TRANSACTIONS

OF THE

AMERICAN

PHILOSOPHICAL SOCIETY,

HELD AT

PHILADELPHIA,

FOR PROMOTING

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PROTHONOTARY's OFFICE, Philadelphia county.

I DO certify that on this 29th day of April, 1789, *a Book entitled* "Tranſactions of the American Philoſophical Society, held at Philadelphia, for promoting uſeful Knowledge," *vol.* I. *the ſecond edition corrected, printed at Philadelphia, by* R. Aitken & Son, *at Pope's Head, in Market-Street, was entered in my office, by* Robert Aitken.

JAMES BIDDLE, Prot.

TRANSACTIONS

OF THE

American PHILOSOPHICAL SOCIETY, *&c.*

SECT. I.

MATHEMATICAL *and* ASTRONOMICAL PAPERS.

A deſcription of a new ORRERY, *planned and now nearly finiſhed by* DAVID RITTENHOUSE, *A. M. of Norriton, in the county of Philadelphia. Communicated by Dr.* SMITH.

Read 21ſt Mar. 1768. THIS *machine* is intended to have three *faces*, ſtanding perpendicular to the horizon: That in the front to be four feet ſquare, made of ſheet braſs, curiouſly poliſhed, ſilvered and painted in proper places, and otherwiſe ornamented. From the center ariſes an axis, to ſupport a gilded braſs ball, intended to repreſent the *ſun*. Round this ball move others, made of braſs or ivory, to repreſent the *planets*: They are to move in elliptical orbits, having the central ball in one focus; and their motions to be ſometimes ſwifter, and ſometimes ſlower, as nearly according to the true law of an equable deſcription of areas as is poſſible, without too great a complication of wheel-work. The orbit of each planet is likewiſe to be properly inclined to thoſe of the others; and their *Aphelia* and *Nodes* juſtly placed; and

following, together with his Lordſhip's obſervations of the comet, which are inſerted below. He writes that he had no opportunities of making any other obſervations reſpecting the *tranſit* of Venus except the contacts, and that his clock was properly regulated.

2. *Obſervation of the contacts of the limbs of* VENUS *and the* SUN, *June 3d, 1769, made by Mr.* William Poole, *at Wilmington, in Pennſylvania.*

Lat. * 39°. 44′. 3″. N. Long. 5h. 2′. 9″. W.

Extracted from a letter to Mr. *Owen Biddle*, and communicated to the Society, Dec. 21ſt 1770.

Apparent Time.		
2h. 12′. 48″½	1ſt Ext. cont.	With a refractor of 12 feet magnifying power about 50 times. Mr. *Poole* thinks the external contact was ſeveral ſeconds before the time marked in the margin.
2. 30. 20 ½	1ſt Int. ditto.	The internal contact was taken juſt as the Sun's light began to ſurround the planet; though his limb was not viſible beyond the planet, till a ſecond or two afterwards.

To the AMERICAN PHILOSOPHICAL SOCIETY, *held at* Philadelphia *for promoting uſeful knowledge.*

GENTLEMEN,

I TAKE the liberty of communicating to you an improvement in the conſtruction of *Godfry*'s double reflecting quadrant, which I have diſcovered about two years ago, which may be of ſervice to ſuch as uſe that excellent inſtrument. The greateſt inconveniencies ariſing from the former conſtruction of it are owing to the badneſs of the glaſſes, the planes not being ground parallel to each other, and to its ſtanding in need of a new and careful adjuſtment almoſt every time it is uſed. Both theſe imperfections, I apprehend, are thoroughly removed by the new conſtruction propoſed. I have heard, that Mr. William Grant, an ingenious mathematician of London had alſo made ſome improvement in that inſtrument; but I had not heard it before eighteen months had elapſed, after I had perfected my demonſtration of it, and ſpoke to the workman to conſtruct it accordingly.

