
The middle of *Sinai*	12	14	28	12	14	12			
All *Sinai*	12	15	34	12	14	55			
The middle of *Beſbicus*	12	17	34				12	17	48
The Center of the Moon, 6 Digits uncover'd	12	18	28						
Thro' the middle of the upper *Hyperborean* lake				12	19	5			
The Shadow thro' the middle of *Bizantium*							12	20	18
Bizantium without the Shadow	12	20	50	12	20	25			
All *Macra*				12	22	36			
All the *Inſula Apollonia*, and *Horminius*	12	24	24	12	24	16			
The lower *Lacus Hyperboreus*				12	26	6			
Mount *Hercules*				12	30	56	12	31	18
The middle of *Corocondometes* at the Shadow	12	31	38						
Mons Corax				12	32	37			
Mæotis begins to be enlightned	12	33	18				12	32	18
Mæotis wholly uncover'd				12	37	57	12	38	3
A ſixth part of the Periphery, the reſt obſcure	12	39	6						
The Middle of the greater Iſland of the *Caſp.* Sea				12	41	22	12	42	18
The whole Iſland uncover'd	12	42	18						
The End doubtful	12	45	10				12	44	48
The End certainly	12	45	38	12	44	35	12	45	18

During the Eclipſe Mr. *Halley*, together with *Thomas Smith*, took the following Diſtances of the Moon from the fixed Stars with a Sextant.

Times correct. by the Clock.	*Obſervations.*	*Diſtances.*
h. ′ ″		° ′ ″
8 53 07	Of the remoter Limb of the Moon from *Regulus*	8 05 20
8 55 07	Repeated	8 06 20
9 2 34	Of the remoter Limb of the Moon from the bright Star in the Lion's Side	14 58 15
9 4 18	Repeated	14 57 55
9 8 42	Of the remoter Limb of the Moon from *Regulus*, again	8 12 50
	The Moon being intirely immerſed in the Shadow, Mr. *Halley* with me.	
10 19 21	Of the neareſt Limb of the Moon from *Regulus*	8 13 30
11 38 06	Of the remote Limb from *Regulus*	9 23 50
11 41 48	Repeated	9 25 35
	And when the Eclipſe was over,	
12 52 00	Of the remoter Limb from *Regulus*, again,	9 58 20
12 55 10	Once more	10 00 00

Phaſes

2. *At Paris, and Copenhagen.* N. 146. p. 145.

Phases.	At *Paris.* In the Royal Observatory. By *Cassini.*	At *Paris.* In the Royal Observatory. By *Picard* and *De la Hire.*	At *Copenhagen.* College of Clarmont. By Father *de Fonteney*	At *Copenhagen.* By *Roemer.* A reduction of Meridians being made, subt. 41′. 40″.
	h. ′ ″	h. ′ ″	h. ′ ″	h. ′ ″
The Beginning	9 20 55	9 21 58	9 21 25	9 21 50
The middle of *Aristarchus*	9 29 57	9 29 33	9 29 28	9 29 50
The middle of *Copernicus*	9 38 45	9 38 25	9 38 40	9 38 48
The Beginning of *Tycho*	9 45 52	9 45 48	9 45 48	9 46 20
The end of *Tycho*	9 47 40	9 47 36	9 47 20	9 47 50
The Beginning of *Plato*	9 49 47	9 49 08	9 49 25	9 49 50
The Center of the Moon		9 51 10		9 50 20
The Center from a Comparison of the beginning and end	9 50 24	9 50 44	9 50 10	9 50 30
The middle of *Manilius*	9 53 16	9 53 30	9 51 18	9 53 20
Menelaus	9 56 43	9 56 20	9 56 14	9 56 20
Dionysius	9 57 09	9 57 40		9 57 20
The Acute Promontory	10 04 31	10 04 15	10 04 12	10 04 20
The Beginning of *Caspia*	10 11 40	10 11 25	10 11 20	10 11 50
The End of *Caspia*	10 16 27	10 16 30	10 15 50	10 16 20
The Moon intirely immersed	10 19 53	10 19 30	10 18 55	10 19 50
The Beginning of Emersion between *Grimald.* and *Galilæus*	11 57 51	11 56 00	11 58 00	11 55 20
The middle of *Aristarchus*	12 02 00	12 01 55	12 03 09	12 01 50
The middle of *Plato*	12 12 06	12 12 10	12 13 26	12 12 20
The middle of *Copernicus*	12 14 32	12 14 30	12 14 29	
The middle of *Tycho*	12 23 35	12 23 55	12 24 21	12 23 20
The Center of the Moon		12 25 50		12 26 20
The Center by Comparison of the Emersion of the Limbs	12 26 09	12 25 15	12 26 08	12 24 50
The middle of *Manilius*	12 26 22		12 26 20	12 26 20
The middle of *Menelaus*	12 29 08	12 29 20	12 29 22	12 29 05
Dionysius	12 32 30	12 33 15	12 32 20	12 32 50
The Acute Promontory	12 39 45	12 39 50		12 39 50
The Beginning of *Caspia*	12 41 53	12 41 30	12 41 11	
The End of *Caspia*	12 47 15	12 46 30	12 48 20	12 47 20
The end of the Eclipse	12 54 27	12 54 30	12 54 17	12 54 20

3.
At Dantzick; *by M.* Hevelius. *Ib. p.* 146.

Time by the Watch	Order of Phases.	Digits eclipsed	Altitudes of the Stars.	By what Spots the Sections of the Shadow pass'd, and what was observed besides.	Time corrected by Altitudes.
h. ′ ″			° ′		h. ′ ″
8 41 18			Bull's Eye 39 53		8 40 46
8 44 9			Again 39 27		8 44 20
8 48 14			Again 39 0		8 47 59
10 8 28				Begin. Penumbra very dilute.	10 9 0
10 12 50				The Penumbra more dense.	10 13 20
10 19 5				The Penumbra still thicker.	10 19 36
10 23 50				The Penumbra very dense	10 24 24
10 24 30				Begin. Eclipse about 150° of the Limb, or 95° from the upper point of perpendicular Line of 90th Deg. towards the East.	10 25 5
10 29 45	1	1¼ Dig.		It proceeded by M. *Germanician* to *Mare Syrticum* and M. *Acabe.*	10 30 30
10 32 13	2	2 almo.		By M. *Porphyr. Loca Paludosa,* Isle *Circinna, Sin. Syrticus,* over M. *Sacer,* and *Mare Caspium.*	10 32 50
10 36 30	3	2½ alm.		By M. *Baron.* the Isle *Æthusa,* thro' the middle of *Sin. Sirbonis,* and Mount *Pharan.*	10 37 10
10 43 25	4	3⅝		Thro' bay of *Apollo,* M. *Ætna,* the Isle *Letoa,* to Isle *Didyma.*	10 44 10
10 47 25	5	4⅝ Dig.		To Isles *Majorca, Vulcania, Lemnos, Carpathia,* and M. *Horeb.*	10 48 15
10 52 20	6	5¾		To the greater black Lake, by M. *Argentariusa, Sipylus, Masicytus; Tabor, Sinai,* and the Desert of *Raphidim.*	10 53 10
10 55 45	7	6½		By the *Hyperborean* Rocks, Isle *Besbica,* M. *Olympus, Didymus,* and M. *Antilibanus.*	10 56 40
11 0 33	8	7¾ Dig.		At the Island *Cyanea,* M. *Horminius,* M. *Uxii,* M. *Coibacarani*	11 1 30
11 4 30	9	8½		By M. *Ambonus* to Isle *Apollonia,* and the *Athenian* Bay, by M. *Uxii,* and *Coibacarani.*	11 5 30
11 9 59	10	9¼		By the upper *Hyperborean* Lake, *Palus, Byces,* by M. *Herculeus,* and the utmost Bay of *Pontus.*	11 10 55

By

h. ′ ″					h. ′ ″
11 13 30	11	10 Dig.		By the lower *Hyperborean* Lake, *Mons Cimmerius*, and to the lower Bay of the *Caspian* Sea.	11 14 27
11 16 30	12	10½ alm		By the *Riphean* Mountains, *Pal. Mæotis*, and Isle *Alopecia*, to the greater *Casp.* Isle, by M. *Nerosus*.	11 17 17
11 19 10	13	11¼		Bank of *Palus Mæotis*, and M. *Hippocus*.	12 20 10
11 22 0	14	11½		By Mount *Alaunus* to the lesser Western Lake.	11 23 0
11 26 30		12 Dig.		Total Obscuration was observed about 297° of the Limb, or in 94° from the upper Point of the perpendicular Line of the 90th Deg. towards the East.	11 27 30
11 35 36			Of *Pollux* 52° 13′		11 37 4
11 37 35			Again 52 0		11 38 42
11 38 50			Again 51 41		11 39 35
12 58 20				The Recovery of Light was about 118° of the Limb, or in 88° from the upper point of the perpendicular Line of the 90th Degree towards the West.	1 0 8
1 0 40	15	½ Dig.		At Mount *Alabastrinus*, Mount *Pentadactylus*, Mount *Audus*, and *Palus Maræotis*.	1 2 31
1 3 35	16	1¼		By M. *Porphyrites*, to *Mare Syrticum*, and by *Mare Eoum*.	1 5 32
1 8 10	17	2 almo.		By M. *Baronius*, the *Loca Paludosa*, the Isle *Circinna*, between *Mare Syrticum* and *Egyptiacum*, at the Bay of *Syrbon*.	1 10 32
1 11 48	18	2½ alm		By the Bay of *Apollo*, the Isle *Taracinia*, the Isle *Æthusa*, and the Bay of *Syrbon*.	1 13 54
1 16 20	19	3½		At the Island *Majorca*, by Mount *Ætna*, M. *Neptune*, *Jachynthus*, the Island *Letoa*, the Island *Didyma*, and Mount *Lyon*.	1 18 33
1 20 50	20	4½ Dig.		At the Island *Corsica*, by the Island *Vulcania*, and *Carpathus*, at *Mare Mortuum*, by the Desert of *Sinai*.	1 23 6

h. ′ ″					h. ′ ″
1 24 39	21	$5\frac{1}{4}$ Dig.		At *Mons Argentarius*, *Mare Pamphilium*, Isle of *Cyprus*, by M. *Horminius*.	1 27 0
1 26 25	22	6 almo.		By M. *Apennine*, to the Lake *Thrasimenum*, at Mount *Sipulus*, by the lower M. *Libanus*.	1 28 40
1 28 32	23	$6\frac{1}{2}$		To Mount *Carpathos*, by the Isle *Besbica*, M. *Olympus*, *Didymus*, and Mount *Dalangueros*.	1 31 0
1 31 12	24	$7\frac{1}{2}$ Dig.		By Mount *Perce*, *Byzantium*, to Mount *Horminius*, and by M. *Antitaurus*.	1 33 44
1 35 59	25	$8\frac{1}{4}$		By *Sinus Circinites*, the Isle *Macra*, the Isle *Apollonia*, the middle of Mount *Moschus*, and the *Sogdian* Mountains.	1 38 37
1 39 33	26	9 Dig.		By the lower *Hyperborean* Lake, the Marsh *Byce*, M. *Strobilus*, by the extream Bay of *Pontus*, and Mount *Paropamisus*.	1 42 15
1 41 45	27	$9\frac{3}{8}$ Dig.		Between the Marsh of *Byce*, Lake *Corocondometes*, by M. *Hercules*, and the lower M. *Caucasus*.	1 44 30
1 44 19	28	10		By M. *Cimmerius*, M. *Tancon*, and Mount *Nerosus*.	1 47 9
1 47 20	29	$10\frac{1}{2}$		By *Palus Mæotis*, by the lesser Isle of the *Caspian* Sea, and by the upp: Mount *Nerosus*.	1 50 14
1 51 44	30	11 little more.		By Mount *Alaunus*, Mount *Sanctus*, and the Mounts *Hippocus*.	1 54 42
1 56 12		12 Dig.		End about 294° of the Limb, or 97° from the upper point of the Perpendicular of the nonagesim towards the West.	1 59 17
1 57 10				A very dense Penumbra.	2 0 17
2 1 15				Still very thick.	2 4 27
2 2 30				Something more dilute.	2 5 45
2 10 20				A very dilute Penumbra.	2 13 42
2 12 30				The End of the Penumbra.	2 15 0
2 15 39			Alt. *Pol.* 29° 12′		2 19 7
2 17 35			Same Alt. 28 46		2 22 8

In

In the Progrefs of the Eclipfe the Shadow was very dilute, and its Limb was uneven and ill terminated, fo that it was very difficult to determine the Phafes from the Beginning, nor could it be exactly diftinguifh'd thro' what Spots the Shadow paffed; yet in procefs of Time as the Eclipfe went on, all things became more diftinct. The Colour from the Beginning was fufficiently dull, obfcure, and gloomy, as if the Eclipfe would fhew itfelf about the greateft Obfcuration, like that in the Month of *April* in the Year 1642, fo overfhadow'd as hardly to be perceived. But the thing fell out otherwife; for when the Moon was quite eclipfed, its whole Difk was perfpicuous enough to the Eye. For then its Colour was quite ruddy, bloody, or like Ruft, which continued till the Moon had half recover'd her Light, and then again it appear'd pretty dark and dufkifh.

L. The Obfervation of this fmall Eclipfe was very difficult, becaufe of the oblique Incidence of the Moon into the Earth's Shadow, and the Thinnefs of the Shadow, through which we could very plainly perceive the Limb of the Moon, even in the middle of the Eclipfe. We could not accurately define the Parts of the Diameter, which were then deficient from the true Shadow, becaufe the Limits were fo confufed. I therefore took the Diftance between the Cufpids tho' ill defined, about the middle of the Eclipfe, from whence the faid Parts might be eafily deduced, and with lefs Danger of Error.

An Eclipfe of the Moon, June 17. m. 1684. at Greenwich; by Mr. Flamfteed. N. 162. p. 689.

Time by the Pendulum Clock.			*True Times correct. by Obfervat.*			*Obfervations.*		
h.	′	″	h.	′	″		′	″
1	40	40	1	31	8	Tendency to an Eclipfe		
2	4	30	2	54	58	Diam. of the M. by a Tube of 16 feet was 1605=	31	57
2	6	40	2	57	8	- - - - - - - - - - - repeated 6430=	32	4
2	12	0	2	2	20	A denfe Penumbra, perhaps the beginning		
2	16	00	2	6	28	The Shadow had defaced the limb above M. *Sinai*		
2	18	00	2	8	28	The Shadow was certainly within the Difk		
2	21	36	2	12	4	The Chord of the darkned Periphery — 1670=	8	28
2	26	00	2	16	28	- - - - - - - - - - - repeated 2010=	10	1
2	30	00	2	26	28	- - - - - - - - - - Again 2290=	11	25
2	42	00	2	32	28	The Eclipfe fenfibly decreafed		
2	43	00	2	33	28	Between the darkned Cufpids again 1895=	9	20
2	50	00	2	40	28	The End, but doubtful to me		
2	54	00	2	44	28	Certainly ended, my Affiftant *Smith* agreeing		
2	57	00	2	47	28	A denfe Penumbra		
3	11	00	3	1	28	And ftill		
3	20	00	3	10	28	The fouthern Limb had hardly yet recover'd the Brightnefs of the northern Limb: But its Light was duller than in the northern Limb, as it appear'd in the firft Obfervation.		

LI. It

An Eclipse of the Moon, Nov. 30. (*St. N.*) 1685. *at* Dantzick; *by M.* Hevelius. N. 178. *p.* 1256.

LI. It required no little Skill and Labour to manage our Tubes, tho' they were but short, of 5, 6, and 7 Feet, and to keep them so steady to the Moon, so that we might truly distinguish the Penumbra, and exactly mark out all the Phases, through what Spots they pass'd, or what they arrived at in every particular Instant of Time. But I perform'd this as well as I was able, and as far as the severe Season and floating little Clouds would allow. First it may be observed, that a very dense Penumbra went before the true Beginning of the Eclipse, so that I could hardly, if at all, distinguish the Beginning. As to the Colour, it is chiefly to be noted in this Eclipse; for I have very rarely found so great a Diversity in Colour. Sometimes it was rusty, or of the Colour of a Weesel; but when the total Obscuration came on, the Limb of the Moon was up and down something livid, and partly brightish and ruddy. But in the middle of the Moon a dense and obscure little Cloud was seen, so that we could not well distinguish the Spots in the Moon. This blackish Cloud advanced by degrees towards the Right Hand, and to the *Palus Mæotis*; so that about the Beginning of the Recovery of Light, the whole genuine Shadow appear'd very dark and black; and about the last Phasis taken Notice of, the remaining part of the Moon still obscured, or its Limb, could not be seen at all.

Order of the Phases.	*Time accor. to Clock cor. by Alt.* h. ′ ″	*Observables.*	*Alt. Sun, Moon, and fixt Stars.* ° ′ ″	*Through what Spots the Sections of the Shadow pass'd.*
		Merid. Alt. of the Sun.	12 39 0	
	3 19 0	Alt. of the S.	1 54 0	
	4 28 0	Alt. Moon	9 0 6	
	5 2 30	Alt. of *Capella*	31 0 0	
	5 8 0	Alt. of *Capella*	31 2 0	Dubious
	9 32 25	Penumbra		
	9 42 35	Penum. more dense		
	9 48 5	Penum. very dense		
	9 50 10	Begin. as far as could be collected		
1	9 53 20	*Pal. Maræotis* wholly cover'd.		At Mount *Andus*, and *Pal. Maræot.*
2	9 57 0			By *Germanicianus*, to *Mare Syrticum*, and Mount *Acabe.*
3	10 0 15	M. *Porphyrit.* not yet cover'd.		To Mount *Porphyrites*, over *Mare Syrticum*, and Mount *Ajax*.

By

	h.	′	″		
4	10	3	5		By *Mons Petri*, between the Iſle *Circinna*, and Iſle *Terracinnia*, by *Sinus Sirbonis*, and the Marſhes of *Arabia*.
5	10	6	25		To the Iſland *Ficaria*, *Malta*, M. *Athos*, by Mount *Pharan*, and Mount *Troicus*.
6	10	10	25		To the Bay of *Apollo*, by the Iſle of *Error*, by Mount *Ætna*, the Iſles *Letoa* and *Didyma*.
7	10	14	55	Iſland *Melos* now wholly cover'd.	Above the Bay of *Apollo*, to the Lake of *Hercules*, the Iſle of *Sicily*, by M. *Parthenius* and *Taigetus*, Iſle *Melos*, and M. *Lion*.
8	10	19	55		To the Iſle *Minorca*, thro' the Bay of *Paſtanus*, M. *Micalo*, Iſle of *Cyprus*, M. *Hor.* to M. *Sinai*, and the Deſert of *Raphidim*.
9	10	24	5		To Mount *Liguſtinus*, *Panyæus*, between M. *Sipulus* and *Didymus*, by M. *Libanus* and *Seir*.
10	10	27	10		Above Mount *Niger the Leſs*, by Mount *Apennine*, Iſle *Beſbica*, Mount *Cimæus*, and Mount *Calchaſtan*.
11	10	31	27		At M. *Serrorum*, and *Carpathos*, at *Byzantium*, by Mounts *Horminius*, *Taurus*, and *Delanguer*.
12	10	36	0		By Mounts *Macrocemnii*, the Iſland *Cyanea*, Mount *Amanus*, and *Antitaurus*.
13	10	41	20		By the Iſland *Macra*, by the *Erichtenian* Rocks, *Athenian* Bay, and *Palus Arceſa*.
14	10	45	35		By the upper *Hyperborean* Lake, *Palus Byce*, Iſle *Aca*, Mount of *Hercules*, the utmoſt Bay of *Pontus*, and M. *Parapomis*.
15	10	48	40		At the lower *Hyperborean* Lake, Mount *Immerius*, by M. *Corax*, *Taucan*, the lower Bay of the *Caſpian Sea*.
16	10	52	10		By the *Riphean* Mounts, *Palus Mæotis*, the greater *Caſpian* Iſland, and *Mons Neroſus*.

	h. ′ ″		° ′ ″	
	10 56 35	Moon not yet fully darkned.		
	10 58 25	Total Immersion.		
	11 20 45	Altitude of *Procyon*.	31 8 0	
	11 25 45	The same Altitude.	31 38 0	
	11 36 0	That dark Shade or little Cloud plainly seen in the mid. of M's Disk		
	12 43 0	The begin. of Emersion, or Recovery of Light.		
17	12 46 40	*Pal. Maræot.* now entirely cover'd.		To Mount *Audus*, not far from *Palus Maræotis*.
18	12 51 0			By *Mare Eoum*, *Mare Syrticum*, and Mount *Casius*.
19	12 57 0			By the lesser Mount *Atlas*, between the Isles *Circinna* and *Taracinia*, by the *Egyptian* Sea, the *Sin. Sirbonis*, and M. *Pharan*.
20	1 5 0			To the Islands *Majorca*, *Sardinia*, and *Hiera*; by M. *Ætna*, the Isle *Melos*, to M. *Anna* and *Hajalon*.

