

X. *Observations on the Dip and Variation of the Magnetic Needle, and on the Intensity of the Magnetic Force; made during the late voyage in search of a North West Passage. By Captain Edward Sabine, of the Royal Regiment of Artillery, F. R. S. and F. L. S.*

Read February 25, 1819.

THE dipping needle used in these observations is the property of HENRY BROWNE, Esq.; it was made by Messrs. NAIRNE and BLUNT, and is similar in construction to one made by the same artists, and described by the Hon. HENRY CAVENDISH in the 66th volume of the Philosophical Transactions, as used in the house of the Royal Society.

Previously to delivering it into my charge, Mr. BROWNE had adjusted the balance of the needle by means of the screws on the cross of wires attached to its axis; so that no alteration took place in the indication of the dip, on reversing the poles.

The instrument was placed in the direction of the magnetic meridian, by a compass stationed at a sufficient distance, and suffered to remain during the observations for the purpose of occasional verification. When time admitted, the correctness of adjustment was also proved, by observing the minimum of dip. An equal number of observations were made with the face of the instrument towards the east and towards the west; the arcs indicated at both ends of the needle were read.

In determining the intensity of the magnetic force, the needle was drawn to an horizontal position by a magnet, and being released at an observed moment of time, was suffered

to oscillate until the arcs became too small to be readily distinguished: the first arc was thus equal to the dip, and at every tenth vibration both the arc and time were noted. The observations in the magnetic meridian were repeated with the face of the instrument towards the east and towards the west.

It is highly satisfactory to notice the agreement of the results which were obtained in London and in Shetland, at different periods, and by different observers; showing that the adjustment of the balance of the needle was preserved during the voyage, notwithstanding the accidents to which it was liable: and as a testimony of the excellence of the instrument, and of the confidence which may be placed in observations made with it.

Observations on the dip.

1818.	Latitude.	Longi- tude.	No. of obser.	Observer.	Dip.	Remarks.
April 13	51 31 N.	0 08 W.	16	Capt. Kater	70 34 39	Regent's Park, London.
30	60 09½	1 12	14	Capt. Sabine	74 22 48	} Brassa Island, Shet- land.
May 1	60 09½	1 12	12	Lieut. Parry	74 20 10	
June 9	68 22	53 50	12	Capt. Sabine	*83 08 07	On ice.
19	70 26	54 52	14	Capt. Sabine	*82 48 47	Hare Island.
July 8	74 04	57 52	10	Capt. Sabine	84 09 15	} (Baffins) three Islands.
23	75 05	60 03	10	Lieut. Parry	84 24 57	
23	75 05	60 03	10	Capt. Sabine	84 25 15	On ice.
Aug. 2	75 51½	63 06	10	Capt. Sabine	84 44 30	On ice.
4	75 59	64 47	10	Capt. Sabine	84 52 06	On ice.
19	76 32	73 45	10	Capt. Sabine	85 44 23	On ice.
20	76 45	76 00	14	Lieut. Parry	86 08 53	} On ice.
20	76 45	76 00	14	Capt. Sabine	86 09 33	
25	76 08	78 29	16	Capt. Sabine	85 59 31	On ice.
Sept. 11	70 35	66 55	10	Capt. Sabine	84 39 21	On ice.
Nov. 3	60 09½	1 12	14	Lieut. Parry	74 21 06	} Brassa Island, Shet- land.
3	60 09½	1 12		Capt. Sabine	74 21 47 15	
1819. March	51 31	0 08	16	Capt. Sabine	70 33 16	Regent's Park, London.

It is probable that the needle was affected by local attraction either on the 9th or on the 19th of June; but on which day it is difficult to say. On the 9th the ships were anchored to an iceberg of very considerable size, on which the observations were made, the instrument being removed as far as possible from the ships. On the 19th it was used in the observatory which was erected on Hare Island; every fastening of this ingenious and useful building was of brass, and the greatest care was taken to prevent the needle being disturbed by local or accidental causes. But there were several basaltic columns on the face of a hill which rose immediately from the observatory, which may have had an influence; as these columns on Hare Island are said, by Professor GIESECKE,* to have a powerful effect on the needle.

