XVIII. *A Description of a new System of Wires in the Focus of a Telescope, for observing the comparative Right Ascensions and Declinations of cœlestial Objects; together with a Method of investigating the same when observed by the Rhombus, though it happen not to be truly in an equatorial Position. By the Rev.* Francis Wollaston, *LL.B. F.R.S.*

Read April 7, 1785.

IN consequence of a paper communicated the last year to this Society, and honoured with a place in our Transactions, it may be expected of me, that I should now deliver in an account of what farther observations I have made on that constellation of which I then gave a rough map. This I readily would do, if they were in any degree worthy of the Society's notice. But as yet they are far from perfect: how much better they may succeed hereafter, time must shew.

Yet has this year perhaps not quite been lost; the difficulties which disappointed my hopes, having led to what appears to me an improvement in the instrument with which to pursue such observations.

My design, as was hinted in that Paper, was to ascertain, as well as I was able, the right ascensions and declinations of the stars I had laid down; by observing their *meridian passages* and *meridian altitudes*, where that could be done with such small instruments as mine; as also by their *comparative passages* through the field of an equatorial telescope furnished with a ſyſtem of wires invented by Dr. BRADLEY, and called by the French *Reticule Rhomboïde*, whence it has commonly obtained in Engliſh the name of the Rhomboid.

In the former I was diſappointed by the weather; which from the time I went into the country, in the middle of May, till the end of June, when that conſtellation came to the meridian in the day-light, afforded me very few evenings fit for obſervation.

In the latter I failed, through the imperfection of my inſtrument, or my own want of ſkill in the uſe of it; for though a ſingle ſet of obſervations in any one evening would appear very good, yet when reduced by calculation, and confronted with other repeated trials, they never gave me the ſatisfaction I wiſhed.

The rhombus (for a rhombus, and not a rhomboid, it ought moſt properly to be called) is very good in theory; but very difficult to get executed with preciſion, and liable to ſome inaccuracy in the obſervation. The truth of it depends upon the longer diagonal being exactly twice the length of the ſhorter one; which requires an aukward angle (53° 7′ 48″) at the vertex, not eaſily to be hit by the workmen, and therefore ſeldom ſufficiently true. Beſide this, as the ſides of the rhombus, on which depends the calculation for differences of declination, are but 26° 33′ 54″ declining from the perpendicular or horary wire, a very ſmall error in obſerving the paſſage of a ſtar makes a very material difference in the reſult.

This determined me upon making trial of a ſquare placed angularly (an addition to M. CASSINI's wires at 45°, as may be ſeen in tab. XII. fig. 1.) which ſeems to anſwer better. I muſt confeſs I have not yet had opportunity for trying it ſo completely as I could wiſh: but I was unwilling to let this year slip by, without making it known; since, I think, from what I have done with it, I may be confident of its utility *.

The *properties* and *advantages* of such a system of wires scarcely need to be pointed out to astronomers. The whole extent of the field is employed as it is in the rhombus (the want of which was said to be Dr. BRADLEY's objection to M. CASSINI's wires); but being formed of right angles or half-right angles, to which workmen are most accustomed, they will always be apt to execute their part better; and the obliques, from the differences being just double to what they are in the rhombus, give the comparative declinations with twice the certainty. To this the number of corresponding observations in the passage of every star add considerably; since you may calculate its distance from the center C, from the angle D or E, or from one of the intermediate angles K, as you shall see occasion. The same indeed you may do in the rhombus from D or from E; or, if the rhombus be formed of wires, from the angle at L, fig. 2.; but only with half the precision. The result of a single passage of any one star (excepting towards the extremities of the field) gives the extent of the field equally in each, provided the declination of the star be known, by deducing its distance from those several angles; and such deductions serve as a still farther check upon every observation; because,