The Beginning of the Eclipse was a little above *Palus Maræotis*.
The total Obscuration was at *Mons Sanctus*, below *Palus Maræotis*.
The Recovery of Light happen'd nearly in the same Place where it was lost.

2. The

h. ′ ″	
9 19 00	The *Penumbra* was very obſcure, and the *Beginning* of the *Eclipſe* was at hand.
9 23 30	The *Eclipſe* was *begun*, the Quantity almoſt half a *Digit*, and the Diſtance between the Cuſps was about 42 Degrees of the Moon's Limb, and *Palus Marœotis* was juſt all *eclipſed*; hence we may conclude the *Beginning* about 9h. 21′. 30″.
10 23 30	As near as I can collect, was the time of the *Total Immerſion* into the Shadow, to verify which, the Azimuth of the Moon's Center was obſerved to the Eaſt, 41°. 18′; 2′ 12″ of Time after the ſaid *Immerſion*.
12 13 0	Or 10′ 13″ before the *Culmination* of the *Right Shoulder* of *Orion*, was the *Emerſion*, or firſt Appearance of the Moon out of the total Darkneſs.
1 14alm	Was the juſt *End* of the *Eclipſe*; being 2′ 20″ before the *Culmination* of *Syrius*.

2. *At Nuremburg; by M.* G. C. Eimmart. N. 182. p. 146.

Whence the *Middle* of this *Eclipſe* ſhould have happened at 11h. 18′ *p. m.* at *Nuremburg:* the *Total Duration* 3h. 52′ 4″; and the *Total Darkneſs* 1h. 49′ 30″.

The Meridian Altitude of the Moon's upper Limb was obſerved 63°. 23′ 50″, and the Moon's apparent Diameter while totally eclipſed was found 30′ 07″.

3. M. *Wurtzelbaur* made uſe of a Pendulum Clock, corrected by Altitudes: According to his Obſervation,

By M. J. Ph. Wurtzelbaur. *Ibid. p.* 147.

h. ′ ″	
9 23 30	Was the *Beginning* of the *Eclipſe*; at about 119 Degrees of the Limb of the Moon in *Hevelius*'s *Selenography*.
9 24 50	*Palus Marœotis* was all covered.
10 25 20	The *Total Immerſion*, about the 299th Degree of the Limb of the Moon.
12 11 30	The Moon began to *emerge* out of the Shadow, about the 112th Degree of her Limb.
1 14 30	The *End* of the *Eclipſe*, about the 295th Degree of the Limb.

By theſe Obſervations, the *Middle* of the *Eclipſe* ought to have been about 11h. 19′. *p. m.* at *Nuremburg*; differing but one Minute from M. *Eimmart*'s Obſervation.

The *Duration* will be 3h. 51′, and the *Total Darkneſs* 1h. 46″.

	h.	′
4. The Beginning - - - -	8	02
Immerſion - - - -	9	06
Emerſion - - - -	10	50
End - - - - -	11	57

At Lisbon; *by Mr.* Jacobs. N. 184. *p.* 206.

Phaſes.

LII.

An Eclipse of the Moon, Nov. 19. 1686. *at* Dublin; *by Mr.* W. Molineux. N. 185. *p.* 236.

Phases.	Times.
	h. ′ ″
A notable Penumbra	9 15 00
Clouds interposing, the beginning could not nicely be determined; therefore with Uncertainty I suppose Ecl. began 9^h. 25′, or 9^h. 27′.	9 27 00 *
The Shadow was at *Palus Maræotis*	9 38 20
Palus Maræotis was cover'd	9 40 20 *
Mount *Sinai* was cover'd	9 46 30 *
Mount *Thambes* was cover'd	10 01 20 *
Mount *Audus* was cover'd	10 08 00 *
Mount *Neptune* cover'd	10 14 00 *
The Shadow at *Mons Sypylus*	10 15 10 *
The Isle *Circinna* cover'd	10 16 40
At *Mons Didymus*	10 18 20 *
Mons Didymus is cover'd	10 20 10
Mount *Audus* emerges	10 23 00
The Shadow at *Palus Maræotis*	10 48 30
Maræotis emerges	10 52 00
At Mount *Sinai*	11 38 00
Sinai emerges	11 39 30
The end of the Eclipse	11 04 00

Observables. The Times were those of a Pendulum Clock, rectified by the fixed Stars.

The Observations marked with an Asterism were taken through the Openings of the Clouds, and therefore I cannot account them as exact. The Quantity of this Eclipse I think was six Digits.

An Eclipse of the Moon, Apr. 5. 1688. *at* Moscow; *by M.* Timmerman. N. 192. *p.* 453.

LIII. Half a Quarter of an Hour after 7 in the Evening, the Moon arose clear, but of a deep Red Colour without any Sign of Eclipse: At $7^h\frac{1}{2}$ the Moon went into a thick Cloud, but was again clear at $7^h. 38'$. when the Under side of the Body of the Moon was *began* to be *obscured*, in a clear Sky; she being then in the 25th Degree of *Libra*, and $6°\frac{1}{2}$ above the Horizon. (Suppose the Center.) At 9^h. the whole Under Side of the Moon was *eclipsed*; and about 8′ after 9^h it was at the Height, or rather seemed to decrease. At $9^h\frac{1}{2}$ there was still a third Part of the Moon eclipsed. (Suppose of her Circumference.) About 10^h. it *decreased* apace, and at $10^h\frac{1}{2}$ there was but little to be seen: At $10^h. 45'$. it was certainly ended, the Moon being then about 22° high.

Immersions.

LIV. 1. *An Eclipse of the Moon, Oct. 19. 1697. at Chester; by Mr. Edm. Halley.* N. 235. p. 784.

Immersions.	*Times.*	*Emersions.*	*Times.*
	h. ′		h. ′ ″
The Beginning	6 8½	*Porphyrites*, and the middle	
Porphyrites immerged	6 16	of M. *Ætna*	8 7 00
North part of *Maræotis*	6 21½	*Horminius* - - - -	8 17 30
Lacus Niger Maj. and South		*Mons Herculis* - - -	8 18 30
End of *Maræotis*	6 26	*Besbicus* - - - -	8 21 00
Besbicus - - -	6 46⅔	*Apollonia* - - - -	8 26 15
Apollonia - - -	6 49½	*Byzantium* - - -	8 29 00
Byzantium - - -	6 53	*Lacus Niger Major*	8 32½
Horminius - - -	6 59	South part of *Mæotis*	8 35
North-part of *Mæotis*	7 2½	North part of *Mæotis*	8 43
Mons Corax - - -	7 3½	The End - - -	8 49½
Mons Herculis - - -	7 10		
South part of *Mæotis*	7 12½		

About the Middle there remained 9′ 26″ of the luminous Part, and consequently the Digits eclipsed 8⅔.

2. *At* Rotterdam; *by M.* Ja. Cassini. N. 236. p. 20. Vid. sup. *Sect.* XXXIX. 2.

	Time corrected.	*Observations.*
	h. ′ ″	
A	6 20 36	The acute Promontory at the first oblique Thread.
B	6 21 27	The preceding Limb of the Moon at the perpendic. Thread.
C	6 22 3	The acute Promontory at the perpendicular Thread.
C — B	0 00 36	The Difference of the Transit over the perpendicular Thread, which is the Longitude of the acute Promontory from the preceding Limb.
C — A	0 1 27	The Difference of the Transit of the acute Promontory between the first oblique Thread and the Perpendicular, which is its Latitude from the Northern Limb.
	6 32 34	The Moon seen among the Clouds seem'd as yet intire.

In

In the first Phase.

	h. ′ ″	
A	6 41 23	The Beginning of *Mare Crisium* at the first oblique Thread.
B	6 41 50	The acute Promontory at the first Oblique.
C	6 42 12	*Pliny* at the first Oblique.
D	6 42 25	*Menelaus* at the first Oblique.
E	6 42 33	*Manilius* at the first Oblique.
F	6 42 43	The first Margin at the Perpendicular.
G	6 43 00	*Proclus* at the Perpendicular.
H	6 43 20	The acute Promontory at the Perpendicular.
I	6 43 26	The subsequent Margin at the first Oblique.
K	6 43 30	*Menelaus* at the Perpendicular.
L	6 44 00	The preceding Horn of the Moon at the Perpendicular; she herself touches the horizontal Thread.
M	6 44 21	The subsequent Horn at the first Oblique.
N	6 44 35	*Menelaus* at the second Oblique.
O	6 44 57	The subsequent Horn at the Vertical.
P	6 45 07	The subsequent Limb at the Perpendicular.
Q	6 45 33	The subsequent Horn at the second Oblique.
R	6 45 55	*Grimaldus* at the second Oblique.
S	6 46 49	Subsequent Limb at the second Oblique.
P — F	0 02 24	The Transit of the Moon over the perpendicular Thread.
S — I	0 03 23	The Transit of the Moon over the second Oblique.
H — F	0 00 37	Longitude of the acute Promont. from the preced. Margin.
H — B	0 01 30	Latitude of the acute Promont. from the North. Margin.
K — F	0 00 47	The Longitude of *Meneluus* from the preceding Margin.
K — D } N — K }	0 01 05	The Latitude of *Menelaus* from the Northern Margin.
L — F	0 01 17	Long. of the preceding Horn from the preceding Margin.
O — F	0 00 00	The Latitude nothing.
O — M	0 02 14	Long. of the subsequent Horn from the preceding Margin.
Q — O	0 00 36	Latitude of the same Horn from the Northern Margin.

In the second Phasis.

	h.	′	″	
A	7	6	40	The preceding Margin at the perpendicular Thread.
B	7	7	8	The preceding Horn to the vertical Thread.
C	7	7	47	The ſubſequent Horn to the firſt Oblique.
D	7	8	19	The ſubſequent Margin to the firſt Oblique.
E	7	9	4	The ſubſequent Horn to the Vertical.
	7	12	22	The Shadow to *Manilius.*
B — A	0	0	28	Long. of the preceding Horn from the preceding Margin.
E — A	0	2	24	Long. of the ſubſequent Horn from the Eaſtern Margin.
E — C	0	1	17	Lat. of the ſubſequent Horn from the Southern Margin.

In the third Phasis.

	h.	′	″	
A	7	19	30	The preceding Horn to the firſt Oblique.
B	7	21	9	The preceding Margin to the Vertical.
C	7	21	19	The preceding Horn to the Vertical.
D	7	21	51	The preceding Margin to the ſecond Oblique.
E	7	22	24	The ſubſequent Horn to the firſt Oblique.
F	7	22	47	The ſubſequent Margin to the firſt Oblique.
G	7	23	9	The preceding Horn to the ſecond Oblique.
H	7	23	31	The ſubſequent Horn to the Vertical.
I	7	24	40	The ſubſequent Horn to the ſecond Oblique.
	7	26	4	The Shadow to *Dionyſius.*
C — B	0	0	10	Long. of the preceding Horn from the Eaſtern Margin.
C — A	0	1	49	Lat. of the preceding Horn from the Southern Margin.
G — C	0	1	50	The ſame Latitude.
H — B	0	2	22	Long. of the ſubſequent Horn from the preceding Margin.
H — E	0	1	7	Lat. of the ſubſequent Horn from the Southern Margin.
I — H	0	1	9	The ſame Latitude.

In

In the fourth Phasis.

	h. ′ ″	
A	7 40 24	The preceding Horn to the firſt Oblique.
B	7 41 35	The preceding Horn to the Vertical.
C	7 42 18	The preceding Margin to the firſt Oblique.
D	7 42 44	The preceding Horn to the ſecond Oblique.
E	7 42 51	The ſubſequent Horn to the firſt Oblique.
F	7 43 14	The ſubſequent Margin to the firſt Oblique.
G	7 43 58	The ſubſequent Margin to the Vertical.
H	7 45 04	The ſubſequent Horn to the ſecond Oblique.
D — 2′ 24″ = I	7 41 34	The preceding Margin to the vertical Thread.
B — I	0 00 01	Long. of the preced. Horn from the preced. Margin.
B — A	0 01 11	Lat. of the preced. Horn. from the South. Margin.
D — B	0 01 09	
H — E	0 2 13	Diff. of the Tranſit of the ſubſ. Horn betw. the Obl.
K	0 1 6½	Half, or Lat. of the ſub. Horn from South. Margin.
E + K	7 43 57½	The ſubſequent Horn to the Vertical.
E + K — I	0 2 23½	Long. of the ſubſ. Horn from the preced. Margin.

In the fifth Phasis.

	h. ′ ″	
A	7 50 22	The preceding Horn to the firſt Oblique.
B	7 51 04	The acute Promontory in the Shadow.
C	7 51 18	The preceding Horn to the Vertical.
D	7 51 58	The preceding Margin to the ſecond Oblique.
E	7 52 29	The ſubfequent Horn to the firſt Oblique.
F	7 52 56	The ſubſequent Margin to the firſt Oblique.
D — 2′ 24″ = I	7 49 34	The preceding Margin to the firſt Oblique.
B — I	0 01 30	Longit. Obl. of the acute Promontory from 1 Obl.
D — 0′ 42″ = L	7 51 16	The preceding Margin to the Perpendicular.
C — L	0 00 02	Long. of the preced. Horn from the preced. Margin.
C — A	0 00 56	Lat. of the preced. Horn from the South. Margin.
E — I	0 02 55	Long. Obl. from 1 Obl. to greateſt Long. 3′. 24″.
	0 00 29	The Complement.
F — E	0 00 27	The ſame Complement. The Medium 0′. 28″.

In

In the sixth Phasis.

	h. ′ ″	
A	7 54 06	The preceding Horn to the firſt Oblique.
B	7 54 44	The acute Promontory to the firſt Oblique.
C	7 54 59	The preceding Horn to the Perpendicar.
D	7 55 38	The preceding Margin to the ſecond Oblique.
F	7 55 52	The preceding Horn to the ſecond Oblique.
G	7 56 04	The ſubſequent Horn to the firſt Oblique.
H	7 56 36	The ſubſequent Margin to the firſt Oblique.
I	7 57 20	The ſubſequent Horn to the Vertical.
D—2′ 24″ = L	7 53 14	The preceding Margin to the firſt Oblique.
D—0 42 = K	7 54 56	The preceding Margin to the Perpendicular.
C — K	0 00 03	Long. of the preced. Horn from preced. Margin.
C — A } F — C }	0 00 53	Lat. of the preced. Horn from Southern Margin.
I — K	0 02 24	Long. of the ſubſ. Horn from the preced. Margin.
I — G	0 01 16	Lat. of the ſubſ. Horn from the South. Margin.
B — L	0 01 30	Obl. Long. of the acute Promont. from 1 Obl.

In the ſeventh Phaſis.

	h. ′ ″	
A	8 6 58	The preceding Horn to the firſt Oblique.
B	8 7 39	The preceding Horn to the Perpendicular.
C	8 8 15	The preceding Margin to the ſecond Oblique.
D	8 8 21	The preceding Horn to the ſecond Oblique.
E	8 8 55	Middle of the Shad. almoſt at the Perpendicular.
F	8 9 14	The ſubſequent Margin at the firſt Oblique.
G	8 9 55	The ſubſequent Horn at the Vertical.
H	8 9 58	The ſubſequent Margin at the Vertical.
C — 2′ 24″ = I	8 5 51	The preceding Margin at the firſt Oblique.
C — 0 42 = K	8 7 33	The preceding Margin at the Perpendicular.
B — K	0 0 06	Long. of the preced. Horn from preced. Margin.
B — A	0 0 41	{ Lat. of the preced. Horn from South. Margin.
D — B	0 0 42	
G — K	0 2 22	Long. of the ſubſ. Horn from the preced. Margin.

In the eighth Phasis.

	h. ′ ″	
A	8 23 53	The preceding Horn to the firſt Oblique.
B	8 24 24	The preceding Horn to the Perpendicular.
C	8 24 55	The preceding Margin to the ſecond Oblique.
D	8 24 57	The preceding Horn to the ſecond Oblique.
E	8 25 55	The ſubſequent Margin to the firſt Oblique.
F	8 26 26	The ſubſequent Horn to the Perpendicular.
G	8 26 38	The ſubſequent Margin to the Vertical.
H	8 28 20	The ſubſequent Horn to the ſecond Oblique.
C — 0′ 42″ = K	8 24 13	The preceding Margin to the Perpendicular.
B — K	0 00 11	Long. of the preced. Horn from South. Margin.
B — A	0 00 31	} Lat. of the preced. Horn from South. Margin.
D — B	0 00 33	
F — K	0 02 13	Long. of the ſubſ. Horn from the preced. Margin.
H — F	0 01 54	Lat. of the ſubſ. Horn from the Southern Margin.

In the ninth Phasis.

	h. ′ ″	
A	8 49 25	The preceding Horn to the firſt Oblique.
B	8 49 42	The Concavity of the Eclipſe to the firſt Oblique.
C	8 50 08	The preceding Horn to the Vertical.
D	8 50 41	The preceding Margin to the ſecond Oblique.
E	8 50 51	The preceding Horn to the ſecond Oblique.
F	8 51 34	The ſubſequent Horn to the Vertical.
G	8 51 43	The ſubſequent Margin to the firſt Oblique.
H	8 52 26	The ſubſequent Margin to the Vertical.
H — 2′ 24″ = I	8 50 02	The preceding Margin to the Perpendicular.
C — I	0 00 06	Long. of preceding Horn from preceding Margin.
C — A	0 00 43	} Lat. of preceding Horn from Southern Margin.
E — C	0 00 43	
F — I	0 01 32	Long. of ſubſequent Horn from preced. Margin.

In the tenth Phasis.

	h.	′	″	
A	9	4	29	The preceding Horn to the first Oblique.
B	9	5	4	The Shadow withdraws from *Pliny*.
C	9	5	53	The subsequent Horn to the first Oblique.
D	9	6	17	The preceding Horn to the second Oblique.
E	9	7	2	The subsequent Margin to the first Oblique.
F	9	7	47	The subsequent Margin to the Vertical.
E — 2′ 42″ = H	9	5	20	The preceding Margin to the Vertical.
D — A	0	1	48	Transit of the preced. Horn between the Obliques.
M	0	0	54	Half is Lat. of preced. Horn from South. Margin.
D — M = I	9	5	23	The preceding Horn to the Vertical.
I — H	0	0	3	Long. of preced. Horn from the preced. Margin.
E — 3′ 24″ = L	9	3	38	The preceding Margin to the first Oblique.
F — 4 06 = L	9	3	41	
C — L	0	2	25	Obl. Long. of subs. Horn from the first Oblique.
	9	9	4	The Shadow withdraws from *Langrenus*.
	0	9	19	The End of the Sea of *Tranquillity*.
	0	13	40	*Aristotle*.
	0	14	39	The End of *Mare Crisium*.
	0	21	34	The End.

LV.

A Transit of the Moon above Venus, Oct. 11. (St. N.) 1670. at Dantzick; by M. Hevelius. N. 66. p. 2026.