Observations on the intensity of the magnetic force.

Regent's Park, London, April, 1818. By Captain KATER.

<i>Perpendicular to the meridian.</i>				
100	8 21,6	Mean	No. of Account of vibrations.	1 0 0 0 0 0 0 0 0 0
100	8 15			0 91 59 42 30 21 15 10 6 4 2 1 0
100	8 18,3			0 10 20 30 40 50 60 70 80 90 100

The subsequent observations were made by Captain SABINE.

* Art. Greenland, BREWSTER's Cyclopædia.

Brassa Island, Shetland, lat. $60^{\circ} 09'$, long. $1^{\circ} 12' W$.

<i>In the magnetic meridian.</i>						
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.	
100	m. s.		Arc.	74°		50
100	7 49.5		53	40		48.5
100	7 50		30	30		47
100	7 49.75		40	46	50	
			16	46	60	
			12	46	70	
			7	47	80	
			5	47	90	
			2	46	100	
			1	46		

<i>Perpendicular to the meridian.</i>						
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.	
100	m. s.		Arc.	90°		52
100	8 00		57	42		49
100	7 59		32	47		48
100	7 59.5		24	48	50	
			18	48	60	
			13	47	70	
			9	47	80	
			5	47	90	
			3	47.5	100	
			1	47.5		

On an iceberg in Davis's Strait, lat. $68^{\circ} 22'$, long. $53^{\circ} 50' W$.

<i>In the magnetic meridian.</i>						
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.	
100	m. s.		Arc.	83°		48
100	7 17		59	45		45
100	7 23		35	45		45
100	7 20		27	43	50	
			21	44	60	
			16	43	70	
			12	44	80	
			9	43	90	
			7	44	100	
			4	44		

<i>Perpendicular to the meridian.</i>						
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.	
100	m. s.		Arc.	90°		47
100	7 33		60	46		46
100	7 33		35	45		45
100	7 33		27	45	50	
			21	45	60	
			16	45	70	
			12	44	80	
			8	51	90	
			6	44	100	
			4	44		

On Hare Island, lat. 70° 26', long. 54° 52' W.

In the magnetic meridian.					
Number of vibrations.	Interval.	Mean	No. of vibrations.	Arc.	Time.
100	m. s. 7 22		0	83°	Seconds. 48
100	7 24		10	59	45
100	7 21		20	46	45
		30	36	45	
		40	27	44	
		50	21	44	
		60	16	44	
		70	12	43	
		80	9	45	
		90	6	43	
		100	4	43	
Perpendicular to the meridian.					
Number of vibrations.	Interval.	Mean	No. of vibrations.	Arc.	Time.
100	m. s. 7 26		0	90°	Seconds. 48
			10	62	46
			20	47	45
		30	37	45	
		40	28	44	
		50	22	44	
		60	17	44	
		70	13	43	
		80	9	45	
		90	7	43	
		100	5	44	

On ice in Baffin's Bay, lat. 75° 05', long. 60° 29'.

In the magnetic meridian.					
Number of vibrations.	Interval.	Mean	No. of vibrations.	Arc.	Time.
100	m. s. 7 29		0	84½°	Seconds. 47.5
100	7 25.5		10	59	45.5
100	7 27.5		20	45	44.5
		30	35	44.5	
		40	26	44.5	
		50	19	44	
		60	14	43	
		70	10	44.5	
		80	7	45	
		90	4	44	
		100	1	43	
Perpendicular to the meridian.					
Number of vibrations.	Interval.	Mean	No. of vibrations.	Arc.	Time.
100	m. s. 7 26		0	90°	Seconds. 48
			10	61	46
			20	46	44.5
		30	36	44	
		40	28	44.5	
		50	21	43	
		60	16	43.5	
		70	12	43.5	
		80	9	44	
		90	6	44	
		100	4	45	

On ice in Baffin's Bay, lat $75^{\circ} 51\frac{1}{2}'$, long. $63^{\circ} 06' W$.