As the propoſed alteration makes the inſtrument capable of affording a number of obſervations, the unavoidable errors

* Mr. *Poole* had no opportunity of aſcertaining the latitude or longitude of Wilmington by celeſtial obſervations, but they are both to be gotten with ſufficient exactneſs from Mr. *Biddle*'s meaſurement between New-Caſtle and the Philadelphia obſervatory p. 87. From that meaſurement, we get Wilmington weſt of Philadelphia obſervatory 6741¼ perches=23′. 38″,8 diff. of meridians, or 1′. 34″,6 of time; and ſouth of the ſame 4732¼ perches=12′. 52″,6 diff. of latitude. Whence the latitude and longitude of Wilmington in reſpect to Greenwich, are as above ſet down. *W. SMITH.*

rors ariſing from them may be greatly leſſened, by taking a mean of them: So that angles may be meaſured by it with much greater preciſion than can be attained by the common quadrants. This will make it peculiarly ſerviceable for finding the longitude at ſea, from the obſerved diſtance of the Moon from the Sun, or from a known ſtar near her path. For unleſs this diſtance is meaſured accurately, it will occaſion a conſiderable error in the deduced longitude.

That the inſtrument may anſwer theſe purpoſes, it is deſigned that the arch ſhall contain an hundred and twenty whole degrees, and be numbered from the middle to 120 both ways, and that inſtead of one central ſpeculum two ſhould be affixed to the index, and inclined to each other in an angle of 60 degrees. When they are once adjuſted to this inclination, let them be ſcrewed faſt by the inſtrument maker.

Now the largeneſs of the arch will enable us to meaſure much greater angles than can be meaſured by the fore obſervation of the common octant. If the Sun be within 30 degrees of the zenith, the double ſextant will give his altitude either above the ſouthern or northern horizon, as may be moſt convenient; or for the ſake of greater preciſion, both may be taken in the ſame manner as by the fore obſervation; and then half the difference between their ſum and 180 degrees, being added to the leſſer altitude when the ſum is leſs than 180 degrees, or ſubtracted from it, when greater, will give his true altitude from neareſt horizon more accurately than either of them ſeparately could give it. This may be done by one central ſpeculum alone and one half of the arch. The ſame may be repeated by the other, and the mean of all the four obſervations taken as ſtill nearer to the truth. Hereby the error of adjuſtment is taken away, and that of the obſervations, leſſened. Or theſe errors may be corrected by the mean of four obſervations, when only one horizon can be made uſe of, in the following manner. Let the altitude be taken in the common way,

way, as by a fore obſervation, by one central ſpeculum and noted; let the index be puſhed ſtill farther along the arch and the image of the Sun will again be brought down to the horizon by the other central ſpeculum, which affords another obſervation of the altitude to be noted alſo; counting from the end of the arch next to the obſerver in the firſt caſe, and from the middle of it in the latter. Then let the arch of the inſtrument be held upwards, and the center downwards, and the index be moved the contrary way; this will give two other altitudes. The mean of any two of theſe obſervations that depend on the ſame glaſſes gives the true altitude free from the abovementioned errors. The ſame may be ſaid of taking any other angles.

The inverting of the inſtrument is not neceſſary in taking angles, when it is indifferent which of the objects is brought to the other by reflection; as in meaſuring the diſtance between two ſtars. But when one of the objects is brighter than the other, it is neceſſary to bring the brighter to the other by reflexion, in that caſe it is neceſſary to invert the double ſextant. In other caſes it will be found more convenient to make all the obſervations, by only moving the index both ways.

When the diſtance of two objects is continually changing, and expedition is neceſſary in the obſervation; two or more pieces of braſs ſhould be made to ſlide on the arch of the inſtrument, that the degrees noted by the index may be marked, by bringing one of them up to the index and ſcrewing it faſt to the arch, where it muſt remain, until all the obſervations are made. In the ſame manner may all the obſervations but the laſt be marked; that no time may be loſt in reading off the degrees and minutes and writing them down. When the obſervations are completed, they may be read off, by bringing the index cloſe up to the abovementioned pieces, and written down at leiſure.