Time by a Watch in the Morn.		*Distances and Altitudes.*	*Time corrected by Altitudes.*
h. ′ ″		° ′ ″	h. ′ ″
3 47 20	Alt. of the bright Star of *Aries*	41 45 0	3 54 10
3 50 35	The same Altitude - - - - -	41 21 0	3 57 28
5 47 44	Distance of *Venus* from *Jupiter*		5 54 44
5 48 35	Dist. of East. Limb of M. from ♃	35 25 30	5 55 35
5 51 59	Distance of ♀ from ♃	35 50 0	5 59 0
5 53 40	Dist. of East. Limb of M. from ♃	35 29 10	6 0 40
6 12 30	Dist. of *Venus* from *Jupiter*	35 50 20	6 6 0
6 14 3	Dist. of the M.'s East. Limb from ♃	35 37 35	6 8 0
6 37 0	Dist. of ♀ from ♃, as near as could be judged by the naked Eye	0 6 0	6 51 0
7 12 0	Dist. of *Ven.* from low. limb of the M	0 5 0	7 7 0
7 17 0	The same - - - - - - - -	0 4 0	7 12 0
7 35 0	*Venus* appear'd clearly - - - -		7 30 0
9 11 0	*Venus* continued conspicuous		9 12 0
9 15 48	The Altitude of the Sun	19 8 0	9 17 20
9 17 39	The same - - - - - - -	19 58 0	9 19 4

An Occultation of Saturn by the Moon, June 1. (St. N.) 1671. at Dantzick; by M. Hevelius. N. 78. p. 3027.

LVI. The Beginning of the Occultation happen'd at $3^h. 38' 27''$. in the Morning, about the Mountain *Germanicianus*. The Line of Passage, as far as could be collected from the Ingress alone, was through Mount *Ætna*, the Center of the Moon nearly, by Mount *Horminium*, the Mount of *Hercules*, and the upper Part of *Mare Caspium* As far as I remember, excepting this Year's Observation, within 41 Years I have seen *Saturn* cover'd by the Moon only twice. First in the Year 1630, *Jun.* 29, 11^h. in the Evening, when I was at the Island *Huenna* in the *Danish* Sea. And again in the Year 1661, *Aug.* 3, 7^h. $58'$. $20''$. in the Evening, here at *Dantzick*.

A Transit of the Moon above Jupiter, Sept. 30. (St. N.) 1671. at Dantzick; by M. Hevelius. Ibid. p. 3031.

LVII. In a very clear Sky, with a Tube of 20 Feet, with great Eagerness we received the rising Moon, and *Jupiter* a little after. We found by our great brazen Octant, of almost 9 Feet Radius, that *Jupiter* was yet $1°. 23'. 40''$. remote from the Eastern Limb of the Moon, and that all his four Satellites were there to the Right Hand, from whence the Moon approached. An unlook'd for and unhappy Accident prevented us from taking the very Moment of Conjunction. For when *Jupiter* now approached to the Eastern Limb of the Moon, at 3′, and was distant only 6′ from the Line of Conjunction drawn through

through both Horns; ſome little Clouds intervening deprived us of the Sight both of *Jupiter* and the Moon. The *Rudolphine* Tables promis'd us an Occultation, and much ſooner than it could happen; yet there was none at all, but only a very cloſe Tranſit, at almoſt two Digits; the Time of which was $7^h. 26'. 0''$.

An Occultation of the Pleiades *by the* Moon, Feb 23. 1671-2. *At* Derby; *by Mr.* Flamſteed. N. 86. *p.* 5034. *Fig.* 116.

LVIII. The Altitude of the Moon being 20°. 50′, I took its Diameter 32′. 48″; and when its Altitude was 19°. 23′, I took it again 32′. 47″. Therefore the true Semidiameter of the Moon in the Horizon was 16′. 19″. Yet it was ſtill at a greater Diſtance from the Weſtern Star of the *Pleiades*, than the Teleſcope could conveniently take in. Now at $11^h. 19\frac{1}{2}'$ after Noon, when the Altitude of the Star *b*, the more Weſtern of the *Pleiades*, was 9°. 50′, I took the Diſtance of the ſame Star from the neareſt Horn of the Moon 11′. 58″; then ſuddenly turning to obſerve the Stars Altitude, (which was ſhewn by a Quadrant of 20 Inches Radius fixt to the ſide of the Tube,) and immediately returning back again, I could not find the Star, being then cover'd by the Moon. In the mean while the Moon had deſcended 10 Minutes, and the Star as much, which from the following Phaſis I gueſs had gone under the Moon at $11^h. 20\frac{1}{2}'$. For at $11^h. 30\frac{1}{4}'$, when the Altitude of the Star *e* was 8°. 43′, I ſaw the Star *c* cover'd by the Moon. When I had taken its Diſtance 16′. 35″ from the neareſt Horn, by my Computations I found the Space of Time between the Occultation of this and of the foregoing to be 9′. 37″, which being taken from the Time of this Phaſis, gives the Time of the foregoing Occultation as I have made it.

At $11^h. 37\frac{1}{2}'$, when the Altitude of the Star *c* was $11°. 37\frac{1}{2}'$, it went under the Moon, as in the mean time I was meaſuring its Diſtance 22′. 36″, from the Horn of the Moon, which was apparently the inferior, but really the ſuperior. When the Star vaniſh'd, the apparent Semidiameter of the Moon was 16′. 21″; and therefore its Occultation was at 87°. 25′ of the Moon's Periphery from the upper Cuſp, whoſe Reclination was 1° 37′ from a Line drawn through its Center perpendicular to the Ecliptic. Thus the Ingreſs of the Star was 4° 12′ above a Line drawn through the Center of the Moon parallel to the Ecliptic, and the Center of the Moon was antecedent of the Star 16′. 18″, with leſs Latitude 1′. 12″.

According to the Author of the *Caroline* Tables, the Place of the fixt Star is 25°. 1′. 24″ in *Taurus*, and its perpetual Latitude 4°. 20′. 39″; ſo that at the apparent Hour at *Derby* $11^h. 37\frac{1}{2}'$ after Noon, the apparent Place of the Moon was 24°. 45. 6″ in *Taurus*, and its Latitude obſerved 4°. 19′. 27″ North.

Moreover it well deſerves to be remarked, that though almoſt all the Hypotheſes of all Aſtronomers aſcribe a greater Diameter to the Perigee full Moon in the Quadratures, and therefore a leſs Diſtance from the Earth than in the Syzygees or Oppoſitions; yet the contrary obtains in the Heavens. For the Perigean full Moon paſſing near the *Pleiades*, *Nov.* 6, 1671, had a greater Diameter.

meter than in this Tranſit, when in almoſt the ſame Place it was diſtant from the Sun 70 Degrees. The Moon's horizontal Diameter according to

	Bullialdus.	*Street.*	*by Obſervations.*
Nov. 6. 1671.	17′ 00″	16′ 30″	17′ 00″
Feb. 23. 1672.	17 50	17 13	16 19
	+ 50	+ 43	− 41

We can no longer wonder, that the Moon ſhould ſo long refuſe the Confinement of Numbers, and that the Times of Appearances, when computed from the Tables, ſhould hitherto ſo far deceive our Expectations; ſince it appears thoſe Tables are generally computed from erroneous Hypotheſes.

The Moon's *Place,* Mar. 23. 1671-2; *by M.* Caſſini. N. 82. *p.* 4047.

LIX. *April* 2. (*St. N.*) 6[h]. 50′ *v.* A Line drawn through the Horns of the *Moon* paſſed through the Star that is at the Point of the *Northern Horn* of *Taurus*; and the Diſtance of this Star to the *Northern Horn* of the *Moon*, was by a Minute greater than the Semidiameter of the *Moon.*

An Occultation of a fixed Star by the Moon, Feb. 29. (*St. N.*) 1676. *at* Paris; *by M.* Caſſini. N. 123. *p.* 564.

LX. An Immerſion of the ſubſequent Star of the two in the Left hinder Foot of the Lion, was at 1[h]. 19′. 34.″ The Coaſt of the Immerſion was near the End of *Schicard* towards *Phocilides* in the Selenography of *Ricciolus.*

The Emerſion was at 11[h] 16′ 40″, in an equal Diſtance from the Right Line between *Vendelinus* and *Petavius.*

A Right Line being drawn through the Points of Immerſion and Emerſion, when carefully obſerved, will divide a Diameter perpendicular to it in the Ratio of 6′. 45″. to 26′. 5″.

But the Diameter of the Moon approaching to the Meridian was 32′. 50″.

At 12[h]. 29′ the upper Margin of the Moon was in the ſame Parallel with the Star, which then preceded the Moon by 1′. 50″ in time.

At 12[h]. 40′. 18″ the Star preceded the Weſtern Margin of the Moon by 2′. 11″ in time. The Diameter of the Moon paſs'd through 2′. 14″.

At 12[h]. 52′. 35″ the Star preceded the ſame Margin 2′. 25″.

The Meridian Altitude of the inferior Limb of the Moon was taken 39°. 25′. 25″.

Hour

Hour of the Clock cor.	Altitudes and Diſtances.	
h. ′ ″		′ ″
4 20 15	*Jupiter* from the bright Limb of the Moon	26 9
4 47 0	The Diameter of the Moon was taken	31 30
4 49 30	*Jupiter* from the neareſt Cuſp	26 28
4 52 15	*Jupiter* had paſs'd over a Right Line drawn through the Cuſps, by a tenth Part of the Diſtance, or about 3′, making a Conjecture by the Eye through the Tube	
4 56 0	*Jupiter* from the Cuſp	27 38
5 1 15	From a Right Line thro' the Cuſps	7 53
5 3 30	From the Cuſp	28 22
5 7 25	From the Right Line	9 58
5 10 50	From the ſame	11 55
5 15 50	From the Cuſp	30 27
5 21 20	From the remoter Limb, dubious	62 4
5 26 0	From the neareſt Cuſp	33 0
5 31 25	From the Right Line thro' the Cuſps	20 9
5 37 0	From the Cuſp	36 15
5 41 10	The Altitude of the Moon being 10½ Degrees, the Diameter was about	31 53
5 48 30	Diff. of the Alt. of the lower Limb of the Moon and of *Jupiter*	23 1
5 52 40	*Jupiter* was diſtant from the neareſt Cuſp	41 40
6 9 40	From the Cuſp, dubious.	47 29

LXI. *A Tranſit of the* Moon *above* Jupiter, Feb. 28. *m.* 1675-6. *at* Greenwich; *by Mr.* Flamſteed. *Ibid. p.* 566.

LXII. 1. *Aug.* 21. A. 1676. before Noon. For the Correction of my Clock, I took theſe Altitudes of the Sun's Limb.

An Occultation of Mars *by the* Moon, Aug. 21. 1676. *at* Greenwich; *by Mr.* Flamſteed. N. 129. *p.* 723.

Hour of the Clock.	Altitudes.		Hour computed.	Error in Time.
h. ′ ″		° ′	h. ′ ″	′ ″
8 04 31	Alt. of the inferior Limb of the Sun	26 04	8 09 26	† 4 55
8 5 42	- - - - - - - - - - - - -	26 14	8 10 35	† 4 53
8 7 58	- - - - - - - - - - - - -	26 34	8 12 53	† 4 55
8 9 10	- - - - - - - - - - - - -	26 44½	8 14 03	† 4 53
8 10 15	- - - - - - - - - - - - -	26 54	8 15 12	† 4 57
8 17 15	- - - - - - - - - - - - -	27 54	8 22 09	† 4 54

Then after Noon, the Sky being exceeding clear.

Hour

Hour of the Clock.	Corrected.	Distances.		
h. ′ ″	h. ′ ″			′ ″
10 45 03	10 49 58	*Mars* from the bright Limb of the M.	5125 =	42 08
11 06 11	11 11 05	The same Distance	3829 =	31 29
11 20 00	11 24 55	Again - - - - -	3007 =	24 44
11 35 57	11 40 52	Over again - - - -	1982 =	16 18
11 57 31	12 02 26	♂ from Zen. Diff. Alt. inf. lim. and of ♂	1912 =	07 35
		With tube of 16 feet, *Mars* from Limb	1158 =	5 47
12 05 00	12 09 55	Planet could no longer be perceived with the naked Eye		
12 9 44	12 14 39	Light of *Mars* confounded with the Light of the M. *Mars* from Zen.	1185 =	9 44
12 10 03	12 14 58	*Mars* intirely cover'd by North. Cusp	3475 =	17 20
12 18 38	12 23 33	[a] 41 in *Taurus* appear'd in a right Line drawn thro' the Cusps		
12 20 36	12 25 31	41 in *Taurus* from the Limb or Cusp; with a shorter Tube	3912 =	32 10
12 24 58	12 29 53	41 in *Taurus* from the Cusp, again with the same Tube	3935 =	32 21
12 46 00	12 50 55	Diam. of the Moon with a longer tube	5971 =	29 47
1 04 30	1 09 25	Again with the same Tube	5973 —	29 48
1 10 56	1 10 51	*Mars*'s Emers. perhaps 4″ or 5″ sooner		
1 13 29	1 18 24	*Mars* from the Northern Cusp	3675 =	18 20
1 18 15	1 23 10	The same Distance	4035 =	20 08
1 22 00	1 26 55	The Moon's Altitude 23°, with the longer Tube. Her Diameter	5988 =	29 55
1 39 00	1 39 55	Moon's Diameter with a shorter Tube	3645 =	29 58

[a] 41 in *Taurus*. According to *Tycho* its Place is now ♉ 17°. 58½′ Latitude 1°. 20′. South. Therefore the Places both of the Moon and *Mars* may be exactly deduced.

Time

2. *At* Oxford; *by* *Mr*. Halley. *Ibid. p.* 734.

Time corrected.	*Distances*		
h. ′ ″			′ ″
11 43 30	The Center of *Mars* from the nearest Limb of the *Moon*	$719\frac{1}{2}=$	12 40
11 49 2	Again - - - - - - - -	571 =	10 3
11 54 48	Again - - - - - - - -	409 =	7 12
12 3 25	The Center of *Mars* from the North Cusp of the *Moon* - - - - - - -	1118 =	19 41
12 10 28	The gibbous part of *Mars* touched the *Moon*'s Limb - - - - - - - - - - - -		
12 10 42	*Mars* was wholly covered, being distant from the Cusp - - - - - - - - - - -	963 =	17 14
1 10 41	*Mars* did emerge, I suppose, his Center		
1 12 45	*Mars* distant from the North. Horn of the *Moon*	1018 =	71 55
1 31 10	*Mars* passed over a Point noted in the Telescope		
1 33 15	The Southern Limb of *Ætna* passed by the same Point		
1 34 00	The lucid Limb passed over the same Point		
1 52 35	The *Moon*'s Diameter observed 1698 = 30′ 1″ *Alt. Moon* 31° circ.		
1 57 52	*Mars* from the Northern Horn of the *Moon*	2042 =	36 5
2 2 53	*Mars* from the Southern Horn of the *Moon*	2266 =	40 3

3. *At* Dantzick, *by M.* Hevelius. *Ibid. p.* 721.

Time by Pend. Clock	*Names of the fixed Stars.*	*Altitudes.*	*Time correct. by Alt.*	*Remarks.*
h. ′ ″		° ′	h. ′ ″	
1 1 25	Swan's Tail	57 10	1 0 24	
1 9 45			1 8 45	*Mars* was nearly as far distant from the bright Limb of the Moon, as Mount *Porphyrites* was from Mount *Ætna.*
1 36 39			1 33 42	*Mars* cover'd by the Moon.
1 45 25	Swan's Tail	51 17	1 44 7	
2 47 54			2 46 29	*Mars* shin'd out again, and made an end of the Occultation.
3 19 50	*Scheat* in *Peg.*	45 3	3 18 19	

Mars was cover'd about Mount *Audus*, proceeding as it were through the *Loca Paludosa* of the Moon, by Mount *Ætna*, below the Island *Besbica*, above the *Palus Acherusia*, above Mount *Corax*, by the *Palus Mæotis*, and a little above the Isle *Alopecia*, and the very Center of the Moon. And thus again going out at the greater Western Lake.

If you ask from whence I could thus exactly mark out his Passage, and that at the obscure Part of the Moon, you are to know it proceeded from hence, that by those Tubes of mine I could very distinctly perceive the chief greater Spots in the shaded part of the Moon; and thus I could observe very plainly, that *Mars* emerged near the middle of *Palus Mæotis*.

An Occultation of Saturn *by the* Moon, Feb. 27. st. n. 1678, *at* Paris; *by M.* Bullialdus. *n.* 139. p. 969.

LXIII. *Bullialdus* observed the Beginning, when the Altitude of *Andromeda*'s Head above the Western Horizon was 18°. 11′; whence the Astronomical Time from Noon is given 7^h 20′; but the mean Time was 7^h 29′ 55″. And he saw the End when the more Southern Star of *Andromeda*'s Girdle of the second Magnitude was 21° 17′ high to the West. Whence the Astronomical Time from Noon will be found to be 8^h 30′ 22′.

Here we are obliged to take notice, that the *Philolaic* Tables make *Saturn* farther advanced in Longitude, by at least 19 Minutes, than he really is by Observation; so that *Saturn* was then in ♊ 3° 28′, with South Latitude 1° 38′.

Farther, in this Observation if we have Recourse to the Description of the Lunar Disk, as described by the illustrious Mr. *Hevelius*; we found *Saturn* to emerge in that part of the Limb, which is situated in a Right Line drawn from the middle of Mount *Berosus* through the *Riphæan* Mountains, a little above Mount *Alanus*, and below the Southern Limits of the *Hyperborean* Marshes.

An Occultation of Jupiter, Jun. 5. (*st. n.*) 1679. *at* Dantzick; *by M.* Hevelius. *Ph. Coll.* n. 1. p. 29.

LXIV. 1. Tho' I have apply'd my self to the Observation of the Heavens now for 50 Years, (for which I ought to give, and do give, all possible Thanks to Almighty God,) yet I have only once seen *Jupiter* cover'd by the Moon, which was in the Year 1646, *Decemb.* 24. (new Style) in the Evening, when the Sun was under the Horizon. Therefore I very much congratulate with my self, that I could make this Observation, not only with a very serene Sky, but also according to my Wish, in the Presence of my most wellcome Guest, the famous and most learned Mr. *Edmund Halley*.

It entered the Moon at Mount *Audus*, and as far as could be expected from its Exit, it pass'd through the *Loca Paludosa* of the Island *Cercinna*, over Mount *Ætna*, through the Island *Besbica*, through *Byzantium*, the Island *Apollonia*, and the upper Part of *Palus Mæotis*; so that it went a little above the Center of the Moon; the Moon having then some South Latitude. Then, which is very rare, we very accurately measured (as it seems to me) the apparent Diameter of *Jupiter* in this Observation. I remember that I have several Times observed the Diameter of *Jupiter* by the Lunar Spots, and found that it came to 55 Seconds more or less. But now the Diameter of *Jupiter* came out much less. For the whole Duration of this Occultation being known to be 58′ 10″, and at the same time the Diameter of the Moon being given 32′ 40″; it presently becomes known from that Mora of Time, when first *Jupiter* with his Limb touch'd the Limb of the Moon, and when again it was hid, (which was done in the same Space of 55 Seconds,) that the Diameter of *Jupiter* is 30″ 53‴.