* What is here offered is by no means to be understood as recommending any system of wires in preference to actual measurement with a micrometer, but to render the use of them as convenient as may be to such gentlemen as are not provided with better instruments. The equatorial micrometer with a large field (such as I have seen at Mr. AUBERT's, of Mr. SMEATON's construction) I take to be the best instrument for taking differences of right ascension and declination out of the meridian; and far superior to any system of fixed wires, or indeed to any equatorial sector whatever.

caufe, if any part of it be thought doubtful, its tallying or not tallying with the known extent of the field will fhew whether there be any error, or where it lies. And, in each of them, the parallel wires will tell you whether the placing of your inftrument be true or faulty; becaufe, if truly made and truly fet, the fame ftar muft take the fame time in paffing from one wire to its correfponding parallel; which will differ confiderably, and in every ftar the fame way, if the pofition be faulty.

Some of thefe latter remarks might have been fpared, but that they may ferve as hints to fuch gentlemen as may be inclined to lend their affiftance to what was propofed the laft year, and who may not have confidered the many helps to be derived from a crofs examination of the obfervations they make. For their ufe alfo it may be proper to add, what indeed is nothing new, that if the pofition of the inftrument be found erroneous, the formula given by M. DE LA LANDE in his Aftronomy will ferve to rectify the obfervation. Calling the larger interval between the paffage of any oblique and the horary wire m, and the fmaller one n, $\frac{m^2n+n^2m}{m^2+n^2}$ will give the difference of declination (in time, to be converted into degrees, and multiplied by the cofine of declination) from the angle where that oblique meets the horary; and $\frac{m^2n-n^2m}{m^2+n^2}$ the difference in right afcenfion from the fame angle. It muft furely be almoft needlefs to mention, that where the pofition is true, *half* the interval of time between a ftar's paffing any two correfponding obliques, converted into degrees, and multiplied by the cofine of declination, will give the difference in declination of that ftar from the angle where thofe obliques meet, as the *whole* interval does in the rhombus.

But

But it may, perhaps, be of ſervice to aſtronomy, or at leaſt not unacceptable to thoſe gentlemen who uſe the Rhombus, that I ſhould ſubjoin another formula (contrived for me the laſt ſummer by my Son, now Mathematical Lecturer at Sidney College, Cambridge) for inveſtigating the comparative right aſcenſions and declinations of ſtars obſerved by it, when the inſtrument is not placed truly in the plane of the equator. I was led into wiſhing for ſome ſuch formula, in conſequence of an ingenious Paper, kindly communicated to me by Sir H. C. ENGLEFIELD, Bart. F. R. S. giving an account of his method of doing it by a ſcale and figure; which, though very eaſy when one is provided with ſuch a ſcale, appeared to me to be of leſs general uſe than by calculation; and I do not know that any thing of the kind is to be met with in any publication.

Let the angle DLL, fig. 2. (which, by conſtruction, is 63° 26′ 6″) be called - - - -

The diagonal LL (whoſe extent, that is, what portion (a great circle it comprehends, muſt be known to the obſerve: be called - - - - -

The larger interval obſerved between the paſſage of a ſta by an oblique and the horary wire (as $b\,c$) - -

The ſmaller ditto of the ſame ſtar (as $c\,d$) - n

The larger ditto of another ſtar (as $\beta\,\gamma$) - - μ

The ſmaller ditto (as $\gamma\,\delta$) - - - ν

Then $\frac{2\,.\,\overline{m-n}}{m+n}$ = tangent of the angle which LL makes with a parallel of declination: call this q

The angle q being thus found, then

$\frac{2\,.\,\overline{n \backsim \nu} \times \text{ſin.}\,\overline{a+q}}{\text{R} \times \text{ſin.}\,a} \times \text{coſ.}\,q.$ = difference in declination between the two points on the vertical wire where

thoſe

thoſe ſtars paſs it. N. B. This being in *time* muſt be converted into *degrees*, and multiplied by coſine of declination as uſual, to give the true difference in declination between the ſtars.

