IV. *A new Method of finding Time by equal Altitudes.* *By* Alexander Aubert, *Esq. F. R. S.*

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AMONG the various methods practifed for finding time, that by equal altitudes of the Sun or of a ftar, hath hitherto been efteemed the moft eligible for obfervers who are not furnifhed with a good and well-adjufted tranfit inftrument. But this method, although one of the beft, is generally attended with inconveniencies, which render the practice of it more difficult, and the refult lefs perfect than one could wifh.

If the Sun or ftars near the equator are made ufe of, as ufual, and the altitudes are taken near the prime vertical, where the change of altitude is the quickeft, the interval of time between the obfervations muft, in moft latitudes, be of fo many hours, that the obfervver cannot always attend to the correfponding altitudes: the weather may prove variable, fo as to difappoint him at laft; the clock or watch may go irregularly during fo long an interval; and if the altitudes cannot, on account of their great diftance from the meridian, be taken very high; an alteration in the ftate of the atmofphere may produce a variation of the refraction, and occafion the horary arcs to be different, although the apparent altitudes will be the fame. To which may be added, the difficulty of making

making the inſtrument follow the object in its motion in azimuth, without danger of diſturbing its adjuſtment in regard to altitude.

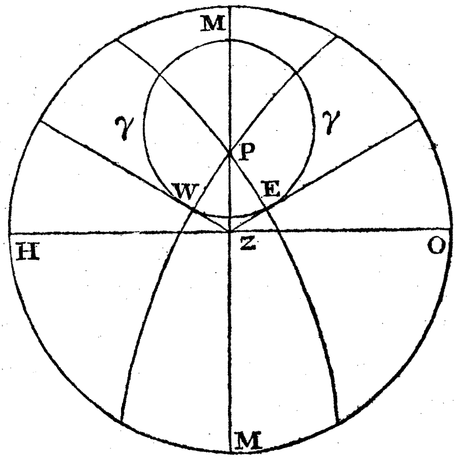
To remedy all theſe inconveniencies, the following method was thought of; and having been practiſed with conſtant ſucceſs, it is preſumed, the communication of it may be acceptable to aſtronomers.

If a ſtar is ſelected, of which the polar diſtance is very little leſs than the complement of the latitude of the place of obſervation, it will, at equal diſtances from the meridian, come to vertical circles, which touch its parallel of declination. The ſtar, when in theſe vertical circles, will be near the meridian, near the prime vertical, and near the zenith; and conſequently, if it be obſerved there, the interval between the Eaſtern and the Weſtern altitudes will be ſhort; the alteration in altitude will be quick; the ſtar cannot be affected by a different refraction; beſides, it will have no motion in azimuth.

To obſerve the ſtar in theſe vertical circles, two things are neceſſary; the firſt is, to be provided with an aſtronomical quadrant, having three or more horizontal wires in the teleſcope, and if it have alſo a *ſpeculum* at the eye-end of the teleſcope, to bring the vertical ray horizontal, it will be found very convenient. The next thing is, to make a computation of the apparent zenith diſtance of the ſtar in the vertical circles which touch its parallel of declination; for if the teleſcope be fixed to this zenith diſtance, as ſoon as the ſtar is found

found to come to it, it will be in the proper vertical circle.

The true zenith diſtance is found eaſily in the following manner; and if diminiſhed by the refraction belonging to it, it will give the apparent zenith diſtance wanted.



Let HMOM repreſent the horizon; Z the zenith; MM the meridian; P the pole of the equator; γγ the parallel of declination of a ſtar, interſecting the meridian very near the zenith between Z and P. Then, the vertical circles ZE on the Eaſtern ſide of the meridian, and ZW on the Weſtern ſide, being drawn to touch the path of the ſtar, the hour circles paſſing through the points of contact E, W, will be at right angles to the circles of azimuth ZE, ZW.

Now in the right-angled ſpheric triangle PEZ; PZ the complement of the latitude, and PE the ſtar's polar diſtance, being known, the other parts are eaſily found; *viz.* ZE the zenith diſtance, PZE the azimuth, ZPE the horary angle. So that the teleſcope may be fixed properly, the poſition of the inſtrument is aſcertained, and the time known when the ſtar may be expected in the field

field of the telefcope; and if the vertical wire is once brought near to the ftar, the ftar will appear to move parallel to it, and will pafs fucceffively over the horizontal wires, while the inftrument remains undifturbed.