Order

Ord. Obser.	*Time by the Pendulum Clock.*	*Altitudes of the fixed Stars and of the Sun, with the Distances of* Jupiter *from the Limb of the Moon.*		*Time corrected by Altitudes.*
	h. ′ ″		° ′ ″	h. ′ ″
	1 18 55	The Altitude of *Andromeda*'s Head	24 52 0	1 20 54
	1 29 0	The Altitude of *Arcturus*	31 3 00	1 31 24
1	1 52 0	The Moon arose ——— ——— ———		1 54 25
2	3 26 0	The Sun rises ——— ——— ———		3 28 25
3	3 33 0	The Distance of *Jupiter* from the Limb of the Moon was nearly equal to the Moon's Diameter		3 35 0
4	3 41 0	*Jupiter* so far dist. from the Limb of the Moon, as is the Distance of M. *Porphyrites* from Mount *Sinai*		3 43 0
5	3 58 0	*Jupiter* was as far from the Eastern Limb of the Moon, as Mount *Ætna* is from *Palus Maræotis*		4 00 0
6	4 13 50	*Jup.* dist. from the limb of the M. two Diam. of *Jup.*		4 16 15
7	4 14 40	*Jupiter* was distant one of his Diameters		4 17 5
8	4 15 40	*Jupiter* grazed upon the Eastern Limb of the Moon		4 18 5
9	4 16 9	Half *Jupiter* was hid		4 18 34
10	4 16 35	All *Jupiter* was quite cover'd		4 19 0
11	5 14 0	A notable part of *Jupiter* now seem'd to come out		5 16 25
12	5 14 20	Half *Jupiter* was now come out		5 16 45
13	5 14 45	All *Jupiter* was now come out		5 17 10
	10 22 30	Altitude of the Sun ——— ———	53 34 44	10 25 2
	10 27 16	Altitude of the Sun ——— ———	53 59 45	10 29 42
	10 30 8	Altitude of the Sun ——— ———	54 14 0	10 32 26
	10 38 0	Altitude of the Sun ——— ———	54 53 40	10 40 26
	10 45 28	Altitude of the Sun ——— ———	55 27 20	10 47 46

2. At $3^h\ 0'\ 11''$, the first *Satellite* was hid by the East Limb of the Moon. At $3^h\ 2'\ 0''\frac{1}{2}$ the East Side of the Moon touched the West-side of *Jupiter*: then I took the Height of *Jupiter*, which was 8° 01′, at $3^h\ 2'\ 51''$. At $3^h\ 2'\ 57''$, *Jupiter* was intirely hid by the Moon. It entered at equal Distance from the two Spots *Grimaldi* and *Aristarchus*; the last of which was in the Section of the Moon, which distinguished the Light from the Dark Part. At $3^h\ 5'\ 1''$, the second *Satellite* was hid by the East-side of the Moon, At $3^h\ 5'\ 48''$, the third *Satellite* was hid. At $3^h\ 56'$, we perceived by the Eye that *Jupiter* was parted from the obscure Side of the Moon.

At Paris, by M. Cassini. ib. p. 33.

M. *De la Hire* took the Height of *Jupiter* two Minutes after parting, and found it 17° 17′.

LXV. *An Occultation of the* Bull's Eye, *at* Greenwich, *Sept.* 4. 1680. *by Mr.* Flamsteed. *Ph. Coll.* n. 4 *p.* 99.

Time corrett. in the Morning.	*Observations.*				
h. ′ ″			′	″	
2 49 52	South Cusp of the M. from the Bull's Eye	5300	=26	26	
2 53 10	The Bull's Eye from the nearest Limb	1028	=05	08	
2 56 54	From the said Cusp ——— ——	4830	=24	06	
3 01 16	Repeated—— ——	4370	=21	48	
3 05 42	Immersion by the Cusp ——— ——	4049	=20	12	or something less.
4 08 20	The Diameter of the Moon	6595	=32	54	
	Repeated by my Assistant ——	6588	=32	52	
4 14 02	The Bull's Eye emerged —— ——				
4 15 12	Was distant from the Southern Cusp	3411	=17	01	
4 18 52	Repeated———	3725	=18	35	
4 22 00	Again —— ——	3980	=19	51	
4 23 52	Once more ———	4098	=20	56	

3ʰ 05′ 40″, the fixt Star seem'd to adhere to the bright Limb of the Moon, and after two Seconds of Time nothing appear'd in the Limb. The Place of Immersion was near the most Southern of three small Spots lying in the middle between *Palus Maræotis* and Mount *Climax*.

At 4ʰ 13′ 45″, the first Star was not yet emerged ; then, or a little afterwards, I know not on what Occasion, I removed my Eye from the Telescope, and when I apply'd it again at 4ʰ 14′ 2″, I saw the Star emerged, and shining with full Light.

h. ′ ″		° ′ ″
4 53 20	Nearest Limb of the M. from the bright Foot of *Orion*	26 12 25
4 56 20	The bright foot of *Orion* from the Bull's Eye	26 29 25
4 58 20	Nearest Limb of the M. from bright Foot of *Orion* again	26 12 00
5 04 02	The nearest Limb of the Moon from *Pollux*	44 09 10
5 06 33	Repeated——	44 08 15
5 11 55	The bright Foot of *Orion* from the Bull's Eye	26 29 40

LXVI. *An Occultation of the* Bull's Eye *at* Greenwich, *Oct.* 28. 1680. *by Mr.* Flamsteed. *Ph. Coll.* n. 4. *p.* 100.

Time corrected.	*Observations.*		
h. ′ ″			′ ″
7 11 52	The Diameter of the Moon ———	6745	=33 39
7 16 26	Repeated———	6744	=33 39
7 19 46	The Bull's Eye from the bright Limb —	5895	=29 24
7 24 44	Repeated———	5095	=25 25
7 40 14	—— —— —— ——	3203	=15 59
7 51 2	—— —— —— ——	1817	=39 04

7 59

h. ′ ″			′ ″
7 59 34	——— ——— ——— ————	810	=04 02
8 02 09	——— ——— ——— ————	490	=02 26
8 06 09	It reached the Limb		
8 06 30	It disappear'd at the Longitude of *Palus Miris* towards the North, at its Northern Extremity.		

The Northern Limb of *Mæotis*, also of *Ætna*, had the same Declination with the Place of Ingress.

The Difference of the Declinations of the Place of Immersion, and of the Northern Limb of the Moon, was 2770=13′. 49″.

At 9h 2′ 58″, it emerged from the obscure Limb, at the Longitude of *Insula Major*, from its Northern Limit.

Its Passage was through the Place of Emersion, to its Diameter North from *Crete*, through the North Limb of *Sirbon*, and Mount *Climax*.

At 9h 10′ 20″, the Moon's Diameter was 6791=33′ 52″.

2. At *London*, we noted the *Immersion* at 8h 6′ 00″, and that Star was newly *emerged* at 9h 2′ 52″. *At* London; *by Mr.* Halley, *and Mr.* Haines. *Ph. Coll.* n. 5. *p.* 124.

3. Mr. *Benj. Harry*, Master of the *Berkley Castle*, riding at Anchor in *Ballasore* Road, about 20 Miles E. S. E. from the Town, observed that the *Moon* passed to the Northward of the *Bull's Eye*, about 24 or 25 Min. and by his Pendulum Watch, rectify'd by Altitudes and the Rising and Setting of the Sun, he noted, that precisely at 16h 00′ the *Bull's Eye* was in equal Altitude with the *Moon*'s Center, and that at 16h 30′ the Star was in equal Altitude with the lower Limb of the Moon, and at 17h 12′ the Occidental Limb of the *Moon* was in a Right Line with the *Bull's Eye* and *Capella*. *At* Ballasore *in* India; *by Mr.* Benj. Harry, *ib.*

LXVIII. *An Occultation of the* Bull's Eye *at* Dantzick, *Jan.* 1. st. n. 1681. *by M.* Hevelius. *Ph Coll.* n. 3. *p.* 65.

Times.	*Observations.*	*Altitudes.*	
h. ′ ″			
6 47 00	The Bull's Eye was so far distant from the Confine of Light and Shadow, as the Mount of *Christ* is removed from the lower Limb of the Moon.		
		°	′
7 37 00	The Star was hid at *Mare Syrticum*, under the Island *Cercinna*, the Altitude of *Andromeda*'s Head being then	50	32
7 46 00	The Altitude of *Andromeda*'s Head ——— ———	49	27
7 49 30	The same Altitude ——— ——— ———	48	55
8 46 00	The Bull's Eye again shone out at the greater Island of the *Caspian* Sea.		
	Therefore its Passage, in respect of the lunar Spots, was through *Mare Syrticum*, Mount *Athos*, under the Island *Lemnos*, and Mount *Didymus*, under the *Athenian* Bay, through the *Pontic* Sea, and the greater Island of *Mare Caspium*.		
8 51 00	The Altitude of *Andromeda*'s Head.	40	22

2. Mr.

At Ballasore; *by Mr.* Ben. Harry. *Ph. Coll.* n. 5. *p.* 125.

2. Mr. *Benj. Harry* in *Ballasore* Road obſerved, that the *Moon* paſt to the Northward of the *Bull*'s *Eye*, and that the Star and the *Moon*'s under-Limb were in equal Altitude when they were both 13° 45′ high to the Weſt, which gives the Time 14^h 49′; and when the *South Horn* of *Taurus* was 23° 30′ high, which makes the Time 15^h 13′, the Weſtern Limb of the Moon was in a Line with *Capella* and the *Bull*'s *Eye*.

At Avignon; *by M.* Gallet. ib.

3. The correct Time of the *Immerſion* was 6^h 18′ 22″, and the *Emerſion* at 7^h 19′ 46″.

A Tranſit of the Moon *below the three* Superior Planets, *and* Regulus, 1682, *at* Dantzick; *by M.* Hevelius. *n.* 143. *p.* 17. *n.* 151. *p.* 325.

n. 143. *p.* 18. *min.* 31. *ſec.* 17. n. 151. *p.* 326. *min.* 31. *ſec.* 55.

LXVIII. *Sept.* 27. *N. S.* 1682, at Three in the Morning, I ſaw with my naked Eye the Moon and the three other Planets; but the Moon at that Time was ſtill diſtant about 7 Degrees, according to the Order of the Signs, towards the Weſt.

But as far as may be collected from the Inclination of the Horns of the Moon in reſpect of the Tendency of the Planets, I preſently concluded, that there would be no Occultations but only Tranſits; ſo as that the Moon would proceed below thoſe ſuperior Planets. In this Opinion I was more and more confirmed, when the following Day, *Sept.* 28. in the Morning, *Regulus* was not cover'd by the Moon, which Star, in reſpect of the Latitude of each, ſhould rather have undergone an Occultation. For *Regulus* in the Conjunction, at 4^h 6′, was diſtant 31′ 17″ towards the North from the upper Horn of the Moon; as I obſerved exactly with an excellent Tube and a very good Micrometer; ſo that there was no Occultation at all of *Regulus*, but only a Tranſit of the Moon. The ſame alſo happen'd *Octob.* 25. And *Jupiter* and *Saturn*, as alſo *Mars*, on *Oct.* 26. were not at all cover'd by the Moon, but the Moon paſs'd far enough beneath the ſaid Planets.

An Occultation of Regulus *by the* Moon, *Feb.* 11. ſt. n. 1683. *at* Dantzick; *by M.* Hevelius. n. 151. *p.* 331.

LXIX. *Feb.* 11. *N. S.* 1683, at 9^h. When firſt the Moon approached my Eye, *Regulus* was at a ſufficient Diſtance towards the Eaſt. So that the Conjunction itſelf (as far as I could make a rude Eſtimate) happen'd at the Riſing of the Moon at Five or Six a-Clock. But whether *Regulus* had been cover'd, or whether it was only a Tranſit, I could not be intirely ſatisfied.

Time.

Time by the Watch.		Distances and Alt.
h. ′ ″		
9 53 30	The beginning of the Occultation of the greater little Star A, of the 5 Magnitude	
10 08 30	The Conjunction of the Moon and the little Star C was distant from the lower Horn of the Moon	° ′ ″ 0 04 00
10 29 36	The beginning of the Occultation of the little Star B of the sixth Magnitude	
10 52 50	The end of the Occultation of the Star A.	
11 45 30	The Altitude of *Lyra* — —	31 44 00
11 46 30	The same — — —	31 55 00
11 47 50	Again — — —	32 06 00

LXX. *An Occultation of two fixed Stars by the* Moon, *and a Transit above of a Third*, Apr. 2. *st. n.* 1683. *at* Dantzick; *by M.* Hevelius. *ib.*

The Section of the Light and Shade this Day fell upon the Mounts *Serrorum* and *Carpathos*, through the *Sinus Peronticus*, between *Byzantium* and the Isle *Cyanea*, through the Mountains *Amanus* and *Taurus*, and the *Urian* Mountains.

The first little Star A is not to be found in *Tycho*'s Catalogue, but in my new one it is call'd, The Subsequent under the Bull's Horn of the fifth Magnitude. At this Time it is ♊ 19° 11′ 35″, and in 4° 43′ 44″ of Southern Latitude. The other B, as far as I could collect from this Observation, is in ♊ 19° 17′ 0″, and in South Latitude 4° 47′ 0″. But the third C, which is hardly to be seen with the naked Eye, is now to be found in ♊ 19° 9′ 0″, and in Latitude 5° 2′ 0″ South. Now the Star A entered the Moon at Mount *Audus*, pass'd over the Island *Cercinna*, Mount *Neptune*, the *Adriatick* Sea, between Mount *Horminium* and Mount *Amanus*, over Mount *Hercules*. So that it emerged again between *Palus Mæotis* and the greater Island of the *Caspian*. Whence it is plain that this little Star A was nearly in a central Conjunction with the Moon.

The other Star B of the sixth Magnitude entered the Moon at *Palus Maræotis*, pass'd through *Sinus Syrticus*, to Mount *Athos*, by Mount *Latmus*, between the Mountains *Sipylus* and *Macystus*, below the Center of the Moon, by the upper Mount *Moschus*, through the *Pontic* Sea, and so below the greater Island of the *Caspian* Sea.

An Occultation of a fixed Star, and a Transit above another, May 2. st. n. 1683. at Dantzick; by M. Hevelius. ib.

LXXI. *May* 2. *n. st.* 1683, at 11^h^ 0′ 0″ in the Evening. The Moon passed above the little Star at the Root of the Tail of *Cancer*, which then was in ♋ 27° 53′ 37″, in South Latitude 2° 18′ 42″; so that in the very Conjunction it was not distant from the lower Horn of the Moon above 12′.

At 12^h^ 0′ 0″, another fixt Star, but a very small one, was cover'd, which otherwise is not in the Catalogue. As far as can be guess'd it was in ♋ 28° 30′, and in South Latitude 1° 54′.

An Occultation of Regulus by the Moon, May 4. st. n. 1683. at Dantzick; by M. Hevelius. ib.

LXXII. I observed most exactly the very Moment of Immersion, which happen'd at 11^h^ 17′ 20″, in the Evening, according to my Watch. The Line of Passage went through *Mare Pamphilium*, below the Island *Carpathos*, the Isle of *Cyprus*, below the utmost Bay of *Pontus*, and the lower Bay of *Mare Caspium*. At 11^h^ 24′ 42″, according to my Watch, the Altitude of the bright Star of the Harp was observed to be 44° 39′ 00″; from whence the beginning of the Occultation may be corrected. The Section of Light and Shade was through the greater black Lake, at the Island *Corsica*, Mount *Niconius*, thro' the *Strymonic* Lake, and the Isle of *Rhodes*; by Mount *Sinai*, and Mount *Techisandam*.

An Occultation of Jupiter by the Moon, Mar. 31, 1686. at London; by Dr. Hook, and M. Halley. n. 181. p. 85.

LXXIII. 1. At 9^h^ 26″ the under Limb of the *Moon* was just risen, and soon after *Jupiter* appeared near the Eastern-Limb of the *Moon*, within a few Minutes of being *eclipsed*.

9^h^ 33′, as near as could be guessed, was the Time of the *Central Immersion*, which was very difficult to be observed by reason of the Asperity of the *Moon*'s Limb, which undulated and sparkled very much, as it appeared through the Vapours near the Horizon: The *Ingress* happened much about the length of the Spot, called by *Hevelius*, *Palus Maræotis*, to the North of the said Spot, or about the 124th Degree of the outer Limb of his *Selenography*, nearly in the same Latitude with the *Moon*'s Center.

10^h^ 30′. The Western Edge of *Jupiter* began to *emerge* out of the dark Limb of the *Moon*.

10^h^ 31′ 20″. The whole Disk of *Jupiter* was entire, so that he was about a Minute and a Third in coming out from behind the *Moon*.

The *Emersion* was exactly in a right Line with the *Moon*'s *Center* and the Northern Part of *Palus Mæotis*, or about the 324th Degree of the inner Limb of the *Selenographick Table* of *Hevelius*.

Time corrected by Pend. Clock				2. At Greenwich; by Mr. Flamsteed. n. 184. p. 206.
h. ′ ″				
9 32 30	*Jupiter*'s Limb touch'd the bright Limb of the Moon, the Diameter of *Maræotis* from its Northern Limit.			
9 33 42	*Jupiter* was wholly cover'd, as far as could be guess'd by means of the Vapours of the Horizon, and the Undulation of the Limb which was very turbid.			
10 11 12	The Difference of the Declinations of the Limb of the Moon which was truly Southward, and of the place of Ingress; by a Tube of 8 Feet and a Micrometer.	1546=	′ 12	″ 42
10 30 30	A little part of *Jupiter* emerged over against the Northern Limb of *Mæotis*.			
10 31 36	All *Jupiter* was free.			
10 35 50	The Difference of Declinations of the Center of *Jupiter*, and the Southern Limb of the Moon	3436=	28	15
10 41 40	Repeated—	3585=	29	28
10 44 00	The Diameter of the Moon — —	3906=	32	07
10 45 44	Repeated—	3915=	32	11

3. At 10^h^ 19′ 56″, *M. I. Ja. Zimmerman* observed the first *Contact* of the Limbs of *Jupiter* and the Moon, and at 10^h^ 20′ 47″, *Jupiter* was all *eclipsed*. *At Nuremburg; by M.* Zimmerman. *n.* 183. p. 177.

At 11^h^ 22′ 51″, *Jupiter* was wholly *clear* from the *Eclipse*.

The *Immersion* was about the 117th, the *Emersion* at the 321st Degree of the Limb, in the *Chart* of *Hevelius*.

At 11^h^ 31′ 06″, the third Satellite of *Jupiter emerged*. These Times were collected from the Culminations of fixed Stars, and the Vibrations of a Pendulum.

4. At 10^h^ 20′ 50″, *Jupiter* applied to the Limb of the Moon, over-against the *Loca Paludosa Insulæ Cercinnæ*. *By M.* Wurtzelbauer. *ib.*

At 10^h^ 22′ 00″, he appeared about half *eclipsed*.

At 10^h^ 22′ 30″, he was wholly *hid*.

At 11 19′ 40″, *Jupiter* began to *emerge*.

At 11^h^ 21′ 20″, he was quite *free* from the Interposition of the Moon. The Point of the *Emersion* was somewhat to the North of the *Palus Mæotis*. No Spot in the Moon was so near the apparent Magnitude of *Jupiter*'s Disk as the *Insula Besbicus Hevelii*.

At 11^h^ 40′ 00″, the Altitude of *Procyon* was 8° 37′; whence the Pendulum Clock, which had been set by Altitudes of the Sun the Afternoon preceding, may be examined.

At Dantzick, by M. Hevelius. ib. p. 178.

5. Tho' hitherto for 56 Years I have neglected no Obſervation of any Moment, yet I have not been able rightly to take and note down above three Eclipſes of *Jupiter*. The firſt was *An.* 1646. *Dec.* 24. in the Evening; but then I could only obſerve the End. The ſecond was *An.* 1679. *June* 5. in the Forenoon; at which Time the whole ſucceeded as I could wiſh. The third was this preſent Year 1686. *Apr.* 10. in the Evening.

Among other things this is to be noted, that this Occultation did not happen when the Moon was quite in the full, but about a Day after the full Moon, in the Evening. And likewiſe at the ſame time, (which is very wonderful, and is a Coincidence which hardly ever happens) and with the ſame Appearance, as was ſeen in that Occultation *An.* 1646. *Dec.* 24. in the Evening. At which Time the Moon had now decreaſed for two Days, and without doubt it exhibited the ſame Libration alſo, as in this our laſt Obſervation. For the Section of Light and Shadow was juſt the ſame, and paſs'd through the ſame Spots, which I cannot ſufficiently admire; that is, at the greater and leſſer *Hyperborean* Lake, alſo at the *Riphean* Mountains, through *Palus Mæotis*, by the greater Lake of the *Caſpian* Sea, and its lower Bay to Mount *Neroſus*.

On the contrary, the Occultation of *Jupiter* obſerved by me *An.* 1679. was very different, as it happen'd not about the full Moon, but the new Moon, about three Days before the Conjunction.