<i>In the magnetic meridian.</i>					
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.
100	m. s.		Arc.		
100	7 21,5		84°	0	
100	7 25		58	10	
100	7 23,25	46	20		
		35	30		
		28	40		
		22	50		
		17	60		
		13	70		
		10	80		
		7	90		
		5	100		
			44		

<i>Perpendicular to the meridian.</i>					
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.
			Arc.		
				0	
				10	
			20		
			30		
			40		
			50		
			60		
			70		
			80		
			90		
			100		

On ice in Baffin's Bay, lat. $76^{\circ} 45'$, long. $76^{\circ} W$.

<i>In the magnetic meridian.</i>					
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.
100	m. s.		Arc.		
100	7 13		86°	0	
100	7 17		60	10	
100	7 15	47	20		
		45	30		
		44	40		
		43	50		
		43	60		
		43	70		
		42	80		
		44	90		
		43	100		
		43	43		

<i>Perpendicular to the meridian.</i>					
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.
100	m. s.		Arc.		
100	7 16		90°	0	
			45	10	
		35	20		
		27	30		
		21	40		
		17	50		
		13	60		
		9 $\frac{1}{2}$	70		
		7	80		
		5	90		
		3 $\frac{1}{2}$	100		
			44		

On ice in Baffin's Bay, lat. 76° 08½', long. 78° 21' W.

<i>In the magnetic meridian.</i>						
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.	
100	m. s. 7 15		Arc.	85°		45
100	7 17					44,5
100	7 16			43,5		
				44		
				43		
				43		
				43		
				42		
				42,5		
				44,5		

<i>Perpendicular to the meridian.</i>						
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.	
100	m. s. 7 18		Arc.	90°		46,5
						45
				44,5		
				42,5		
				43,5		
				43,5		
				43,5		
				43		
				43,5		
				42,5		

On an iceberg in Davis's Straits, lat. 70° 35', long. 66° 55' W.

<i>In the magnetic meridian.</i>						
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.	
100	m. s. 7 16		Arc.	85°		46
100	7 16					44
100	7 16			44		
				44		
				44,5		
				43		
				43		
				43,5		
				43,5		
				43		
				42		

<i>Perpendicular to the meridian.</i>						
Number of vibrations.	Interval.	Mean	Time.	Seconds.	No. of vibrations.	
100	m. s. 7 18,5		Arc.	90°		46
						45,5
				44		
				44,5		
				43,5		
				43,5		
				43,5		
				43		
				43,5		
				43		
				41,5		

1819, March. In the Regent's Park, London, lat. $51^{\circ} 31' 40''$,
long. $0^{\circ} 08' W$.

In the magnetic meridian.						
Number of vibrations.	Interval.	Mean	No. of vibrations.	Arc	Time.	Seconds.
100	m. s.		0	71°		50
100	8 01,5		10	55		50
100	8 08		20	40		49
100	7 56,5	30	30		48	
100	8 02	40	23		49	
		50	17		48	
		60	13		47	
		70	9		48	
		80	6		48,5	
		90	3		47	
		100	1		47	
Perpendicular to the meridian.						
Number of vibrations.	Interval.		No. of vibrations.	Arc	Time.	seconds.
100	m. s.		0	90°		52
	8 18,5		10	55		52
			20	40		52
		30	30		49,5	
		40	22		49,5	
		50	16		49	
		60	11		48,5	
		70	7		49,5	
		80	4		48,5	
		90	2		50,5	
		100	1		49,5	

Abstract of the times in which 100 vibrations were performed.