The advantage of this method will appear in the following example of equal altitudes, taken the 15th July, 1773, at Loam-pit Hill, near Deptford, in latitude 51° 28′ 7″ N. and longitude 5″ in time W. of the Royal Obfervatory at Greenwich.

The ftar felected was γ Draconis, having 38° 28′ 21″ apparent North polar diftance, being very little lefs than the complement of the latitude 38° 31′ 53″.

Then cof. PE : rad. :: cof. PZ : cof. ZE = 2° 19′ the zenith diftance,
and fin. PZ : rad. :: fin. PE : fin. PZE = 87° 5′ 20″ the azimuth,

alfo rad. : tan. PE :: cotan. PZ : cof. ZPE = 3° 43′ 13″ the horary arc = 14′ 52″,9
in fidereal time, or 14′ 50″,5 in mean time.

The true zenith diftance being 2° 19′, the fame was diminifhed by 2″ for refraction, and the telefcope fixed to 2° 18′ 58″, the apparent zenith diftance; and when the ftar came to the wires, the times by the clock were as follow:

	Eaftern altitudes. h ′ ″			Weftern altitudes. h ′ ″	Meridian paffage. h ′ ″
1ft wire at	9 55 43	2′ 14″	2′ 14″	10 29 46	10 12 44,5
2d	9 57 57	2 12	2 12	10 27 32	10 12 44,5
3d	10 0 9			10 25 20	10 12 44,5

fo that in about 34′ the compleat fet of altitudes was obtained near the prime vertical, free from the effects of a different refraction, and any motion in azimuth. The

horary

horary arc obſerved by the middle wire not turning out exactly according to the computation, is of no conſequence to the obſervations. Some little difference may ariſe in it from ſmall inaccuracies in the eſtimation of the ſtar's apparent polar diſtance, the latitude of the place, or the error of the line of collimation; or from not ſetting the teleſcope exactly to the proper zenith diſtance; but as the chief intention of the computation is to find the vertical circles in which the ſtar hath no motion in azimuth, the other parts of it need not be ſtrictly attended to.

The following manner of inferring mean time from the ſtar's meridian paſſage being more convenient and conciſe than the uſual one, may alſo be acceptable.

From the ſtar's apparent right aſcenſion, increaſed by 24 hours if neceſſary, ſubtract the Sun's apparent right aſcenſion for apparent noon; diminiſh the remainder by the proportional part of the ſtar's acceleration, at the rate of 3′ 55″,91 for 24 hours, of which a table is eaſily computed; to this laſt remainder apply the equation of time for apparent noon, according as it is additive or ſubtractive; the reſult will be the mean time of the ſtar's paſſing the meridian.

EXAMPLE.

	h	′	″
The apparent Æ of γ Draconis the 15th July, 1773, was	17	51	24,0
—the apparent Æ of the Sun at apparent noon,	7	39	59,0
Firſt remainder,	10	11	25,0
— the ſtar's acceleration for $10^h\ 11'\ 25''$, at $3'\ 55'',91$ for 24 hours		1	40,2
Second Remainder,	10	9	44,8
+ the equation of time at apparent noon, additive,		5	27,7
Star's meridian paſſage in mean time,	10	15	12,5

But the clock ſhewed $10^h\ 12'\ 44'',5$ when the ſtar paſſed, conſequently it was $2'\ 28'',0$ too ſlow for mean time.

Obſervers, who are not furniſhed with tables of the Sun's right aſcenſion and of the equation of time for the apparent noon of their meridian, may apply both as they are given in the Nautical Ephemeris for the meridian of the Royal Obſervatory at Greenwich; the reſult will be the mean time of the ſtar's paſſing the Greenwich meridian. And by applying the proportional part of the foregoing acceleration of $3'\ 55'',91$, belonging to the difference of longitude in time of the place of obſervation from Greenwich, the mean time of the ſtar's paſſing the meridian of the place of obſervation will be found. If the place be to the Eaſt of Greenwich, the acceleration will be additive; if to the Weſt, ſubtractive.

In a fimilar manner, the mean time of any obfervation made with a clock, regulated to fidereal time, may be inferred, provided the preceding tranfit of the Sun hath been obferved; for if from the time of the obfervation by the clock, increafed, if neceffary, by 24 hours, the time of the obferved tranfit of the Sun be fubtracted, the remainder, diminifhed by the proportional part of 3′ 55″,91 and duly corrected by the equation of time for the preceding noon, will give the mean time required. It is underftood, that the clock keeps the rate of fidereal time exactly; for if not, a further correction for the lofs or gain fince noon muft be applied.