Hour by the Watch.		*Altitudes taken with a Quadrant*	*Time corrected by the Alt.*
h. ′ ″		Gr. ′ ″	h. ′ ″
5 10 10	The Sun's Altitude.	13 47 0	5 11 43
5 12 30	The Sun's Altitude.	13 28 0	5 13 55
5 17 40	The Sun's Altitude.	12 41 0	5 19 21
5 23 50	The Sun's Altitude.	11 46 0	5 25 43
8 7 10	The Altitude of *Arcturus*.	29 55 0	8 12 50
8 11 15	The Altitude of *Arcturus*.	30 32 0	8 17 4
8 15 10	The Altitude of *Arcturus*.	30 59 0	8 20 51
	The Moon riſes about—— —— ——		9 24 0
9 44 50	*Jupiter* was diſtant from the Iſland of *Cercinna* about 43 Minutes.		9 52 50
10 21 30	*Jupiter*'s Diſtance was ſuch, as the Diſtance of M. *Sinai* from *Palus Maræotis*.		10 31 30
10 40 35	*Jupiter*'s Diſtance was nearly equal to the Diſtance between Mount *Ætna* and Mount *Porphyrites*.		10 51 5

The

h. ′ ″			h. ′ ″
10 51 30	The Limb of *Jupiter* was as far distant from the Limb of the M. as *Pal. Maræotis* from the Limb of the M.		11 2 0
10 56 9	*Jupiter* with his Limb began to touch the Limb of the M. and thus the beginning of the Occultation came on.		11 7 9
10 56 54	Half *Jupiter* was hid.		11 7 54
10 57 39	All *Jupiter* was wholly cover'd by the Moon.		11 8 39
11 8 31	The Occultation of the outmost of *Jupiter*'s Companions happen'd at *Mons Alabastrinus*.		
	Only two of his Companions could be seen on the Eastern Side.		
11 15 54	The Altitude of *Lyra*.	32° 59′ 0″	11 26 0
11 19 0	The Island *Besbica* and *Rhodes* were found under the same Perpendicular, which was removed about 35 Degrees from the vertical Line of the Moon.		
11 21 37	The Altitude of *Lyra*.	33 50 0	11 32 15
11 24 57	Again.	34 24 0	11 36 24
11 38 15	The beginning of *Jupiter*'s Emersion.		11 49 15
11 39 0	Half *Jupiter* emerged.		11 50 0
11 39 45	All *Jupiter* appeared.		11 50 45
	Diam. of the M. observed with a Microm. was 31′ 0″.		
11 54 10	The Distance of *Jupiter* from the Confine of Light and Shade was equal to the Distance of Mount *Ætna* from Mount *Porphyrites*.		12 5 40
11 57 20	Distance of *Jupiter* from the Confine of Light and Shade was equal to the Dist. between the Island *Besbica* and Mount *Ætna*. And the most remote of *Jupiter*'s Companions was as far distant from *Jupiter*, as that Companion from the said Confine of Light and Shade.		12 9 20
12 6 9	The Altitude of *Lyra*.	40 19 0	12 18 39
12 9 18	The same Altitude again.	40 46 0	12 21 40
12 13 20	The Altitude of the Moon.	16 15 0	

First it is plain from the Observation itself, that the Path or Line of *Jupiter*'s Passage was by Mount *Alabastrinus*, by the Mount of *Christ*, Mount *Carpathos*, below Mount *Macrocemnios*, and by the lower *Hyperborean* Lake. Secondly, that the Island *Besbica* and the Isle of *Rhodes* were under the same Perpendicular, at the Time of the Occultation, about $11^h\ 30'$; so that 35 Degrees of the Moon's Limb culminated. Therefore *Jupiter* enter'd the bright Limb of the Moon about the 61 Degree, that is, from the Perpendicular Line of the Nonagesm and the Point of the Zenith, towards the East. And he went out about the 31 Degree from the said perpendicular Line of the Nonagesm towards the West, at the obscure Limb of the Moon. Therefore *Jupiter*'s Path-Line was a Subtense of almost 104 Degrees, in the North Part of the Moon.

Besides it is very well worth observing, that from this Observation I could derive the Diameter of *Jupiter* exactly; which was 51″ 42‴. And of this Magnitude was the Diameter of *Jupiter*, or about 50″, whenever I measured it by the Spots of the Moon. But in the Year 1679, on the 5th of *June*, when I observed a like Eclipse of *Jupiter*, it was much less than this, being only 30″ 53‴. Which I imagine to proceed from hence, because that Observation was made in the Day-time, and while the Sun shined, when the adventitious Rays of the Stars and Planets are more dispell'd by the Sun's Light, than in a dark Night. Now if you should inquire which of these apparent Diameters I take to be the truer, I should answer that which was observed on the 5th of *June* in the Year 1679, when the Sun shined. Not because the last was not observed with the same Diligence and Exactness; but because, as I said before, the adventitious Rays in the Night-time are a greater Hindrance than in full Day-light.

At Paris; *by M.* Cassini. *n.* 183. p. 175.

6. At 9ʰ 31′ 6″, *Jupiter* was in a Perpendicular falling on the Limb of the *Moon* over-against the Northern-part of the Spot *Grimaldi*, (*Maræotis*) near to *Riccioli* (*Stag. Miris*) and distant from the Limb about 4 Times as much as the said Spot.

9ʰ 40′ 21″, *Jupiter* touched the Circumference of the *Moon*, which undulated by reason of the Vapours near the *Horizon*.

9ʰ 41′ 20″, He quite disappeared in the Inequalities of the *Moon*'s Limb, the *Total Immersion* might be some Seconds later. So the *Central Immersion* was at 9ʰ 40′ 51″. *Jupiter* entered over-against that Part of *Grimaldi* next *Riccioli*.

10ʰ 30′ 2″, The *outermost Satellite* which preceded *Jupiter* appeared over-against the Middle of the *Caspian Spot* (*Pal. Mæotis*) through which the *Section of Light and Darkness* passed, and made nearly an Equilateral Triangle, with the Extremities of that Spot.

10ʰ 40′ 24″, The first Limb of *Jupiter* began to come out of the dark Side of the *Moon*, over-against the North-part of the *Caspian* Spot, about *Cleomedes*, (*ad Montes Riphæos.*)

10ʰ 40′ 56″, The Center of *Jupiter* did *emerge*. It was difficult to distinguish the Moment when *Jupiter*'s Disk was fully clear, but at 10ʰ 41′ 36″, the Eclipse was certainly past.

At the *Emersion* of the Center, the Altitude of *Jupiter* was 11° 31′.

At 10ʰ 42′ 49″, The *Second Satellite*, being the nearest of the three that followed the Planet, *emerged*.

At 10ʰ 45′ 1″, The *Innermost Satellite*, being near its greatest *Elongation*, *emerged*.

At 10ʰ 50′ 40″, The *Third*, or *Penextimus Satellites*, being likewise near its greatest *Elongation*, began to appear over-against the Northern-Edge of the *Caspian* Spot.

At

At $11^h\ 45'$. The Diameter of the *Moon* was $32'\ 27''$; and according to the *Calculus* of M. *Cassini*, her *Parallax* was 61 Min.

7. The Central *Immersion* was at $9^h\ 42'\ 13''$; and the Central *Emersion* at $10^h\ 45'\ 26''$, over-against the Southern-part of the *Caspian* Spot. *At* Avignon; *by* R. P. Bonfa. *ib. p.* 176.

LXXIV. 1. The *Immersion* was seen at *Totteridge* (which Place is about 9 Miles from *London*, and nearly 25″ of Time to the Westward thereof) by Mr. *Ed. Haines*, who between a Gap of the Clouds observed the *Contact* of the *Moon*'s Limb and *Jupiter*'s, at $3^h\ 3'\frac{1}{2}$. *An Occultation of* Jupiter *by the* Moon, Apr. 28. 1686. *n.* 181. p. 87.

The Clouds closing again permitted him to observe no more: however from this we may conclude the *Central Immersion* at *London*, to have been $3^h\ 4'\frac{1}{2}$, *mane*.

The *Emersion* was observed at *London*, by Mr. *Edm. Halley*, to fall out at $3^h\ 49'$: for at $3^h\ 50'$, *Jupiter* was all out, and the Limbs so little separated, that he judged, that a Minute before, the *Center* of *Jupiter* had been upon the *Moon*'s Edge: The Point of the *Emersion* was over-against the Southern-part of the Spot, call'd by *Hevelius Insula Macra*, or at the 342d Division of the inner Limb of his *Map* of the *Moon*.

2. The *Immersion* of the *Center* happened at $3^h\ 37'\ 23''$, on the East-side of the Spot *Xenophanes*. The *Emersion* was at $4^h\ 28'\ 24''$, between *Seneca* and *Berosus*, according to *Riccioli*, or *ad Montes Alanos Hevelii*, a little to the Northward of the *Palus Mæotis*. *At* Avignon; *by* R. P. Bonfa. *n.* 183. p. 177.

3. *At* Dantzick; *by M.* Hevelius. *ib.* p. 184.

By the Watch.			*Time corrected.*
h. ′ ″		° ′ ″	h. ′ ″
3 23 20	Altitude of *Arcturus*.	31 16 0	3 20 12
3 24 25	The same Altitude.	31 04 0	3 21 35
3 44 30	*Jupiter* was distant from the M.'s Limb by a greater Interval than that of Mount *Sinai* from Mount *Ætna*.		3 41 30
3 47 00	*Jupiter*'s Distance was as much as that of Mount *Porphyrites* from *Byzantium*.		3 44 00
3 52 00	Distance of *Jupiter* from the Limb of the M. was equal to the Dist. of the Isle of *Sardinia* from *Pal. Maræotis*.		3 49 00
3 59 00	*Jupiter* was distant from the Limb of the Moon something more than *Palus Maræotis* from *Ætna*.		3 56 00
4 16 40	Dist. of *Jupiter* from the Limb of the Moon was almost equal to that of M. *Porphyr*. from the Island *Cercinna*.		4 13 40
	The Planets were now set.		4 17 00

LXXV. 1. *An Occultation of* Saturn *by the* Moon, Mar. 19. 1686-7 *at* Totteridge; *by Mr.* Ed. Haines. *n.* 186. p. 268.

The Hour by a large Clock.				*The Time corrected.*
h. ′ ″		°		h. ′ ″
12 06 10	The Altitude of *Pollux.*	28	35	12 12 14
12 16 47	———————	26	59	12 22 47
1 18 00	The Limb of the Moon touched the Weſtern Anſa of *Saturn.*			1 24 00
1 18 30	The Immerſion of *Saturn*'s Center a little below *Palus Maræotis.*			1 24 30
1 19 00	Now *Saturn* was quite hid.			1 25 00
4 01 25	The Altitude of the Center of the Sun.	20	00	7 07 17
4 09 06	———————	18	55	4 14 43

In Ireland; *by* Dr. Aſh, *Biſhop of* Cloyn. *n.* 243. p. 293.

2. *March* 18. At Night I obſerved here the *Occultation* of *Saturn* by the *Moon*, which happened at $12^h\ 13'\ 55''$: it paſſed directly under the Midſt of the *Moon's Diſcus*.

Phaſes of Saturn, *An.* 1665. *at* Mainhead *near* Exeter; *by Mr.* William Ball. *n.* 9. p. 152. *Fig.* 132.

LXXVI. 1. *Oct.* 13. 1665. at ſix of the Clock, with a very good Teleſcope near 38 Foot long, and a double Eye-glaſs, *Saturn* appeared to me ſomewhat otherwiſe than I expected, thinking it would have been decreaſing, but I found it as full as ever, and a little hollow above and below.

An. 1666. *at* London; *by Dr.* Hook. *n.* 14. p. 246. *Fig.* 133.

2. *June* 29. 1666. between 11 and 12 at Night, I obſerved the Body of *Saturn* thro' a 60 Foot Teleſcope, and found it exactly of the Shape repreſented in the Figure. The *Ring* appeared of a ſomewhat brighter Light than the Body; and the black Lines *a a*, croſſing the *Ring*, and *b b*, croſſing the Body (whether Shadows or not I diſpute not) were plainly viſible; whence I could manifeſtly ſee, that the Southernmoſt part of the *Ring* was on this ſide of the Body, and the Northern-part behind or covered by the Body.

An. 1668. *at* Paris; *by M.* Hugens *and M.* Piccart. *n.* 45. p. 900.

3. *Aug.* 17. 1668. at $11\frac{1}{2}^h$ theſe *Pariſian* Obſervers, imploying a Teleſcope of 21 Foot, ſaw the *Globe* of *Saturn* in the Middle manifeſtly appearing above and below, beyond the Oval of his *Anſes*; which was hardly diſcernible the laſt Year. They meaſured divers ways the *Inclination* of the greater Diameter of the *Oval* to the *Æquator*, and found it of about 9 Degrees. By this Obſervation and other like ones of this and the preceding Year, M. *Huygens* finds, that, inſtead of 23° 30′, the Angle of the Planes of the *Ring* and of the *Ecliptick* muſt be of 31°, or thereabouts.

An. 1670. *at* Dantzick; *by M.* Hevelius. *n.* 65. p. 2089. *Fig.* 134.

4. *Aug.* 26. New Style, 1670. That Teleſcope of 50 Foot long, which you lately ſent me, ſhew'd me the Face of *Saturn* very plainly and clearly, notwithſtanding the Preſence of the Moon. Now how it appear'd to me may be ſeen by this Delineation. It had a very different Appearance from what was ſeen by Mr. *Huygens*, and you alſo, *An.* 1666. and likewiſe by the *Paris* Obſervers

Obſervers in 1668. For the Ring which encompaſſes *Saturn* was now found to be much narrower and cloſer than at that Time, its Path now being much more oblique in reſpect of the Earth.

5. This Summer Mr. *Huygens* obſerved *Saturn* with his Teleſcope of 22 Feet, and ſaw his Figure to be very conformable to what it ſhould be according to his *Hypotheſis*; viz. the *Anſæ* or Arms to be very narrow, inſomuch that their Opening appeared not but very obſcurely. *At* Paris; *by M.* Huygens. *Ib.* p. 2093.

6. *Sept.* 16. Dr. *Hook* obſerved the Phaſe of Saturn as here repreſented, *Fig.* 135. *At* London; *by* Dr. Hook. *ib.*

7. *Saturn*, according to the *Hypotheſis* of Mr. *Huygens*, was to have retaken his *Round Figure* in the Months of *July* and *Auguſt* 1671. But this Appearance hath been perceived ever ſince the End of *May*, at a Time when he was diſtant enough from the *Sun* and the *Horizon*, to be well obſerved. He hath remained in this Figure unto the 11*th* of *Auguſt*, and Mr. *Caſſini* did then obſerve him thus; but three Days after he ſaw him with *Arms*, though very narrow ones. An. 1671. *at* Paris; *by M.* Caſſini. *n.* 78. p. 3024.

8. Our *Philoſophers* here know very well, that as ſoon as Mr. *Caſſini* had told me that the *Arms* of *Saturn* were returned in *Auguſt*, I ſaid that aſſuredly they would diſappear before the End of this Year. I ſtill obſerved them, *Nov.* 6. *ſt. n.* in the Evening, but they were ſo faint and obſcure, that it was hard to diſcern them; ſo that within a few Days they will appear no more at all. This confirms altogether my *Hypotheſis* of the *Ring*, which now diſappears in proportion as the Rays of the *Sun* do obliquely illuminate the flat Surface of it, obverted to our Sight. *By M.* Huygens. *ib.* p. 3025, 3026.

9. How it appear'd lately, on *Sept.* 11. New Style, I have delineated very truly and carefully, and have here ſent you the Scheme. But in the Months of *June*, *July*, and *Auguſt*, that you ſhould ſee it quite round, as the *Pariſians* affirm, I can hardly imagine. For tho' the Arms of *Saturn* might appear very cloſe at the Sides, even in a Tube of 60 or 70 Feet, yet I can hardly think they could quite vaniſh, ſo that no Remains of them could be ſeen. Perhaps the *Pariſians* might view *Saturn* in ſhort Teleſcopes, during the Twilight, when the Moon was up. *At* Dantzick; *by M.* Hevelius. *ib.* p. 3032. *Fig.* 136.

10. *Oct.* 12. with my leſs Tube I thought I ſaw ſomething on each Side of *Saturn*, amidſt the Colours of my Glaſs, and the ſpurious Rays of his Body. Directing my longer Tube (of 14 Feet) to him, I could ſee his *Anſæ* ſomewhat more diſtinctly, but very ſlender, and to one, that thought not of them, ſcarce diſcernible. *At* Derby *by Mr.* Flamſteed. *ib.* p. 3034.

Nov. 30. I obſerved him with my 14 Foot Teleſcope, the Aperture being $1\frac{1}{2}$ Inch, and its Eye-Glaſs drawing two Inches. He appeared perfectly *round*, free from Rays and Colours, and no *Anſæ* to be ſeen. Mr. *Townley* in his laſt (*Nov.* 20.) tells me, that he looked at him one Night, and could hardly diſtinguiſh his Line of the *Anſulæ*, but plainly ſaw a dark Line through him near his upper Part.

11. *Dec.* 16. we found that *Saturn* had retaken his *round Figure*. *At* Paris; *by M.* Caſſini. *n.* 92. p. 5180. An. 1675.

12. *June* 27. in the Morning 1675. we ſaw *Saturn* improved with his wide and open *Anſæ*. *At* London; *by Mr.* Flamſteed. *n.* 116. p 372.

13. In *Auguſt*, the Figure of *Saturn* appear'd, as *Fig.* 137. *At* Dantzick; *by M.* Hevelius. *n.* 127. p. 661.

14. From

An. 1676. at Paris; by M. Cassini. n. 128. p. 690. Fig. 137. Fig. 138.

14. From the Scheme of *Saturn*, as observed by Mr. *Hevelius* a Year ago, I perceived that he made use of Telescopes which were much inferior to ours. For at that Time, as also now *Aug.* 1676. in the Globe of *Saturn*, an obscure Zone was seen by us, a little to the South of the Center, not unlike the Zones of *Jupiter*. Moreover the breadth of the Annulus was divided into two Parts, by an obscure Line that to appearance was elliptical, but was really circular, as it were into two concentrick Rings, the Interval of which was brighter than the External. I saw this Phasis immediately after the Emersion of *Saturn* out of the Sun's Rays through the whole Year quite to his Immersion; first with a Telescope of 35 Feet, and afterwards with a less of 20 Feet.

Places of Saturn *observed An.* 1670, *at* Dantzick; *by M.* Hevelius. *n.* 63. p. 2089.

LXXVII. 1. *Aug.* 26. *st. n.* 1670. I saw *Saturn*, the Altitude of *Aquila* being 24° 32′ 0″, at the Distance of 33° 48′ 0″, from the utmost Wing of *Pegasus*, and 24° 51′ 40″ from his Mouth; in 4° 11′ of *Pisces*, and in 1° 53″ of South Latitude, being then in Opposition to the Sun.

An. 1677. *at* Paris; *by M.* Bullialdus. *n.* 139. p. 973.

2. *Dec.* 29. new Style, 1677. at 8^h 58′. In the same Azimuth, and in the nonagesim Degree of the Ecliptick from the Horizon, we saw *Saturn* and the Northern Eye of the Bull, which was below *Saturn.* Whence we found that the Planet and the fixt Star had the same Longitude in the Zodiack; that is, ♊ 3° 58′ 53″, according to *Tycho*.

The outermost Satellite *of* Saturn *discover'd by M.* Cassini. *n.* 92. p. 5178.

LXXVIII. 1. About the End of *October* 1671. we discovered, by a Telescope of 17 Feet, 11 small Stars near *Saturn*, one of which by its particular Motion shew'd itself to be a true *Planet*; which we found, by comparing it not only to *Saturn* and his ordinary *Satellite*, discovered 1655 by *M. Huygens*, but also to the Fix'd Stars. The Motion of it was very manifest in respect of the Fix'd Stars, but less sensible in respect of *Saturn*; yet it appear'd, that from *October* 25, unto *November* 1, his Distance from *Saturn* increased Westward, and from that time unto *Novem.* 6. it diminished: So that his greatest *Digression* from *Saturn* happened in the Beginning of *November*.