That the moving the index backwards, will give the altitude of the Sun or ſtar above the horizon, when the arch hangs

hangs downwards, will appear very evident, by conſidering, that the image of the Sun is brought down to the horizon, by puſhing the index from the obſerver, and conſequently the image of the horizon is alſo ſunk as much below the true horizon; therefore, when the index is moved in a contrary direction or towards the obſerver, the image of the horizon is thereby raiſed up to the Sun in the Heavens, and their diſtance is ſhewn on the arch. But as it is requiſite to bring the image of the Sun to the horizon, by moving the index both ways, this is effected by invertingthe inſtrument; holding the arch downwards, while one obſervation is made, and upwards while the other is made.

The above illuſtration is ſufficient to anſwer all the purpoſes of a demonſtration to ſuch as are acquainted with the theory and principles of this inſtrument; as it ſhews, that the demonſtration is nearly the ſame for the obſervations made both with the arch hanging down, and with it inverted. But as it may be deſired by ſome, I ſhall inſert the demonſtration for the obſervation with the inverted double ſextant, which will ſhew more clearly the reaſon of graduating the arch both ways from the middle.

Let the double ſextant inverted be repreſented by APQR; (See Plate IV. Fig. II.) QAR being the common ſextant, and QAP the additional part propoſed; in which it is to be proved, that while the index moves from the poſition QCA, to that of AFD, the ſolar image will move twice as far from S, down to the horizontal line IDG, and will be ſeen by the eye at I, in the horizontal line IG, parallel to HO; ſo that the angle QAD ſhall be half of the angle SFH, which is the Sun's altitude.

Let SF be a ray of light from the Sun at S, falling on the ſpeculum at F, and from thence reflected to the ſpeculum at G, and from thence reflected again to the eye at I, where the ſolar image will be ſeen in the horizontal line IG; the ſpeculum at G, being ſet parallel to the line AQ, or to the larger ſpeculum at F, when the index is at Q, or the

the beginning of the graduations. Now it is to be proved, that the angle SFH, is equal to twice the angle QAD, which is the diſtinguiſhing peculiarity of this inſtrument.

DEMONSTRATION.

Since NGM, is parallel to CBA, the angle NGC, is equal to GCB, and the angle MGB, is equal to GBC, being alternate; but the angles NGC, and MGB, are equal from the laws of reflexion, which make the angle of incidence equal to that of reflexion. Therefore GBC is an iſoſceles triangle, having the angles at B, and C, equal.

Again, ſince HFS+SFD=(HFD=QAD+FEA=QAD+ +DEA=QAD+FBC=QAD+QAD+BFA=2QAD+BFA =1QAD+GFA=) 2QAD+SFD. Therefore, HFS=2 QAD.

That the inſtrument may be held with greater eaſe, an handle may be affixed to the back of it, or another ſextant might be added directly oppoſite to the middle of the other two, and the index continued to the oppoſite arches, moving on the center; which would have its advantages eſpecially on land. And as the errors of adjuſtment and obſervation may be corrected without the ſecond central ſpeculum, it may be neglected.

This improvement of an inſtrument, which was firſt invented and conſtructed by Mr. *Godfrey* of this city, and which, I do not heſitate, to call the moſt uſeful of all aſtronomical inſtruments that the world ever knew, I hope will make it ſtill more ſerviceable to mankind. But however this may be, it is ſubmitted with all due reſpect to the ſociety, by

Their very humble Servant,

JOHN EWING.

To

To the AMERICAN PHILOSOPHICAL SOCIETY, *held at Philadelphia, for promoting uſeful Knowledge.*

GENTLEMEN,

SINCE my delivering in the ſhort account of the improvement, which I propoſed in the conſtruction of Mr. *Godfrey*'s double reflecting octant, at a late meeting of this ſociety, I have been induced to ſubjoin a relation of the manner in which I was firſt led into it, and of the time when it was effected. In the beginning of the year 1767, finding that the common arch of the octant was too ſhort, for taking large angles by a fore obſervation, I thought that it might be conveniently enlarged; and ſoon after found that this enlargement might anſwer valuable purpoſes both at ſea and on land. I communicated, to Mr. *Benjamin Condy*, mathematical inſtrument-maker of this city, my propoſal for making the inſtrument with double the uſual arch, and the addition of a ſecond ſpeculum on the index, inclined to the other in an angle of half the length of the arch; as appears by his certificate, which I have here inſerted in the following words, viz.

