

TRANSACTIONS

135-5-6

OF THE

AMERICAN

PHILOSOPHICAL SOCIETY,

HELD AT

PHILADELPHIA,

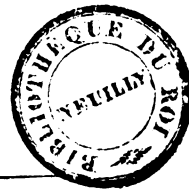
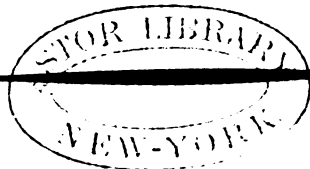
FOR PROMOTING

USEFUL KNOWLEDGE.

VOLUME I.

THE SECOND EDITION CORRECTED.

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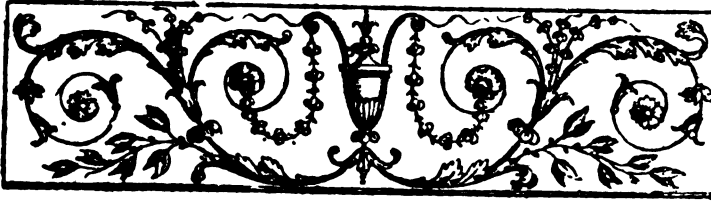
1789

1789

PROTHONOTARY'S OFFICE, Philadelphia county.

I DO certify that on this 20th day of April, 1789, a Book entitled "Transactions of the American Philosophical Society, held at Philadelphia, for promoting useful Knowledge," vol. 1. 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.

SECTION 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

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their

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^o. 44'. 3". N. Long. 5h. 2'. 9". W.

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

Apparent Time.

2h. 12'. 48¹/₂ 1st Ext. cont.

2. 30. 20¹/₂ 1st Int. ditto.

} 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.
 } 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 6741¹/₄ perches=23'. 38¹/₂ diff. of meridians, or 1'. 34¹/₂ of time; and south of the same 4732¹/₄ perches=12'. 52¹/₂ diff. of latitude. Whence the latitude and longitude of Wilmington in respect to Greenwich, are as above set down.

W. S M I T H.

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 inverting the 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.

D E M O N S T R A T I O N.

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, $HFS = 2QAD$.

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,

J O H N E W I N G.

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 Condry*, 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 10th 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,

“ *I*N 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,

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