Dec. 16. We found that on the East of *Saturn*, there was a small Star, far distant, in a streight Line to *Saturn*, and to his ordinary *Satellite*, which was Oriental also, but little distant from *Saturn.* And *Dec.* 24*th.* we saw this *Satellite* in the West, and a Star, Oriental likewise, less distant from *Saturn* than that we had seen the 16*th*.

Dec. 13. and 17. 1672. We perceived, with an excellent Telescope, (of 35 Feet, made by *Campani*) an Occidental Star, remote from *Saturn*, which in both those Observations had a Southern Latitude in respect of the Line of his *Wings*; but in the first it was further distant from *Saturn* than in the second: so that, if this was the same Star, as I suppos'd it to be, it mov'd towards *Saturn* on the East, and consequently (supposing it to be his *Satellite*) it was in the superior Part of his Circle.

Feb. 6. 1673. We began to see him again, and we observed him almost all the Days following till the 20*th*. This new *Planet* did more and more remove from *Saturn* till the 19th of *Feb.* when we measured the Difference between his Passage and that of the Center of *Saturn* to be 30″ of an Hour, which gave at least 10 Diameters of *Saturn*, and on the 20*th* the Distance was judged by Estimate to be yet greater.

This Digreſſion, being treble to that of the *Ordinary Satellite*, enabled us at firſt to judge the Time of this Revolution to be Quintuple, applying to the *Satellites* that Proportion, which *Kepler* hath noted in the *Principal Planets*, between the Periodical *Times* and their *Diſtances*. We were afterwards confirmed in this Opinion; for by the apparent Swiftneſs of his Motion, it was eaſy to ſee that this *Planet* had been in Conjunction with *Saturn Feb.* 3. 1673. and by his Motion on the Weſt, it appears, that he was in the inferior part of his Circle: And becauſe during this time of 17 Days he remov'd more and more from *Saturn*, 'tis certain that he remained in the ſame Quadrant of the inferior Occidental Circle above 17 Days, and that his whole *Revolution* is more than 68 Days. He was theſe laſt Days at a Diſtance almoſt equal to that which he had about the end of *October* 1671; ſo that in 480 Days or thereabout he made a certain Number of Intire *Revolutions*, which can be no more than 7; ſince each of them is without Queſtion of more than 68 Days. If you ſhould count 7 of them, each would be $68\frac{1}{2}$ Days; if you count 6, each would be 80 Days; and if you count but 5, each would be 96 Days. But this laſt Suppoſition can by no means be made to agree with the two Obſervations of *Dec.* 1672; and the firſt doth not agree ſo well with them as the ſecond. Ib. p. 5179, 5184.

Mr. *Caſſini* has ſince found, that this *outermoſt Satellite* is diſtant from the Center of *Saturn* $10\frac{1}{2}$ Diameters of his *Ring*; that the Period of his *Revolution* in 80 Days is ſo juſt, that he doth not anticipate 9 Revolutions, which are made in two Years, but by one whole Day; and that in the Conjunctions with *Saturn*, his Latitude encreaſes according as the *Ring* of *Saturn* enlargeth itſelf; though the Line of his Motion is not parallel to the Circumference of the *Ring*. n. 133. p. 831.

Mr. *Caſſini* hath alſo diſcovered, after many Revolutions, that this *Satellite* hath a Period of *Apparent Augmentation* and *Diminution*, by which Period he becomes viſible in his greateſt Occidental Digreſſion, and inviſible in his greateſt Oriental Digreſſion; he begins to *appear* two or three Days before his Conjunction in the inferior part, and to *diſappear* two or three Days after his Conjunction in the ſuperior part: So that he remains inviſible in every Revolution of 80 Days for a whole Month together.

This Viciſſitude of *Phaſes* makes it ſeem probable, that one part of his Surface is not ſo capable of Reflecting to us the Light of the Sun, which maketh it viſible, as the other part is. Whence we may conjecture, that the *Globe* of the *Satellite* hath ſome Diverſity of Parts analogous to that of the Earth, the one part of whoſe Surface is cover'd by the Sea; which is not ſo fit to reflect from all parts the Light of the Sun, as the Continent which maketh up the other part: So that this *Planet* by a Converſion about his *Axis*, or by an Expoſition of the ſame Hemiſphere to *Saturn* (much after the manner of the Hemiſphere of the *Moon* to the *Earth*) ſometimes turns to us the part analogous to the Continent, ſometimes that part which anſwers to the Sea.

The Third Satellite of Saturn discover'd; by M. Caffini, *n.* 92. p. 5181.

LXXIX. *Dec.* 23. 1672. We found a fmall Star Weftward of *Saturn*, between him and his *Ordinary Satellite*, which was on the Weft alfo, almoft at a double Diftance. *Dec.* 30. we faw a little Star, on the Eaft of him and his *Ordinary Satellite*, which had paffed alfo to the Eaft of him.

Jan. 10. 1673. This little Star appeared to have returned almoft to the fame Pofition in refpect of *Saturn* and his *Ordinary Satellite*, where it had been *Dec.* 23. *Jan.* 15. the *Ordinary Satellite* was Oriental, and the *New* one Occidental, as it had been in the precedent, but a little nearer to *Saturn*: We had that Evening time enough attentively to obferve this *Planet* for a whole Hour together, during which we perceived, it approached to *Saturn* on the Weft, and confequently was in the fuperior part of his Circle: Which did fully confirm us in the Suppofition we were inclined to, that it was an *Interior Satellite*.

Comparing the Obfervations together, we began to find the Rule of the Motion of the new *Interior Satellite*. For the two laft fhewed us, that in 5 Days he had made more than a whole Revolution. The firft Obfervation compared with the third made us judge, that in 18 Days he had made a Number of Revolutions, almoft whole ones, which certainly were 4; each of them was of $4\frac{1}{2}$ Days: So that between the 10*th* and 15*th* it might be, that there had been one Revolution of $4\frac{1}{2}$ Days, or two Revolutions of $2\frac{1}{4}$ Days each. But the Combination of the firft with the fecond, made us feclude the Period of $2\frac{1}{4}$ Days. We therefore judged by thefe Obfervations, that this laft *Planet* finifhes his Refolution about *Saturn* in $4\frac{1}{2}$ Days; that the Semidiameter of his Circle is $1\frac{5}{8}$ of the Diameter of *Saturn*'s *Ring*; and that he was towards his greateft Occidental Digreffion the 23d of *December*, and *Jan.* 1. about 7 a Clock in the Evening. We have fince found, that his greateft Digreffion from the Center of *Saturn* is only $1\frac{2}{3}$ of his *Ring*, and the Period of his Revolution is 4 Days 12^h and 27′. His Latitude augments alfo according as the *Ring* enlargeth, and at the prefent that the largenefs of the *Ring* is greater than the Diameter of the Globe of *Saturn*, he is to pafs in the Conjunctions without touching either *Saturn* or his *Ring*. Yet notwithftanding we have not yet been able to diftinguifh him in the Conjunctions either in the upper or lower part of his Circle; but only in his greateft, as well Oriental as Occidental, Digreffions.

n. 133. p. 833.

Two Interior Satellites of Saturn *difcover'd; by M.* Caffini. *n.* 181. p. 79.

LXXX. Thefe two *Satellites* were firft of all feen in *Mar. An.* 1684. by two excellent Object Glaffes of 100 and 136 Feet; and afterwards by two others of 93 and 70 Feet; all made by *S. Campani*, after the Difcovery of the 3d and 5th *Satellites*, which had been made by others of his Glaffes of 47 and 34 Feet. We have fince feen all thefe *Satellites* with that of 34 Feet, and continued to obferve them with Glaffes of *M. Borelli* of 40 and 70 Feet, and by thofe which *M. Ariouquel* hath lately made, of 80, 155, and 220 Feet. It was eafy for us to fee thefe two *Satellites* by thefe different forts of Glaffes, after having found the Rules of their Motion, whereby we might with more particular Attention look upon the Places where they ought to be.

The

The *First Satellite* was observed 45° distant from its *Perigee*, moving toward the West, *Mar.* 11. 1686. *st. n.* at 10^h 40′ at Night, and returned to the same Position on the 14th of *April* at the same Hour.

The *Second* was 36° distant from the *Perigee* to the West, the 30*th* of *Mar.* 1686. *st. n.* at 8 a Clock in the Evening.

The *First* or *Innermost Satellite*, is never distant from *Saturn*'s *Ring* above $\frac{2}{3}$ of the apparent Length of the same *Ring*; it makes one *Revolution* in 1^d 21^h 19′; and the Circle of its Orb is nearly in the same Plane with the *Ring*.

The *Second* or *Penintime Satellite* is $\frac{3}{4}$ of the Length of the *Ring* distant therefrom, and makes his Revolution in 2^d 17^h 43′.

After a great Number of choice Observations, it was concluded, that the Proportion of the *Digressions* of the *Second* to that of the *First*, (counting both from the Centre of *Saturn*) is as 22 to 17; and of its *Revolution* as $24\frac{3}{4}$ to 17. This is that very same Proportion which *Kepler* observes between the *Distances* and *Period* of the *Primary Planets*, and which we have found between the other *Satellites* of *Saturn*, and is verified in the *Satellites* of *Jupiter*. There is nothing that better shews the admirable Harmony of the particular *Systems* with the great *System* of the World.

The antient Astronomers having translated the Names of their Heroes among the Stars, whose Names have continued down to us unchanged, notwithstanding the Endeavour of the following Ages to alter them; and *Galileo* after their Example, having honoured the House of the *Medici* with the Discovery of the *Satellites* of *Jupiter*, made by him under the Protection of *Cosmus* II. (which Stars will be always known by the Name of the *Sidera Medicea.*) Wherefore the Discoverer concludes that the *Satellites* of *Saturn*, being much more exalted and more difficult to discover, are not unworthy to bear the Name of *Louis Le Grand*, under whose Reign, and in whose *Observatory* the same have been detected; which therefore he calls *Sidera Lodoicea*, not doubting but to have perpetuated the Name of that King, by a Monument much more lasting than those of Brass and Marble, which shall be erected to his Memory.

M. Huygens's Theory of the Fourth Satellite of Saturn corrected; by Mr. Ed. Halley. n. 145. p. 82. Mar. An. 1683.

LXXXI. The *Fourth* or *Penextime Satellite* of *Saturn*, first discover'd by M. *Huygens* 1655, I have of late frequently observ'd with a 24 Foot *Telescope*: And I perceiv'd that M. *Huygens*'s Numbers were considerably run out, and about 15° in 20 Years two swift; this made me resolve more nicely to enquire into it's *Period*, and accordingly I waited till I had gotten a competent Number of Observations, the most considerable whereof are these.

1682. *Nov.* 13. 13^h 00′ *p. m.* the *Satellite* appear'd on the North side of *Saturn*, and a Perpendicular let fall from it on the transverse Diameter of the *Ring*, fell upon the middle of the dark Space of the following *Ansæ*; and the same Night 19^h 00′, it had past the Conjunction, and the Perpendicular fell exactly on the Western Edge of the *Globe* of *Saturn*: the Northern Latitude and Retrograde Motion made it evident, that the *Satellite* was then in *Perigæo*.

Again,

Again, *Nov.* 21. 16^h 15′, this *Satellite* of *Saturn* was on his South-side; the Perpendicular on the Line of the *Ansæ* fell on the Middle of the dark Space of the Western *Ansæ*, and the same Night 19^h 00′, the Perpendicular fell precisely on the Center of *Saturn*, and the Distance therefrom was somewhat less than one Diameter of the *Ring*. By this it was evident that the *Satellite* was in *Apogæo*.

I observed it in *Apogæo* again on the 24*th* of *Jan.* 1683. at 8^h 00′ *p. m.* the Perpendicular on the Line of the *Ansæ* fell exactly on the Western Limb of the *Globe* of *Saturn*, and at 9^h 30′, *p. m.* the said Perpendicular fell within the *Globe* more than half way to the *Center*, and the Distance from the Line of the *Ansæ* towards the South, seemed much about one Diameter of the *Ring*.

Lastly, *Feb.* 9. 1683. 8^h 10′, *p. m.* it was again in *Apogæo*, and I could by no means discern towards which side it inclined most, nor whether the Transverse Diameter of the *Ring*, or the Distance of the *Satellite* therefrom, were the greater; so that at that time it was precisely *Apogæon*.

To compare with these, I chose two out of those of *Huygens*, which seemed the most to be confided in; the first made 1659. *March* 14. *st. n.* 12^h 00′ at the *Hague*; when the *Satellite* appeared about one Diameter of the *Ring* under *Saturn*; but it was gone so far to the Westward, that he concluded, that about 4 Hours before, or 7^h 40′ at *London*, it had been in *Perigæo*.

Again, *March* 22. 1659. 10^h 45′, the *Satellite* was a whole Diameter above the Line of the *Ansæ*, and the Perpendicular thereon fell nearly upon the Extremity of the Eastern *Ansæ*.

By the First of my Observations it appears that the *Satellite* was in *Perigæo* 1682. *Nov.* 13. 17^h 00′, *circiter*, at which time *Saturn* was 30^s 29° 39′ from the first Star of *Aries* in the *Ecliptick*, but the *Earth* reduced to *Saturn*'s *Equinoctial*, and the *Satellite* was 9^s 23° 46′, à 1^a ✱ ♈. And *March* 4. 1659. 7^h 40′, *Saturn*'s Place in the *Ecliptic* was 6^s 0° 41′; but the *Earth* reduced, and consequently the *Satellite*, in 11^s 28° 18′, *à Prima Stella Arietis*. The Interval of Time is 8655 Days, 9° 20′; in which the *Satellite* had made a certain Number of Revolutions to the Fix'd Stars, and besides 9^s 25° 28′, or 295 Degrees 28′, whose Complement to a Circle 64° 32′ is 2 Days 20^h 36′ Motion of the *Satellite*, according to *Huygens*. So that 8655 Days 5^h 56′, or 12467846 Minutes of Time, is the Time of some Number of intire Revolutions; and dividing that Interval by 15 Days 22^h 39′, or 22959′ (the Period of *Huygens*) the Quotient 543 shews the Number of Revolutions; and again dividing 12467876 by 543, the Quotient 22961 $\frac{1}{10}$ *min.* or 15 Days, 22^h 41′ 6″, appears to be the true Time of this *Satellite*'s *Period*. Hence the Diurnal Motion will be 22° 34′ 38″ 18‴, and the Annual, besides 22 Revolutions, 10^s 20° 43′. Having made Tables to this Period, I found that in the *Apogæon* Observation of *Huygens*, the *Satellite* was above 3 Degrees faster than by my *Calculus*, and that in the three other Observations of my own, being likewise in the superior part, it was $2\frac{1}{2}$ *Deg.* slower than by the same Calculation. Now 'tis evident, that the Differences must arise from some

Eccentricity

Eccentricity in the *Orbit* of this *Satellite*, and that in *Mar.* 1659. the *Apocronion* (as I may call it) was ſomewhere in the Oriental Semicircle, and that in *Nov.* 1682. it was in the Weſtern Semicircle; and ſuppoſing the *Apocronion* fix'd, it muſt neceſſarily be between $9^s\ 23^\circ\ 46'$, and $11^s\ 28^\circ\ 18'$, à 1^a ⁎ ♈, that being the common Part between thoſe two Semicircles; and becauſe the Difference was greater in *Huygens*'s Obſervation than in mine, 'twill follow that the *Linea Abſidum*, or *Apocronion*, ſhould be nearer to $9^s\ 23^\circ\ 46'$, than to $11^s\ 28^\circ$ $18'$. I will ſuppoſe $10^s\ 22^\circ\ 00'$ *à Prima Stella Arietis*, (which happens to be alſo the Place of *Saturn*'s *Equinox*) and the greateſt Equation about $2\frac{1}{2}$ *Degrees*. Upon the Score of this Inequality the mean Motion of the *Satellite* will be found about $2^\circ\ 45'$ ſlower in $23\frac{1}{2}$ Years, or 7 Minutes in a Year, whence I ſtate the Annual Motion $10^s\ 20^\circ\ 36'$, above 22 Revolutions, and the correct *Epocha* for the laſt Day of *December* 1682, at Noon in the Meridian of *London* $9^s\ 10^\circ\ 15'$ à 1^a ⁎ ♈; from which *Elements* I compoſe the following Table.

Table

Tab. of the Mean Mot. of the Satel. of *Sat.* found by *Huygens*, from the first * ♈

Current Year of Christ.	*Epoques.* s	°	′
1641	8	29	17
1661	10	14	10
1681	11	29	3
1682	10	19	39
1683	9	10	15
1684	8	00	51
1685	7	14	2
Month common Year.	*Mean Mot.* s	°	′
Jan.	0	0	0
Feb.	11	9	53
March	8	12	2
April	7	21	56
May	6	9	14
June	5	19	7
July	4	6	26
August	3	16	19
Sept.	2	26	12
October	1	13	31
Nov.	0	23	24
Dec.	11	10	43

Years.	*Mean Mot.* s	°	′
1	10	20	36
2	9	11	12
3	8	1	48
4	7	14	59
5	6	5	35
6	4	26	11
7	3	16	47
8	2	26	57
9	1	20	23
10	0	11	9
11	11	1	45
12	10	14	56
13	9	5	32
14	7	26	8
15	6	16	44
16	5	29	54
17	4	20	30
18	3	11	6
19	2	1	42
20	1	14	53

Days.	*Mean Mot.* s	°	′
1	0	22	35
2	1	15	9
3	2	7	4
4	3	0	18
5	3	22	53
6	4	15	28
7	5	8	2
8	6	0	37
9	6	23	12
10	7	15	46
11	8	8	21
12	9	0	55
13	9	23	30
14	10	16	5
15	11	8	39
16	0	1	14
17	0	23	48
18	1	16	23
19	2	8	58
20	3	1	32
21	3	24	7
22	4	16	42
23	5	9	16
24	6	1	51
25	6	24	25
26	7	17	00
27	8	9	35
28	9	2	9
29	9	24	44
30	10	17	18
31	11	9	53
32	0	2	28

H. Min.	*Mean Mot.* ° / ′	′ / ″
1	0	56
2	1	53
3	2	49
4	3	46
5	4	42
6	5	39
7	6	35
8	7	32
9	8	28
10	9	24
11	10	21
12	11	17
13	12	14
14	13	10
15	14	7
16	15	3
17	16	0
18	16	56
19	17	52
20	18	49
21	19	45
22	20	42
23	21	38
24	22	35
25	23	31
26	24	27
27	25	24
28	26	20
29	27	17
30	28	13

Minutes	*Mean Mot.* ′	″
31	29	10
32	30	6
33	31	3
34	31	59
35	32	55
36	33	52
37	34	48
38	35	45
39	36	41
40	37	38
41	38	34
42	39	31
43	40	27
44	41	24
45	42	20
46	43	17
47	44	13
48	45	10
49	46	6
50	47	3
51	47	59
52	48	56
53	49	52
54	50	49
55	51	45
56	52	42
57	53	38
58	54	35
59	55	31
60	56	27

In Leap-Year after *February* add one Day, and the Motion belonging to it.

I here

I here ſuppoſe the *Linea Apſidum* fix'd, as having no Argument from Obſervation to prove the contrary, though it be very probable that as the *Apogæon* of our *Moon* has a Motion about the *Earth* in about 9 Years, ſo that of this *Satellite* ought to have about *Saturn*, but with a much longer Period, which future Obſervation may diſcover.

The Diſtance of this *Satellite* from the Center of *Saturn* ſeems to be much about 4 Diameters of the *Ring*, or 9 of the *Globe*, and the Plane wherein it moves, very little or nothing differing from that of the *Ring*, that is to ſay, interſecting the Orb of *Saturn* 4^s 22°, and 10^s 22° à 1^a ∗ ♈, with an Angle of $23\frac{1}{2}$ Degrees, ſo as to be nearly parallel to the *Earth*'s *Equator*; whence the *Latitude* of the *Apogæon* Semicircle from 4^s 22° to 10^s 22° of *Saturn*'s *Longitude* from the firſt Star of ♈, will be Northern, and of the other Semicircle Southern; and the contrary in the other half of *Saturn*'s *Longitude*, to wit, from 10^s 22° to 4^s 22° of his diſtance from the firſt Star of ♈.

