ral days before, was fo cloudy that I attempted in vain to regulate my clock, though I watched every favourable opportunity. On the day of the eclipfe I got it pretty well adjufted by feveral correfponding altitudes of the fun. About 1^h P. M. the clouds gathered fo much round the fun, that I was apprehenfive they would prevent any obfervation. But being pretty much fcattered, at $1^h\ 36'\ 42''$ apparent time, I could very plainly perceive that the eclipfe was juft begun. This I judged was very near the beginning, if not exactly fo, though it was attended with fome uncertainty. In a few minutes the fun was wholly covered with the clouds, and remained thus till $3\frac{1}{2}^h$, when they began again to fcatter, and left that part of the heavens in which the fun appeared, perfectly clear. The weather continued thus till the end of the eclipfe, which by a good obfervation was at $3^h\ 47'\ 2''$. Thefe obfervations were made with a reflector made by *Nairne*, magnifying as near as I could judge about fixty times; but as to the *quantity* of the eclipfe, no obfervation could be made, the fun being obfcured by the clouds the biggeft part of the time.

N° XXXIII.

An eafy and accurate Method of finding a true Meridian Line, and thence the Variation of the Compafs.

By ROBERT PATTERSON.

Read Apr. 7, 1786.

OF the various methods which aftronomers employ for finding a true meridian line, none feems fo well adapted, as could be wifhed, to the common ufe of furveyors, in finding the variation of the Compafs.

To find the azimuth of the fun by a fingle obfervation of his altitude, befides a quadrant which is neceffary fo thi this purpofe, requires the previous knowledge either of the latitude of the place, or hour of the day, at the time of obfervation; neither of which can, by the common apparatus of a furveyor, be found with fufficient accuracy.

The fun's azimuth may, it is true, be found without knowing either the latitude of the place or hour of the day, by taking equal altitudes before and after noon; but this requires time, attention and inftruments, which furveyors can but feldom command.

That method, which is perhaps the moft exact, viz. meafuring the time between the paffage of two ftars which differ confiderably, in declination and but little in right afcenfion, over the fame vertical circle, is ftill farther out of the reach of common furveyors.

The following table of the pole ftar will, it is prefumed, furnifh a more eafy, and yet fufficiently accurate method of determining this problem; free from all the above inconveniencies, and requiring no difficult calculation, nor any other inftrument than the common theodolite, or circumferentor. For though the latitude of the place fhould not be known within a whole degree, nor the hour of the night within 2 or 3 minutes, this table, by a fingle obfervation of the magnetic azimuth or bearing of the pole ftar, will generally give the variation of the needle true to a fingle minute of a degree. Nay if the obfervation be made (as it may be every night) when the ftar is near its greateft elongation, an error of 10, or even 20 minutes in time will, as is plain from the table, produce little or no fenfible error in the azimuth. And as thefe obfervations may be repeated at pleafure during the night, and a mean of all taken, the variation may, by this means, be found to any degree of accuracy that can be defired. Befides, the needle is not at this time affected with any diurnal variation; which in the day-time is very uncertain, and frequently amounts to more than one quarter of a degree.

The

The beſt inſtrument for obſerving the ſtar's magnetic azimuth is a theodolite, furniſhed with ſpirit-levels, and a ſmall teleſcope with a perpendicular wire. A common circumferentor may, however, anſwer the purpoſe. When this inſtrument is uſed, a fine thread or hair muſt be ſtretched along from the top of one ſight to that of the other, directly over the center of the compaſs; and the obſerver muſt be very careful to place the ſights perpendicular to the horizon when he makes the obſervation; for this purpoſe a ſmall pocket ſpirit-level, in the form of a carpenter's ſquare, would be very convenient.

By the common circumferentor we cannot, indeed, take the bearing of an object with very minute accuracy; for though the eye can very well judge of the coincidence of two lines, or of the point of the needle with any whole degree on the compaſs, yet the parts of a degree cannot readily be obſerved to greater exactneſs than one third or one fourth of the whole. This inconvenience may, however, be eaſily remedied, and at a very trifling expence, in the following manner.