And the ſame expreſſion, *viz.*

$\frac{2 . \overline{n \backsim \nu} \times \text{ſin.} \overline{a+q}}{R \times \text{ſin.} a} \times \text{ſin.} q =$ the difference in Æ between thoſe two points; to be applied as a correction to the obſerved times.

The ſame may be done by the larger intervals m and μ, only by ſubſtituting $\overline{a-q}$ in the place of $\overline{a+q}$, thus:

$\frac{2 . \overline{m \backsim \mu} \times \text{ſin.} \overline{a-q}}{R \times \text{ſin.} a} \times \text{coſ.} q =$ difference in declination as above;

or . . . . . . $\times \text{ſin.} q =$ aſcenſional difference.

If the ſtars differ too much in declination to come within the expreſſion above (as N° 2. and 3.) then the differences of the angles D and E in declination and right aſcenſion may be found thus:

$\frac{2 . b \times \text{coſ.} q}{R} =$ difference in declination between D and E;

$\frac{2 . b \times \text{ſin.} q}{R} =$ their aſcenſional difference;

and the difference of each ſtar from its reſpectively neareſt angle of the rhombus, may be deduced by the former expreſſion, leaving out the conſideration of the other ſtar, thus:

$\frac{2 . n \times \text{ſin.} \overline{a+q}}{R \times \text{ſin.} a} \times \text{coſ.} q =$ difference of the ſtar in declination from its neareſt angle.

and . . . . $\times \text{ſin.} q =$ its difference in right aſcenſion.

The application of theſe formulæ is very eaſy: for having ound q, if you ſet down its coſine in one column for declina-

 tion.

tion, and its ſine in another column for right aſcenſion, and under each the conſtant ſin. $\overline{a+q}$, and the arithmetical compl. of ſin. a; theſe being added together will make two ſums, for the comparative obſervations of every ſtar which may paſs your field; and, unleſs your field be very large, and the declination of the ſtars very great, if to the column for declination you add the coſine of declination of the center of your field, it will adapt itſelf to all the products.

FRANCIS WOLLASTON.

Charter-houſe-Square,
March 15, 1785.

P O S T S C R I P T.

SINCE the delivery of this Paper, it has occurred to me, that it may ſometimes be convenient to know the angle of deviation from the true equatorial poſition in the new ſyſtem of wires. This is to be deduced nearly in the ſame manner as in the rhombus; for $\frac{m-n}{m+n}$ = tang. q. By this angle any obſerved differences in right aſcenſion may be corrected: for the difference in declination between any two ſtars (or their difference from the angle) multiplied by ſin. q, will give the correction required.

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Fig. 1.

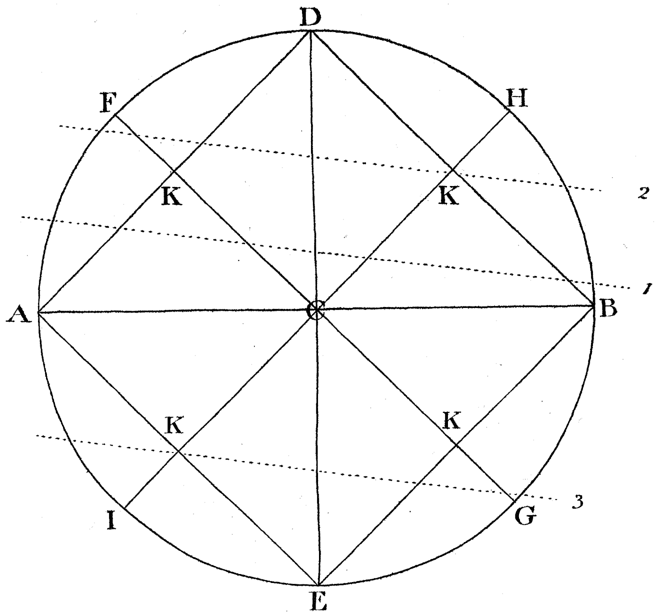

Fig. 2.