It follows now to ſhew how by the help of this Table to compute the place of this *Satellite*, to any Time required.

Firſt we muſt have the true *Longitude* of *Saturn* from the *Earth*, and numbred from the firſt Star of ♈, (or rather the Place of the Earth viewed from *Saturn*, together with its Latitude from the Orb of *Saturn*; but that being never fully $\frac{1}{2}$ of a Degree we neglect it as a Nicety) and therefrom ſubtract 10^s 22°, there remains the Diſtance of *Saturn* from this *Equinoctial* Point, with which Diſtance with the *Longitude* of the *Sun*, take out the *Right Aſcenſion* and *Declination* thereto ($23\frac{1}{2}$ Degrees being the Obliquity common to both) and to the *Right Aſcenſion* adding 10^s 22°, the Sum ſhall be the *Longitude* of the *Satellite*'s *Apogæon*. Then ſay, as *Radius* to *Sine* of the *Declination*, ſo 8 to the greateſt *Latitude* in *Apogæo*, or *Perigæo* in the parts of the Semidiameter of the *Ring*.

Next collect the *Middle Motion* of *the Satellite*, and from it ſubtract 10^s 22°, the Remainder ſhall be the mean Anomaly, with which in the Table of the *Moon*'s primary *Equation*, take out the *Equation* anſwering thereto, and the half thereof added or ſubtracted to or from the *Middle Motion*, according to the Table, gives the true Motion of the *Satellite*; from which ſubtract the *Apogæon*, and if the Remainder be more than 6 *Signs*, the *Satellite* is Occidental, if leſs, Oriental; and as *Radius* to *Sine* of the Remainder, ſo 8 to the Semidiameters of the *Ring*, or 18 to the Semidiameters of the *Globe*, that the *Satellite* is to the Eaſtward or Weſtward of the Center of *Saturn*, according to the foregoing Precept.

Laſtly, as *Radius* to *Coſine* of the ſaid Remainder, ſo is the greateſt *Latitude* from the Line of the *Anſæ*, to the *Latitude* ſought.

Here note, that I purpoſely neglect the Inequality of the Diſtance ariſing from the *Eccentricity*, as being too ſmall to be any way obſervable.

Laſtly, to clear all Difficulties that may ariſe to them that are but little verſed in this ſort of Calculation, I have added an Example of the Work, that where the Precept may ſeem obſcure it may be thereby illuſtrated.

 An.

An. 1657. *May* 9. *ft. n.* M. *Huygens* obferved the *Satellite* very near *Saturn* on the Weftern Side, and very little above the Line of the *Anfæ*. I fuppofe this about 10ʰ *p. m.* Let us now *calculate* to that time.

1657, *May* 9ᵈ 9ʰ 10′, at *London*.			
The Place of *Saturn*		28°	57′
Sat. from firft Star of *Aries*	5ˢ	0	32
Equinoct. fubtract.	10	22	00
Saturn from the Equinox	6	8	32
Right Afcenfion	6	7	50
Apogæon	4	29	50
Declination South.		3	23

Mean Motion of the Satel.	s	°	′
1641	8	29	17
16	5	29	54
May	6	9	14
9ᵈ	6	23	12
9ʰ 40′	0	9	5
Mean Long. of the Satellite	4	10	42
Apocronion	10	22	00
Mean Anomaly	5	18	42
Equation fubtract.	0	0	31
True Long. of the Satellite	4	10	11
Apogæon	4	29	50
Remainder	11	10	21
That is, before the *Apogæon*	0	19	39

Therefore it is $2\frac{7}{10}$ Semidiameters of the Ring, and $\frac{0}{10}$ to the North, agreeing exactly with the Defcription and Figure of M. *Huygens*.

I here call the Plane of this *Satellite*'s Orb, which hitherto I fuppofe the fame with that of the *Ring*, *Saturn*'s *Equinoctial*; not that any Difcovery hath been able to prove that the *Axis* of that *Globe* is at right Angles thereto, but becaufe it hath pleafed M. *Huygens* to call it fo, and likewife becaufe it is fo nearly parallel to our *Globe*'s *Equinoctial*; neverthelefs, to fpeak my Opinion, I believe that the *Axis* is inclined, and that not a little, to the Plane of the *Ring*: for as the Reflection of the *Sun*'s Light from the *Ring* is a great Convenience to that Hemifphere of *Saturn*, which beholds its illuminate Side; fo the other Hemifphere is very much incommoded by the Shadow of the *Ring*, which for many Months, and in fome Parallels for feveral Years, occafions a continual Night by the Interception of the *Sun*'s Beams, which is a Confequence that demonftratively follows the Pofition of the *Ring*, in the Plane of *Saturn*'s *Æquator*. Now this great Inconvenience would be in fome meafure relieved by the oblique Pofition of the *Axis*; for then the Parallels of Latitude interfecting the Plane of the *Ring*, many, and in moft cafes all of them, might for fome time in every diurnal Revolution of the Globe, free themfelves from this *Eclipfe*, which otherwife were fufficient to render this Globe of *Saturn* unfit for any fettled Habitation; but this is but Conjecture.

The

The other two *Satellites* of *Saturn* discovered by *S. Cassini* at *Paris*, *An.* 1672. and 1673. I must confess I could never yet see; I have been told that they disappear for about $3\frac{2}{3}$ of *Saturn*'s Revolution, and were only to be seen when the *Ansæ* were very small, it being supposed that the Light which proceeds from the *Ansæ*, when considerably opened, might hide these *Satellites*.

The Theory of the 5 Satellites of Saturn corrected; by M. Cassini. n. 187. p. 299.

LXXXII. 1. The Distance of the first Satellite from the Center of *Saturn*, appears to me to be variable, and its Motion is sensibly unequal, swifter at this Time in the Western Semicircle than in the Eastern. I have finally determin'd its mean Distance to be $\frac{39}{40}$ of the Diameter of *Saturn*'s Ring, its daily Motion to be $6^s\ 10^\circ\ 41'\ 31''$. So that if its Motion were equal, the Duration of its Conjunction with *Saturn*, that is to say, all the Time it takes up in passing through the Ring, would be $7^h\ 46'$. It appear'd greater to me by immediate Observations; but it is to be observed, that as yet I have not been able to see this Satellite nearer to *Saturn* than a quarter part of an *Ansa*.

I have calculated the Epoque of its Motion, for the last of *December* 1685, at Noon, at the Meridian of *Paris*, to be in ♑ $24^\circ\ 50'$.

The Distance of the second Satellite from the Center of *Saturn* has seem'd to me to be more uniform. I have determined it to be $1\frac{1}{4}$ Diameter of the Ring. Its Motion also seems to be more equal. I have calculated the daily Motion, and find it $4^s\ 11^\circ\ 31'\ 30''$. Therefore the Duration of its Conjunction should be $8^h\ 36'$. Nor have I yet been able to see this Satellite nearer the Ring of *Saturn* than $\frac{1}{4}$ of an *Ansa*. As this Satellite was seen, for the greatest part of its Time, within the Confines of the Distance of the first, to which it is equal in Magnitude, and like to it in Colour; the Difficulty to distinguish one from the other was very great; so that without a constant Application to Observations, and a great Multitude of Combinations, I could by no means perform it.

I have determin'd the Epoque of this Satellite, for the 31st of *December* 1685, at Noon, to be ♍ $9^\circ\ 10'$.

The Distance of the Third from the Center of *Saturn* seems to be $1\frac{3}{4}$ Diameters of the Ring. Its daily Motion is $2^s\ 18^\circ\ 41'\ 50''$. Therefore its Conjunction must continue 10 Hours. The Epoque of its Motion for the last Day of the Year 1685 at Noon is ♏ $9^\circ\ 39'$.

The Distance of the fourth Satellite from the Center of *Saturn* seems to be 4 Diameters of the Ring. Its daily Motion is $22^\circ\ 34'\ 38''$. The Duration of its Conjunction is $15^h\ 6'$. The Epoque of its Motion in the same Time and Place as the others, in ♓ $16^\circ\ 19'$. On these Principles Tables and Ephemeris's may be constructed.

By . . . . . ib. p. 300.

2. The following Tables are calculated from these Elements, and reduced to the Meridian of *London*.

A Table of the Mean Motion of the inmoſt Satellite of *Saturn*, diſcover'd by Mr. *Caſſini*, *An.* 1686.

Current Year of Chriſt.	*Epoques.* s ° '	*Years.*	*Mean Mot.* s ° '	*Days.*	*Mean Mot.* s ° '	*H. Min.*	*Mean Mot* s ° ' / ' "	*Minutes*	*Mean Mot.* ° '
1681	♒ 19 34	1	4 2 34	1	6 10 42	1	0 7 57	31	4 6
1685	♑ 10 30	2	8 5 7	2	0 21 23	2	0 15 53	32	4 14
1686	♉ 13 4	3	0 7 41	3	7 2 5	3	0 23 50	33	4 22
1687	♏ 15 37	4	10 20 56	4	1 12 46	4	0 31 47	34	4 30
1688	♑ 18 11	5	2 23 30	5	7 23 28	5	0 39 44	35	4 38
1689	♐ 1 26	6	6 26 4	6	2 4 9	6	0 47 40	36	4 46
1701	♌ 4 14	7	10 28 38	7	8 14 15	7	0 54 37	37	4 54
		8	9 11 52	8	2 25 32	8	1 3 34	38	5 2
Months common Year.	*Mean Mot.* s ° '								
		9	1 14 26	9	9 6 14	9	1 11 31	39	5 10
		10	5 17 00	10	3 16 55	10	1 19 28	40	5 18
		11	9 19 34	11	9 27 36	11	1 27 24	41	5 26
Jan.	0 0 0	12	8 2 48	12	4 8 18	12	1 35 21	42	5 34
Feb.	5 1 27								
March	3 0 49	13	0 5 22	13	10 19 00	13	1 43 18	43	5 42
April	8 2 16	14	4 7 56	14	4 29 42	14	1 51 15	44	5 50
		15	8 10 29	15	11 10 23	15	1 59 11	45	5 58
May	6 23 2	16	6 23 43	16	5 21 4	16	2 7 8	46	6 5
June	11 24 29								
July	10 15 15	17	10 26 17	17	0 1 46	17	2 15 5	47	6 13
Auguſt	3 16 42	18	2 28 51	18	6 12 28	18	2 23 1	48	6 21
		19	7 1 25	19	0 23 9	19	2 30 58	49	6 29
Sept.	8 18 9	20	5 14 39	20	7 3 50	20	2 38 55	50	6 37
October	7 8 54								
Nov.	0 10 21			21	1 14 32	21	2 46 52	51	6 45
Decemb.	11 1 7			22	7 25 13	22	2 54 49	52	6 53
				23	2 5 55	23	3 2 45	53	7 1
				24	8 16 36	24	3 10 42	54	7 9
				25	2 27 18	25	3 18 39	55	7 17
				26	9 7 59	26	3 26 35	56	7 25
				27	3 18 41	27	3 34 32	57	7 33
				28	9 29 22	28	3 42 28	58	7 41
In Leap-Year after *February* add one Day, and the Motion belonging to it.				29	4 10 3	29	3 50 25	59	7 49
				30	10 20 45	30	3 58 22	60	7 57

A Table

A Table of the Mean Motion of *Saturn*'s Satellite the inmost but one, discover'd by Mr. *Cassini*, *An.* 1686.

Current Year of Christ	Epoques. s	°	'
1681	♓	20	41
1685	♐	28	42
1686	♉	5	20
1687	♏	11	57
1688	♑	18	35
1689	♎	6	44
1701	♒	0	48

Month common Year.	Mean Mot. s	°	'
Jan.	0	0	0
Feb.	3	27	16
March	6	19	58
April	10	17	15
May	10	3	0
June	2	0	16
July	1	16	1
August	5	13	18
Sept.	9	10	34
Octob.	8	26	19
Nov.	0	23	36
Dec.	0	9	21

Years.	Mean Mot. s	°	'
1	4	6	37
2	8	13	15
3	0	19	52
4	9	8	1
5	1	14	39
6	5	21	16
7	9	27	54
8	6	16	3
9	10	22	40
10	2	29	18
11	7	5	55
12	3	24	4
13	8	00	42
14	0	7	19
15	4	13	57
16	1	2	6
17	5	8	43
18	9	15	21
19	1	21	58
20	10	10	7

Days.	Mean Mot. s	°	'
1	4	11	31
2	8	23	3
3	1	4	34
4	5	16	6
5	9	27	37
6	2	9	9
7	6	20	40
8	11	2	12
9	3	13	43
10	7	25	15
11	0	6	46
12	4	18	18
13	8	29	49
14	1	11	21
15	5	22	52
16	10	4	24
17	2	15	55
18	6	27	27
19	11	8	58
20	3	20	30
21	8	2	1
22	0	13	33
23	4	25	4
24	9	6	36
25	1	18	07
26	5	29	39
27	10	11	10
28	2	22	42
29	7	4	13
30	11	15	45

H. Min.	Mean Mot. Sex. °	'	"
1	0	5	29
2	0	10	58
3	0	16	26
4	0	21	55
5	0	27	24
6	0	31	53
7	0	38	22
8	0	43	51
9	0	49	19
10	0	54	48
11	1	00	17
12	1	5	46
13	1	11	15
14	1	16	44
15	1	22	12
16	1	27	42
17	1	33	11
18	1	38	39
19	1	44	8
20	1	49	37
21	1	55	6
22	2	00	34
23	2	6	3
24	2	11	31
25	2	17	00
26	2	22	29
27	2	27	58
28	2	33	26
29	2	38	55
30	2	44	24

Minutes	Mean Mot. °	'
31	2	50
3	2	56
33	3	1
34	3	7
35	3	12
36	3	17
37	3	23
38	3	28
39	3	34
40	3	40
41	3	45
42	3	50
43	3	56
44	4	1
45	4	7
46	4	12
47	4	17
48	4	23
49	4	28
50	4	34
51	4	39
52	4	45
53	4	50
54	4	56
55	5	1
56	5	7
57	5	12
58	5	18
59	5	23
60	5	29

In Leap-Year after *February* add one Day, and the Motion belonging to it.

A Table of the Mean Motion of the middlemost Satellite of *Saturn*, discover'd by *Cassini*, *An.* 1686.

Current Year of Christ.	*Epoques.* s ° '	*Years.*	*Mean Mot.* s ° '	*Days.*	*Mean Mot.* s ° '	*H. Min.*	*Mean Mot Sex.* ° ' "	*Minutes*	*Mean Mot.* ° '
1661	♎ 22 50	1	9 14 29	1	2 18 42	1	0 3 17	31	1 41
1681	♐ 16 3	2	6 28 58	2	5 7 24	2	0 6 33	32	1 45
1685	♒ 2 41	3	4 13 27	3	7 26 5	3	0 9 50	33	1 48
1686	♏ 17 10	4	4 16 38	4	10 14 47	4	0 13 7	34	1 52
		5	2 1 8	5	1 3 29	5	0 16 24	35	1 55
1687	♍ 1 39								
1688	♊ 16 9	6	11 15 37	6	3 22 11	6	0 19 40	36	1 58
1689	♊ 19 20	7	9 00 6	7	6 10 53	7	0 22 57	37	2 1
1701	♌ 9 15	8	9 3 17	8	8 29 35	8	0 26 14	38	2 5
		9	6 17 46	9	11 18 16	9	0 29 31	39	2 8
Months common Year.	*Mean Mot.* s ° '	10	4 02 15	10	2 6 58	10	0 32 47	40	2 11
		11	1 16 45	11	4 25 40	11	0 36 4	41	2 14
		12	1 19 55	12	7 14 22	12	0 39 21	42	2 18
Jan.	0 0 0	13	11 4 24	13	10 3 4	13	0 32 38	43	2 21
Feb.	9 9 37	14	8 18 54	14	0 21 46	14	0 45 55	44	2 24
March	10 23 8	15	6 3 23	15	3 10 27	15	0 49 11	45	2 28
April	8 2 45								
		16	6 6 34	16	5 29 9	16	0 52 28	46	2 31
May	2 23 40	17	3 21 3	17	8 17 51	17	0 55 45	47	2 34
June	0 3 17	18	1 5 32	18	11 6 33	18	0 59 1	48	2 37
July	6 24 12	19	10 20 1	19	1 25 15	19	1 2 18	49	2 40
August	4 3 49	20	10 23 12	20	4 13 57	20	1 5 35	50	2 44
Sept.	1 13 25			21	7 2 39	21	1 8 52	51	2 47
October	8 4 20			22	9 21 20	22	1 12 8	52	2 50
Nov.	5 13 57			23	0 10 02	23	1 15 25	53	2 54
Decemb.	0 4 52			24	2 28 44	24	1 18 42	54	2 57
				25	5 17 26	25	1 21 59	55	3 00
				26	8 6 8	26	1 25 15	56	3 4
				27	10 24 50	27	1 28 32	57	3 7
				28	1 13 32	28	1 31 49	58	3 10
				29	4 2 13	29	1 35 6	59	3 13
				30	6 20 55	30	1 38 22	60	3 17

In Leap-Year after *February* add one Day, and the Motion belonging to it.

A Table of the Mean Motion of *Saturn*'s Satellite the outmoſt but one, diſcover'd by *Huygens*, *An.* 1673.

Current Year of Chriſt.	*Epoques.* s	°	′	*Years.*	*Mean Mot.* s	°	′	*Days.*	*Mean Mot.* s	°	′	*H. Min.*	*Mean Mot.* ° ′	′ ″	*Minutes*	*Mean Mot.* ′	″
1641	♑	24	43	1	10	20	41	1	0	22	35	1	0	56	31	29	10
1661	♓	11	19	2	9	11	22	2	1	15	9	2	1	53	32	30	6
1681	♈	27	56	3	8	2	3	3	2	7	44	3	2	49	33	31	3
1685	♐	13	15	4	7	15	19	4	3	0	18	4	3	46	34	31	59
1686	♏	3	56	5	6	6	00	5	3	22	53	5	4	42	35	32	55
1687	♍	24	37	6	4	26	41	6	4	15	28	6	5	39	36	33	52
1688	♌	15	19	7	3	17	22	7	5	8	2	7	5	35	37	34	48
1689	♋	28	34	8	3	00	39	8	6	0	37	8	7	32	38	35	45
1701	♊	14	32	9	1	21	20	9	6	23	12	9	8	28	39	36	41
				10	0	12	1	10	7	15	46	10	9	24	40	37	38
Month	*Mean Mot.*																
common				11	11	2	42	11	8	8	21	11	10	21	41	38	34
Year.	s	°	′	12	10	15	58	12	9	0	55	12	11	17	42	39	31
				13	9	6	39	13	9	23	30	13	12	14	43	40	27
Jan.	0	0	0	14	7	27	20	14	10	16	5	14	13	10	44	41	24
Feb.	11	9	54	15	6	18	1	15	11	8	39	15	14	7	45	42	20
March	8	12	3														
April	7	21	57	16	6	1	17	16	0	1	14	16	15	3	46	43	17
				17	4	21	58	17	0	23	48	17	16	0	47	44	13
May	6	9	16	18	3	12	40	18	1	16	23	18	16	56	48	45	10
June	5	19	10	19	2	3	21	19	2	8	58	19	17	52	49	46	6
July	4	6	29	20	1	16	36	20	3	1	32	20	18	49	50	47	3
Auguſt	3	16	22														
								21	3	24	7	21	19	45	51	47	59
Sept.	2	26	16					22	4	16	42	22	20	42	52	48	56
October	1	13	35					23	5	9	16	23	21	38	53	49	52
Nov.	0	23	29					24	6	1	51	24	22	35	54	50	49
Dec.	11	10	48					25	6	24	25	25	23	31	55	51	45
								26	7	17	00	26	24	27	56	52	42
								27	8	9	35	27	25	24	57	53	38
								28	9	2	9	28	26	20	58	54	35
								29	9	24	44	29	27	17	59	55	31
								30	10	17	18	30	28	13	60	56	27

In Leap-Year after *February* add one Day, and the Motion belonging to it.

A Table of the Mean Motion of the outmost Satellite of *Saturn*, discover'd by *Cassini*, *An.* 1671.