Let one of the ſights, by means of a ſcrew, be made movable at right angles to the index; and on the end of the index, cloſe to the movable ſight, ſet off, on each ſide of the central line, the tangent of three degrees to a radius equal to the whole length of the index, or diſtance between the two ſights. Let each of theſe degrees be divided into ſix equal parts; then will a nonius diviſion on the ſight, where ten equal parts muſt correſpond with eleven on the index, ſubdivide theſe parts into minutes of a degree.

It will be unneceſſary to make the ſight move in the arch of a circle, the difference between this and the tangent, in ſo ſmall an arch, being quite imperceptible. With this ſimple improvement the common circumferentor will take the bearing of an object true to a minute, thus: Let the end of the needle be made exactly to coincide with the neareſt whole degree, then move the ſcrew till the object appears in the direction of the ſights, and the nonius on the movable ſight will point out the odd minutes.

Explanation and Uſe of the TABLE.

The left hand double column of the table contains the time before the ſtar's paſſage over the meridian above the pole, for every twenty minutes of its whole diurnal circuit. The firſt column, under each particular latitude, ſhews the azimuth of the ſtar at theſe times, reſpectively, in degrees, minutes and tenths of a minute. The ſecond column ſhews the difference of azimuth in every twenty minutes of intermediate time, in minutes and tenths.

To find the true azimuth of the ſtar in any latitude, at any given time.

From the ſtar's right aſcenſion, viz. $0^h\ 49^m$, increaſed by 24^h if neceſſary, ſubtract the right aſcenſion of the ſun computed to the time of the ſtar's paſſage over the meridian, above the pole, nearly, the remainder will be the time of ſaid paſſage, reckoned from noon. From which, increaſed by 24^h if neceſſary, ſubtract the time of the obſervation, reckoned alſo from noon, the remainder will ſhew the time before the ſtar comes to the ſaid meridian. Look for this time in the left hand column of the table, oppoſite to which in the column of azimuth, under the proper latitude, you will have the true azimuth of the ſtar at that time.

If the time before the ſtar comes to the meridian be leſs than 12 hours, its azimuth will be eaſterly; but if more than 12 hours, its azimuth will be weſterly.

If the magnetic azimuth, and the true azimuth at the time of the obſervation, be both eaſterly or both weſterly, their difference will be the variation of the needle. But if one be eaſterly and the other weſterly, their ſum will be be the variation. And if the magnetic be to the weftward of the true azimuth, the variation will be wefterly; but if to the eaftward, the variation will be eafterly.

If the time before the ftar's paffage over the meridian be fome intermediate minute, or the latitude of the place fome intermediate degree, not found in the table, a proportional intermediate azimuth, by means of the differences, muft be taken.

The right afcenfion of the pole ftar annually increafes 10 feconds of time, and its polar diftance decreafes 20 feconds of a degree, therefore to its prefent right afcenfion (in 1785,) viz. $0^h\ 49^m$, muft be added one minute every year; and from its prefent polar diftance ($1^\circ\ 50'.5$) one minute muft be fubtracted, and a proportional part from all the numbers in the columns of azimuth, every three years. The effect of aberration and nutation may be fafely neglected; as the error arifing from thefe caufes can never amount to more than half a minute of a degree in azimuth.

In computing the fun's right afcenfion to the time of the ftar's paffage over the meridian nearly, the following little table will be ufeful.

TABLE.

Time.		Star passes Meridian nearly at
April	2	Noon
	19	11 A. M.
May	5	10
	20	9
June	4	8
	18	7
July	3	6
	17	5
August	2	4
	17	3
September	3	2
	19	1
October	6	Midnight
	22	11 P. M.
November	6	10
	21	9
December	5	8
	19	7
January	1	6
	15	5
	29	4
February	13	3
March	1	2
	17	1

EXAMPLE I.