Latitude. N.	Longitude. W.	In the meridian.	First Arc.	Perpendicular to the meridian.	First Arc.	
0	0	m. s.		m. s.	0	
51 31	0 08	0 0	0	8 18,3	90	Regent's Park, London.
60 09	1 12	7 49 $\frac{3}{4}$	74	7 59,5	90	Shetland.
68 22	53 50	7 20	83	7 33	90	On ice, Davis's Straits.
70 26	54 52	7 21	83	7 26	90	Hare Island.
75 05	60 23	7 27 $\frac{1}{2}$	84	7 26	90	On ice, Baffin's Bay.
75 51 $\frac{1}{2}$	63 06	7 23 $\frac{1}{4}$	84	0 0	—	On ice, Baffin's Bay.
76 45	76 00	7 15	85	7 26	90	On ice, Baffin's Bay.
76 08	78 21	7 16	85	7 18	90	On ice, Baffin's Bay.
70 35	66 55	7 16	83	7 18,5	90	On ice, Davis's Straits.
51 31	0 08	8 02	70	8 18	90	Regent's Park, London.

The 100th vibration never exceeded an arc of 3°

Observations to determine the variation of the needle, in Davis's Strait, and Baffin's Bay.

The azimuth compasses used in these observations were constructed on an improved plan, the invention of Captain KATER. It is thus described in the "Instructions for the use of the Instruments furnished to the Northern Expeditions," printed by order of the Royal Society :

"The compass is five inches diameter; by means of an inclined mirror and lenses, the degrees are seen by reflection considerably magnified; a line drawn on a piece of ivory is viewed at the same time, and serves as an index by which the degrees are to be read off.

"At the opposite side of the box is a sight on which slides, in a frame, the segment of a glass cylinder, ground to a radius of five inches. By means of this, a fine line of light is thrown on the index, and may be seen at the same time as the degrees on the card.

"The degrees on the card are read from the north towards the east, and are carried round to 360° , in order to obviate the possibility of error in this respect."

The observations were made either on shore or on the ice, sufficiently distant from the ship to be beyond the influence of her attraction. The compass was placed on a copper fastened stool, and was carefully levelled by means of a spirit level, to ensure the perpendicularity of the sight vane.

Each altitude and azimuth is a mean of several observations, the compass being removed and levelled afresh between every one, thus making each faithfully distinct.

The mean Greenwich time is given, as it determines the amount of the sun's polar distance.

The latitudes and longitudes are of the spot, deduced by the ship's log from the nearest observed.

The altitudes are corrected for index error only, the letters or signs annexed denote the limb, and whether by reflection or by the natural horizon.

The observed azimuths are of the sun's centre cleared of index error; the compasses used were No. 1 and 2, supplied to the *Isabella*, and No. 3 to the *Alexander*; the true azimuths deduced from the elements contained in the preceding columns, are expressed in a corresponding manner to the reading of the compass, for the purpose of comparison.

The observations were made on ice, except when otherwise noted in the column of remarks.

When due consideration is given to the greatly diminished power, with which the earth's magnetism acts on the horizontal direction of the needle, when the dip becomes so considerable as it was found in Davis's Straits and Baffin's Bay, namely, from 83° to 86° ; the satisfactory results which have been obtained, even under such extreme circumstances with Captain KATER's compasses, afford the best testimony of their excellence, and of the precision which may be expected from them in the ordinary course of observation.

It may also be remarked, that a difference in the result of azimuths observed at different hours of the day may not be altogether an error of observation, since it is probable that as the directive power of magnetism diminished, the causes which produce the hourly change in the variation itself may act with increased effect.

Should the amount of this change be considerably augmented in high magnetic latitudes, careful observations on the direction of the needle at different hours of the day, on all convenient occasions, might be serviceable towards a more certain knowledge of its causes, than has been hitherto obtained from observations made where the effects are so inconsiderable.