Current Year of Christ.	*Epoques.* s ° ′	*Years.*	*Mean Mot.* s ° ′	*Days.*	*Mean Mot.* s ° ′	*H. Min.*	*Mean Mot.* ° ′ / ′ ″	*Minutes*	*Mean Mot.* ′ ″
1661	♓ 24 45	1	7 6 23	1	0 4 32	1	0 11	31	5 51
1681	♈ 25 15	2	2 12 47	2	0 9 5	2	0 23	32	6 3
1685	♍ 25 21	3	9 19 10	3	0 13 37	3	0 34	33	6 14
1686	♉ 1 44	4	5 00 6	4	0 18 9	4	0 45	34	6 25
		5	0 6 29	5	0 22 41	5	0 57	35	6 37
1687	♐ 8 7								
1688	♋ 14 31	6	7 12 53	6	0 27 14	6	1 8	36	6 48
1689	♒ 25 27	7	2 19 16	7	1 1 46	7	1 19	37	7 00
1701	♉ 25 45	8	10 0 12	8	1 6 18	8	1 31	38	7 11
		9	5 6 35	9	1 10 50	9	1 42	39	7 22
Month common Year.	*Mean Mot.* s ° ′	10	0 12 59	10	1 15 23	10	1 53	40	7 34
		11	7 19 22	11	1 19 55	11	2 5	41	7 45
		12	3 0 18	12	1 24 27	12	2 16	42	7 56
Jan.	0 0 0	13	10 6 41	13	1 28 59	13	2 27	43	8 8
Feb.	4 20 41	14	5 13 5	14	2 3 32	14	2 39	44	8 19
March	8 27 45	15	0 19 28	15	2 8 4	15	2 50	45	8 30
April	1 18 25								
		16	8 00 24	16	2 12 36	16	3 1	46	8 42
May	6 4 34	17	3 6 47	17	2 17 8	17	3 13	47	8 53
June	10 25 15	18	10 13 11	18	2 21 41	18	3 24	48	9 4
July	3 11 23	19	5 19 34	19	2 26 13	19	3 35	49	9 16
August	8 2 4	20	1 0 30	20	3 0 46	20	3 47	50	9 27
Sept.	0 22 45			21	3 5 18	21	3 58	51	9 38
October	5 8 53			22	3 9 50	22	4 9	52	9 50
Nov.	9 29 34			23	3 14 22	23	4 21	53	10 1
Dec.	2 15 43			24	3 18 54	24	4 32	54	10 12
				25	3 23 27	25	4 43	55	10 24
				26	3 27 59	26	4 55	56	10 35
				27	4 2 31	27	5 6	57	10 46
				28	4 7 4	28	5 17	58	10 58
				29	4 11 36	29	5 29	59	11 9
				30	4 16 8	30	5 40	60	11 21

In Leap-Year after *February* add one Day, and the Motion belonging to it.

I ſhall only add, that the Proportion of the Squares of the *Times* of the *Periods* to the Cubes of the *Diſtances* (which is propoſed as probable by *Kepler*, but how demonſtratively found true by Mr. *Newton*) gives us nicely the Proportion of the *Diſtances* of theſe *Planets* from the Center of *Saturn*; and ſuppoſing the Satellite of *Huygens* four Diameters of *Saturn*'s *Ring* diſtant from him, we ſhall find by the *Periods* the Diſtances as follows.

	Period.			*Diſtances.*
	d.	h.	′	*Diameters.*
Of the Inmoſt ———	1	21	$18\frac{1}{2}$	0, 964
Of the Inmoſt but one —	2	17	$41\frac{1}{2}$	1, 235
Of the Middlemoſt ——	4	13	$47\frac{1}{4}$	1, 740
Of the Outmoſt but one	15	22	41	4, 000
Of the Outmoſt ———	79	7	54	11, 621

Theſe Diſtances may be uſed, as more accurate than thoſe obtained by Obſervation, which yet differ but little therefrom.

LXXXIII. *An.* 1666. *June* 26, between 3 and 4 of the Clock in the Morning, I obſerved the Body of *Jupiter* through a 60 Foot Glaſs, and found the apparent Diameter of it through the Tube, to be ſomewhat more than two Degrees, that is about 4 Times as big as the Diameter of the *Moon* appears to the naked Eye.

The Phaſis of Jupiter; *by* Dr. Hook. n. 14. *p.* 245. *Fig.* 139.

I ſaw the Limb pretty round, and very well defined without Radiation. The Parts of the *Phaſis* of it had various Degrees of Light; about *a* and *f*, the North and South Poles of it, ſomewhat darker, and by degrees it grew brighter; towards *b* and *e*, two *Belts* or *Zones*, the one of which, *b*, was a ſmall dark *Belt* croſſing the Body ſouthward; adjoining to which was a ſmall Line of a ſomewhat lighter part; and below that again, ſouthwards, was the great black *Belt*, *c*. Between that, and *e*, the other ſmaller black *Belt*, was a pretty large and bright *Zone*; but the Middle, *d*, was ſomewhat darker than the Edges.

LXXXIV. 1. *S. Campani* affirms, that, by the Goodneſs of his Glaſſes, he hath obſerved certain *Protuberances* and Inequalities of *Jupiter*: and he is now obſerving whether they do not change their Situation.

The Revolution of Jupiter *upon his* Axis; *by* S. Campani. n. 1. *p.* 3.

2. *An.* 1664. *May* 9. about 9 a Clock at Night, Mr. *Hook* with an excellent 12 Foot Teleſcope obſerved a ſmall Spot in the biggeſt of the three *obſcurer Belts* of *Jupiter*; and obſerving it from time to time, he found that within two Hours after, the ſaid Spot had moved from Eaſt to Weſt, about half the Length of the Diameter of *Jupiter*.

By Dr. Hook. *ib.*

3. *Euſtachio de Divinis* pretends, that the *Permanent Spot* in *Jupiter* hath been firſt of all diſcover'd with his Glaſſes; that *P. Gotignies* is the firſt that

By S. Divini. n. 12. *p.* 209.

hath thence deduced the Motion of *Jupiter* about his *Axis* and that M. *Cassini* at first opposed it: *But that Spot was observed in* England *a good while before.*

By *M.* Cassini. n. 8. p. 143. n. 10. p. 172. n. 35. p. 687. n. 82. p. 4039.

4. There are two Sorts of *Spots* at certain times to be seen in the Disk of *Jupiter*. One Sort are nothing but the Shadows of his Satellites; but the other have some resemblance to those that are seen in the *Moon*; and they are perhaps of the same Nature with those that are called *Belts*. They move from the Eastern to the Western Limb; their apparent Motion is unequal, and swifter near the Center than the Circumference; and they never are so well as when they approach to the Center, they being very narrow and almost imperceptible when they approach to the Circumference; which makes us believe, that they are flat and superficial to *Jupiter*.

Among these *Spots* there is none so sensible, as that which is situated in the Northern-part of the *Southern-Belt*. Its Diameter is about the tenth part of that of *Jupiter*; and at the Time that its Center is nearest to that of *Jupiter*, it is distant from it about the third part of the Semidiameter of that *Planet*.

M. *Cassini*, after he had made many Observations of this *Spot* during the Summer of the Year 1665, found, that the *Period* of its apparent *Revolution* is of 9^h 56′. He continued to observe it till the Beginning of 1666, when *Jupiter* approach'd to the Beams of the *Sun*; but after he was got free of the *Sun-Beams*, it was difficult to be discern'd. This giving grounds to think that it might be of the Nature of the *Spots of the Sun*, (which after appearing for a while, disappear for ever) M. *Cassini* ceased at length to observe them.

But *Jan.* 19. 1672. (*st. n.*) when he observ'd *Jupiter*, at $4\frac{3}{4}$h. in the Morning, he perceived in the same Place of his Disk the Figure of the same *Spot*, adhering to the same *Southern-Belt*. It was already gone beyond the Moiety of this *Belt*, and he saw it advance little by little towards the Western Limb, to which it seemed to be very near at $6\frac{1}{4}^h$.

By the Celerity of its Motion near the Center, and by the Place where he had begun to see it, he judged that it might have been in the midst of the *Belt* at 4^h 35′ in the Morning. And as he prepared himself to make Ephemerides of its Motion for that *Year* 1672, he perceived that in those he made for the Year 1666, this *Spot* had been in the midst of *Jupiter* the same Day, namely the 19th of *January* at the same Hour. So that in six Years, of which one is a *Bissextile*, it is found to have made, in respect of the Earth, at least 5294 Revolutions, each of 9^h 55′ 85″, compensating one Revolution by another; and at most 5294 Revolutions of 9^h 55′ 51″; forasmuch as he was assured of the Preciseness of one *Mean Revolution* to one eighth of a Minute.

Until then he had never seen an immediate Return of this *Spot* after 9 Hours and 56 Minutes; because it had not happened, that *Jupiter* after the Apparition of the *Spot* had stayed, in one and the same Night, long enough above the *Horizon*, at least a sufficient Height, to observe him with due Distinctness. He had only concluded the Time of this *Revolution* by Returns observed after about 20, 30, and 50 Hours; and he had more precisely limited it by Observations more distant. But the Night after *March* 1, at $7\frac{1}{2}^h$ in the Evening, he saw this *Spot* in the midst of the *Belt*; and the same Night

Night at 5^h 26′, in the Morning, he saw it again returned precisely to the same Place. *Mar.* 3. He together with M. *Buot* and M. *Mariotte*, began to see at 8^h 4′ the *Spot* already somewhat removed from the Oriental Limb, but yet obscure and small. At 8^h 47′, they saw it very distinctly advancing towards the middle of the *Belt*. At 9^h 15′ 40″, until 9^h 8′, they saw it in the midst of the *Belt*. At 9^h 15′, it was past the middle, and was come nearer to the Occidental Limb. And a little after the Heavens being over-cast, he could observe it no further.

LXXXV. 1. *An.* 167½. *Feb.* 16. 7^h 44½. The Altitude of *Jupiter* was 18° 10′. I measured with a long Tube its Distance from a fix'd Star of the fourth Magnitude, and found it 16′ 33″. The Latitude of this Star was 1° 40′ northerly. Its Place according to me was ♍ 10° 7′ 16″: But according to *Street* it was 14° 3′ 54″. The Difference of the Altitudes of the Centers of *Jupiter* and the fix'd Star was 1′ 1″.

Places of Jupiter observ'd; by Mr. Flamsteed at Derby, n. 82. p. 4036.

17 *Feb.* 7^h 25′. After Noon, the Altitude of *Jupiter* being 15° 54′, he was distant from the fix'd Star 21′ 50″; the Difference of Altitudes was 8′ 40″.

18 *Feb.* 7^h 0′. The Distance of the fix'd Star from the Center of *Jupiter* was 28′ 15″. The Difference of Altitudes was about 15′ 29″. In each Observation the Planet was higher than the fix'd Star, from whence it always stood towards the Meridian.

Hence making a Calculation for every Day and Hour of the Observations; I found

	d.	h.		d.	h.	′	d.	h.	′
February	16	7	44½	17	7	25	18	7	0
	°	′	″	°	′	″	°	′	″
The Longitude of *Jupiter* from the fix'd Star in Antecedentia	0	9	16	0	17	22	0	25	12
Latitude from it towards the South	0	13	30	0	13	14	0	12	45
Therefore *Jupiter*'s Northern Lat. was	1	26	30	1	26	46	1	27	15
Its true place in *Virgo* according to me	13	58	0	13	49	54	13	42	4
according to *Street*	13	54	38	13	40	32	13	38	42

2. *March* 15 in the Evening, I undertook to observe the Distances and Positions of *Jupiter* from the Star ♌ 38, whose Latitude is 1° 20½ North; its Place according to *Street* ♍ 9° 54′ 0″; but according to me is ♍ 9° 57′ 20″. At 7^h 25′ afternoon, the Altitude of *Jupiter* was 32° 52′. The Distance of its Center from the fix'd Star was 33° 50′ The Difference of Altitudes was about 20′ 2′.

March 16. At 7^h 8′. The Altitude of the fix'd Star being 36°, the Distance of *Jupiter* from it was 27′ 7″. The lesser Altitude 16′ 3″.

March 19, at 6^h 45′, the Altitude of *Jupiter* was 29° 35′. The fix'd Star was 2′ 24″ higher than the Planet; from which at 6^h 55′, its Distance was 10′ 21″.

At 7^h 11′, the fourth Satellite was distant 7′ 28″ from the fix'd Star. Tho' the Planet always appear'd to be higher than the fix'd Star, yet it was really lower; afterwards it seem'd to be lower, but was really higher.

March 20. The Micrometer being better adapted to the taking of the Differences of Altitudes, I made the following Obſervations, which I take to be very exact.

Alt. of Jupiter.		*Times.*				
°	'	h.	'		'	"
30	0	6	44	*Jupiter*'s Center was really higher than the Star——	2	13
30	47	6	51 1/5	The ſame Difference of Altitudes taken over again	2	14
32	0	6	59	*Jupiter*'s Center was diſtant from the fix'd Star——	7	0
38	30	7	54 3/4	The Center of *Jupiter* really higher than the fixt Star	3	14
40	50	8	18 2/3	The Difference of Altitudes taken again——	3	42
				Then the Diſtance of the Centers was ——	7	5

For obtaining the Place of *Jupiter* from theſe Obſervations, I computed

	h. ' "	h. ' "
	6 51 30	8 18 40
	° ' "	° ' "
The Angles of the Vertical Circle with the Ecliptick	35 39 —	46 15 —
The Diſtance of *Jupiter* from the fix'd Star was ——	0 7 0	0 7 0
The Difference of Altitudes ——	0 2 14	0 3 42
Therefore *Jupiter* was in conſequence of the fix'd Star	0 2 3	0 1 44
With a greater Latitude——	0 6 42	0 6 47
So that the true Latitude of *Jupiter* was——	1 27 12	1 27 17
The true Place ♍ according to *Street* ——	9 56 3	9 55 44
according to me ——	9 59 23	9 59 4

N. 86. p. 5037.

May	*Time.*		*Alt. of* Jupiter.			
d.	h.	'	°	'		° ' "
24	10	00	14	10	The Center of *Jupiter* was lower than the ſaid Star ♌ 38 ——	0 7 46
					From which I took its Diſtance firſt ——	0 20 00
					Afterwards ——	0 19 54
26	8	46	33	30	Diſt. of the Cent. of *Jup.* from the firſt Star	0 10 4
Sky	9	00	31	50	The fix'd Star was higher than *Jupiter*——	0 6 30
very	9	20	29	10	The Difference of Altitudes was ——	0 6 38
clear.	9	33	27	20	Diff. of Azimuth of *Jup.* and the fix'd Star	0 7 19
	9	36	27	00	Diſt. of *Jup.* from the fix'd Star taken again	0 10 2

	h.	'	°	'		°	'	''	
27.	8	59	31	24	Dift. of the Center of ♃ from the fix'd Star	0	6	2	*
Wind	9	7	30	30	The Difference of Azimuths— ———	0	1	50	
fome-	9	16	29	13	The fame Difference again —— ——	0	1	52	*
times moved	9	23	28	10	Dift. of the Center of *Jupiter* from the Star	0	6	1	
the Tube.									
28.	8	57	31	8	Again —— —— —— —— ——	0	6	2	*
Wind	9	19	28	10	Diff. of the Azimuths of the Center, &c.	0	3	29	
blew	9	31	26	30	The fame Difference again ——— ———	0	3	32	
hard, and	9	34	26	8	The Diftance again —— —— ——	0	6	7	
fhook the Tele-fcope.									
30.	9	36	26	15	*Jupiter*'s Diftance from the fix'd Star	0	15	38	
Sky was pretty clear.	This and the foregoing Night *Jupiter* was in confequence of the fix'd Star, but always before in Antecedence.								

Thofe Obfervations which are mark'd with an Afterifk I look upon as the moft certain. I imagine the Differences of Azimuths, which were obferved on the 27 and 28 Days, were taken rather too fmall, becaufe of the fhaking of the Tube; therefore fince I could not meafure them as accurately as I defired, I took care not to take them too large.

To obtain *Jupiter*'s Place from three Obfervations, I have computed

	d.	h.	'	d.	h.	'	d.	h.	''
May	26	0	0	27	9	7	28	9	19
	°	'	''	°	'	''	°	'	''
The parallactical Angles, or of the vertical Circle with the Ecliptick — — ———	80	47	—	79	49	—	78	36	—
The obferved Dift. of *Jup.* from the fix'd Star	9	10	4	0	6	2	0	6	3
The Difference of Altitudes — — —	0	6	30	Azy.	1	52	Azy.	3	30
Therefore the Angle of Pofition	31	1		62	38	0	66	3	0
And the Planet in Antecedence of the fix'd Star	0	8	38	0	2	51	conf.	2	27
With leffer Northern Latitude — — —	0	5	11	0	5	19	0	5	32
Tycho's Northern Latitude of the fix'd Star	1	20	30	1	20	30	1	20	30
The Place of the Star ♍ according to *Street*	9	54	9	9	54	9	9	54	9
according to me	9	57	30	9	57	30	9	57	30
Therefore *Jupiter*'s Place according to *Street*	9	45	31	9	51	18	9	56	36
according to me	9	48	52	9	54	39	9	59	57
With Northern Latitude — — — —	1	15	19	1	15	11	1	14	58

* 54. p. 6033. 3. *An.* 1673. *March* 13. in the Evening. *Jupiter* in his *Aphelion*, going to his *Acronical* Phasis, having pass'd a little the Northern Limit of his Orbit, proceeded retrograde towards the 9th Star of ♍ of the fourth Magnitude, from which (his Altitude being about 6 Degrees) I took the Distance of his remotest Limb, with a seven-foot Tube, and *Townley*'s Micrometer, 4560= 52′ 34″.

March 17. About half an Hour after *Jupiter* arose, with the same Tube I again took the Distance of his remotest Limb from the fix'd Star, 2073= 23′ 54″.

March 20. I made the following Observations; the first with a shorter Tube of 85 Inches, the rest with a longer of 164 Inches.

	Alt. of fixt Star.		Hour by Calc.				Limb		Cent.	
	°	′	h.	′			′	″	′	″
1	6	0	7	14	Dist. of the remoter Limb of ♃ from the fixt Star	850	9	48	9	24
2	—	—	—	—	The same Distance taken with the longer Tube	1650	9	52	9	28
3	14	40	8	16	Lower Limb of ♃ more depress'd than the fixt *	784	4	41	4	17
4	15	40	8	23	The same Difference of Altitude repeated ——	786	4	41	4	17
5	—	—	—	—	The Diameter of *Jupiter* ——————	135	0	48		
6	16	25	8	26	The Distance of the Limb taken again ———	1665	9	57	9	33
7	—	—	—	—	Once more —— —— ———	1658	9	54	9	30
8	19	00	8	50	Diff. of Alt. of *Jupiter*'s Limb and the fixt Star	138	5	00	4	36

March 26. in the Evening. The Altitude of *Jupiter* being 15° 50′, I measured the Distance of his remoter Limb from the fix'd Star with the same lesser Tube, 4205=48′ 30″.

For finding the Place of the Planet from these Observations, I made the following Calculations.

Mar.	h.	h.	′	h.	h.	′
	20	8	16	—	8	50
	°	′	″	°	′	″
The Parallactical Angle was—— —— ——	34	44	0	37	30	0
The Center of *Jupiter* was distant from the fix'd Star	0	9	38	0	9	30
The Difference of Altitudes was ————	0	4	17	0	4	36
Therefore the Angle of Position was ————	80	6	0	78	21	0
And *Jupiter* in Antecedence of the fix'd Star ——	0	1	38	0	1	55
With lesser Latitude ————————	0	9	19½	1	9	18

According to me the Place of the fix'd Star was ♎ 13° 37′ 11″ (taking the annual Motion at 50″,) which the Author of the *Caroline* Tables takes to be 13° 33′ 47″. Its North Latitude 1° 45′. Therefore according to me the true Place of *Jupiter* will be

8h 16′ ♎ 13° 35′ 33″ } its true { 1° 35′ 40″½
8 50 ♎ 13 35 16 } Latitude { 1 35 42

At

Plate III. Vol 1. pag. 388