Suppose on the 12th of September 1785, at 8 o'clock in the evening, in the latitude of 40° N. the magnetic azimuth of the pole-star had been observed to be 0° 38′ easterly; required the variation of the needle at the time and place of observation.

Star's

	H.	M.
Star's R. A. increafed by 24 hours, -	24	49
Sun's R. A. computed to 1^h A. M. (taken from the nautical almanac, or any other table of the fun's R. A.) fubtract -	11	25
True time of ftar's paffage over meridian, reckoned from noon, - -	13	24
Hour of the night fubtract, - -	8	0
Time before ftar's paffage, - -	5	24

Which correfponds to true azimuth,	2°	23′	E.
Magnetic azimuth, - -	0	38	E.
Variation of the needle, -	1	45	W.

EXAMPLE II.

In the latitude of about 32° north, on the 4th of July 1785, at 48 minutes after 10 o'clock at night, fuppofe the magnetic azimuth of the pole ftar, to be 2° 40′ eaft; required the variation of the needle.

	H.	M.
Star's R. A. + 24^h, - - -	24	49
Sun's R. A. - - - -	6	54
Time of ftar's paffing meridian, -	17	55
Time of obfervation, - - -	10	48
Time before ftar comes to meridian, -	7	7

Which correfponds to true azimuth,	2°	4′	E.
Magnetic azimuth, - -	2	40	E.
Variation, - -	0	38	E.

Ex-

EXAMPLE III.

Latitude of the place 42° north, time of obſervation, January 17th 1785, at 2^h 40^m A. M. Magnetic azimuth, 1° 5′ eaſterly.

	H.	M.
Star's R. A. + 24^h - - -	24	49
Sun's R. A. - - - -	20	1
Time of ſtar's paſſing the meridian, -	4	48
	24	
	28	48
Time of obſervation reckoned from noon,	14	40
Time before ſtar comes to meridian, -	14	8

Correſponding to true azimuth,	1° 16′	W.
Magnetic azimuth, - -	1 5	E.
Variation, - - -	2 21	E.

A TABLE

A TABLE of the Azimuth of the Pole-ſtar for every 20 Minutes of its diurnal Motion round the Pole.