"*THIS is to certify, That ſometime in the ſpring or ſummer of the year* 1767, *the Revd. Mr. John Ewing, of this city, communicated to me a propoſal of his, for making Godfrey's Sextant with double the uſual arch, and the addition of another ſpeculum affixed to the index, and inclined to the other in an angle of half the enlarged arch; and that we had frequently converſed together on the purpoſes deſigned to be anſwered by this new conſtruction. As witneſs my hand this* 10*th day of January,* 1770.

BENJAMIN CONDY."

About two years after I had thought of this conſtruction of the inſtrument and perfected the demonſtration of it, which I laid before the ſociety on the original ſcrap of paper, on which it was firſt written, I learned by converſing with

with Mr. *William Grant*, an ingenious mathematician and merchant of London, who came to this city about April or May 1769, that he had alſo propoſed an improvement in the ſame inſtrument, but different from mine in theſe reſpects, viz. His was a complete ſemicircle, having the horizon glaſs and place of the eye fixed on the arch, and without the ſecond ſpeculum on the index; which anſwered nearly the ſame purpoſes, with mine; excepting that by its wanting the above mentioned ſpeculum, it afforded but half the number of obſervations which my conſtruction admits of. The firſt intimation I ever had of his improvement was from the Rev. Dr. *William Smith*, provoſt of the college in this city, in May laſt; to whom I had ſome time before mentioned, that I had thought of ſomething, which might be deemed an improvement in the conſtruction of *Godfrey*'s quadrant. This Dr. *Smith* intimated to Mr. *Grant*, upon his informing him that he had improved that inſtrument before he left London; which circumſtance induced the Doctor to promiſe him an introduction to my acquaintance, as appears by his certificate in the following words, viz.

Philadelphia, 12th Jan. 1770.

" REV. SIR,

" *IN anſwer to your requeſt, that I ſhould certify the occaſion of my introducing Mr. Grant to you, I do well remember it to have been as follows.——That ingenious gentleman having been recommended to my acquaintance, by ſome of my friends to the northward, we happened, one day about the beginning of laſt May, to fall into converſation upon ſome literary ſubjects. Among other things, Mr. Grant mentioned an improvement which he had made in the conſtruction of Godfrey's quadrant, and with a truly communicative ſpirit ſeemed willing to explain the nature of his improvement, by making out a draft or ſketch of it for me. It happened that I was to ſet out the day following, on a journey to Northampton County, and Mr. Grant was apprehenſive*

henſive that he ſhould leave Philadelphia before my return. I then recollected what you had told me ſome time before, concerning your improvement of Godfrey's quadrant, and ſpoke to Mr. Grant as follows: I am ſorry, I am obliged to go out of town to morrow, as I could wiſh to have ſome further converſation on this ſubject; but there is a gentleman of this city, the Rev. Mr. Ewing, who ſome time ago mentioned to me an improvement of a ſimilar nature, which he had made, and I believe he has engaged a workman to finiſh a quadrant for him, on the plan he has projected. Are you acquainted with Mr. Ewing? If not, I will bring you together, for I would wiſh you to compare your ſchemes, and to have a conference with each other. Mr. Grant expreſſed his deſire to be acquainted with Mr. Ewing, and I accordingly introduced them to each other, before I went on my journey.

WILLIAM SMITH."

To the Rev. Mr. Ewing.

Theſe things I have mentioned not from a ſolicitude about the invention, but to ſhew, that, what has often been ſuppoſed probable in affairs of this nature, has actually taken place in the preſent inſtance; that men at the diſtance of many thouſand miles might fall nearly upon the ſame inventions, about the ſame time, without any previous correſpondence or acquaintance with each other. J. E.

An ESSAY on the Uſe of COMETS, and an Account of their LUMINOUS APPEARANCE; *together with ſome Conjectures concerning the Origin of HEAT.*

By HUGH WILLIAMSON, *M. D.*

Read before the Society, Nov. 16th, 1770.

A COMET is a ſolid dark body revolving round the Sun in ſtated periods, receiving light and heat from the Sun. Comets revolve as other planets do in an ellipſis,