Time before the ſtar comes to the meridian above the pole.				Latitude 30°		Latitude 35°		Latitude 40°		Latitude 45°		Latitude 50°		Latitude 55°	
H.	M.	H.	M.	Star's azimuth. ° ′	Diff. ′	Star's azimuth. ° ′	Diff. ′	Star's azimuth. ° ′	Diff. ′	Star's azimuth. ° ′	Diff. ′	Star's azimuth. ° ′	Diff. ′	Star's azimuth. ° ′	Diff. ′
0	0	24	0	0 0.0	11.3	0 0.0	12.0	0 0.0	12.9	0 0.0	14.1	0 0.0	15.6	0 0.0	17.6
	20	23	40	11.3	11.3	12.0	12.0	12.9	12.8	14.1	13.9	15.6	15.4	17.6	17.4
	40		20	22.6	11.1	24.0	11.7	25.7	12.6	28.0	13.7	31.0	15.2	35.0	17.2
1	0		0	33.7	10.7	35.7	11.5	38.3	12.3	41.7	13.4	46.2	14.8	52.2	16.7
	20	22	40	44.4	10.4	47.2	11.0	50.6	11.9	55.1	12.9	1 1.0	14.3	1 8.9	16.0
	40		20	54.8	10.0	58.2	10.6	1 2.5	11.3	1 8.0	12.3	15.3	13.6	24.9	15.4
2	0		0	1 4.8	9.5	1 8.8	10.0	13.8	10.9	20.3	11.8	28.9	12.9	40.3	14.5
	20	21	40	14.3	8.9	18.8	9.4	24.7	10.0	32.1	10.9	41.8	12.0	54.8	13.5
	40		20	23.2	8.2	28.2	8.8	34.7	9.3	43.0	10.1	53.8	11.2	2 8.3	12.5
3	0		0	31.4	7.6	37.0	7.8	44.0	8.5	53.1	9.1	2 5.0	10.0	20.8	11.2
	20	20	40	39.0	6.7	44.8	7.1	52.5	7.5	2 2.2	8.2	15.0	9.0	32.0	10.0
	40		20	45.7	5.9	51.9	6.3	2 0.0	6.7	10.4	7.2	24.0	7.7	42.0	8.7
4	0		0	51.6	5.0	58.2	5.2	6.7	5.5	17.6	6.0	31.7	6.6	50.7	7.3
	20	19	40	56.6	4.1	2 3.4	4.3	12.2	4.5	23.6	4.9	38.3	5.4	58.0	6.6
	40		20	2 0.7	3.1	7.7	3.3	16.7	3.6	28.5	3.7	43.7	4.0	3 4.6	3.6
5	0		0	3.8	2.2	11.0	2.3	20.3	2.4	32.2	2.5	47.7	2.6	8.2	3.0
	20	18	40	6.0	1.3	13.3	1.4	22.7	1.3	34.7	1.4	50.3	1.4	11.2	1.4
	40		20	7.3		14.7		24.0		36.1		51.7		12.6	
6	0		0	7.6	.7	14.8	.6	24.2	.9	36.2	1.0	51.8	1.1	12.5	1.5
	20	17	40	6.9	1.7	14.2	1.9	23.3	2.0	35.2	2.2	50.7	2.5	11.0	2.9
	40		20	5.2	2.5	12.3	2.8	21.3	3.0	33.0	3.3	48.2	3.9	8.1	4.3
7	0		0	2.7	3.5	9.5	3.8	18.3	4.1	29.7	4.5	44.3	4.9	3.8	5.6
	20	16	40	1 59.2	4.5	5.7	4.6	14.2	5.0	25.2	5.5	39.4	6.2	2 58.2	7.0
	40		20	54.7	5.1	1.1	5.6	9.2	6.0	19.7	6.5	33.2	7.1	51.2	8.2
8	0		0	49.6	6.2	1 55.5	6.4	3.2	6.9	13.2	7.5	26.1	8.4	43.0	9.3
	20	15	40	43.4	6.8	49.1	7.3	1 56.3	7.6	5.7	8.5	17.7	9.2	33.7	10.4
	40		20	36.6	7.5	41.8	7.9	48.7	8.5	1 57.2	9.2	8.5	10.2	23.3	11.5
9	0		0	29.1	8.2	33.9	8.7	40.2	9.4	48.0	9.9	1 58.3	11.0	11.8	12.1
	20	14	40	20.9	8.8	25.2	9.2	30.8	9.9	38.1	.0.8	47.3	11.7	1 59.7	13.2
	40		20	12.1	9.3	16.0	9.8	20.9	10.4	27.3	11.3	35.6	12.4	46.5	13.8
10	0		0	2.8	9.7	6.2	10.3	10.5	11.0	16.0	11.8	23.2	12.9	32.7	14.5
	20	13	40	0 53.1	10.2	0 55.9	10.7	0 59.5	11.4	4.2	12.3	10.3	13.4	18.2	14.9
	40		20	42.9	10.5	45.2	11.0	48.1	11.7	0 51.9	12.7	0 56.9	14.0	3.3	15.6
11	0		0	32.4	10.7	34.2	11.3	36.4	12.0	39.2	12.9	42.9	14.2	0 47.7	15.7
	20	12	40	21.7	10.8	22.9	11.4	24.4	12.2	26.3	13.1	28.7	14.3	32.0	15.9
	40		20	10.9	10.9	11.5	11.5	12.2	12.2	13.2	13.2	14.4	14.4	16.1	16.1
12	0		0	0.0		0.0		0.0		0.0		0.0		0.0	