The influence of the ship's iron on their compasses increasing, as the directive power of magnetism diminished, produced irregularities that rendered observations on board ship of little or no value towards a knowledge of the true variation; a few azimuths which were observed in the *Isabella*, have been selected for the purpose of exemplifying this remark. They will also show, how essential it is to navigation in high latitudes, that the nature of the errors which the ship's attraction produces in her compasses, should be understood.

Observations to determine the variation of the needle, made on shore, or on the ice. Observer, Captain SABINE.

1818.	Mean Greenwich time.	Latitude.	Longitude.	Observed Altitude.	Observed azimuth.	Compass.	True azimuth.	VARIATION.	Remarks.
June 9	22 0 0	68 23 1/2 N.	53 47 W.	48 23 15 ̄	156 27	1	88 55 1/2	67 31 1/2 W.	Observatory, Hare Island.
11	23 20 0	68 14	54 15	63 20 58 ̄	175 47	2	108 07	67 40	
12	0 0 0	68 14	54 15	70 02 33 ̄	186 16	1	118 12	68 04	
17	8 20 0	70 26 1/2	54 52	56 15 36 ̄	332 54	1	260 08	72 46	
17	8 30 0	70 26 1/2	54 52	55 32 34 ̄	334 05	1	261 11 1/2	72 53 1/2	
18	8 28 0	70 26 1/2	54 52	55 20 52 ̄	332 52	1	261 33	71 19	
18	8 35 0	70 26 1/2	54 52	{ 55 33 45 ̄ 53 57 35 ̄ }	{ 334 24 334 24 }	1	263 10 1/2	71 13 1/2	
18	23 20 0	70 26 1/2	54 52	64 43 18 ̄	184 35	1	112 55 1/2	71 39 1/2	
27	9 00 00	71 02 1/2	54 13	50 18 13 ̄	343 26 2/3	1	268 13 2/3	75 13	
27	9 20 00	71 02 1/2	54 13	49 18 20 ̄	346 33 2/3	1	271 13	75 20 2/3	
27	9 40 00	71 02 1/2	54 13	47 07 0 ̄	349 54 1/3	1	274 23	75 31	
27	10 00 00	71 02 1/2	54 13	44 36 40 ̄	353 35	1	278 0	75 35	
27	10 20 00	71 02 1/2	54 13	42 07 17 ̄	357 24 1/3	1	281 36 1/3	75 48	
July 4	10 45 00	72 44 1/2	56 49	37 18 47 ̄	7 13 2/3	1	288 18 2/3	78 55	
6	9 12 0	73 22 1/2	57 32	49 10 00 ̄	348 16	1	268 15	80 01	
12	23 30 0	74 01 1/2	57 52	55 11 52 ̄	186 49 1/3	1	106 05 2/3	80 43 2/3	
21	10 05 0	74 58	59 16	38 49 57 ̄	0 33 1/2	1	276 00 1/2	84 33	
22	23 02 0	75 04	60 03	45 46 0 ̄	185 16	1	98 16 1/2	86 59 1/2	
28	10 20 0	75 28	60 34 1/2	35 04 10 ̄	7 40	1	279 21 1/2	88 18 2/3	
30	8 17 0	75 32	61 0	48 23 57 ̄	336 24 1/3	1	248 46 2/3	87 37 1/3	
30	10 20 0	75 32	61 0	36 29 35 ̄	0 55 1/3	1	272 41 2/3	88 13 2/3	
Aug. 2	10 00 00	75 44 1/2	64 0	17 33 15 L.	2 26	1	273 25	89 01	
2	10 10 00	75 44 1/2	64 0	17 01 25 L.	4 31	1	275 37 1/3	88 53 1/3	
4	0 12 30	75 59	64 32	46 39 55 ̄	204 01	1	113 43 1/3	90 17 2/3	
6	9 34 0	70 50 1/2	64 34	37 27 20 ̄	354 24	1	263 16 1/3	91 07 2/3	
12	0 00 51	75 54 1/2	65 30	40 19 34 ̄	202 31 1/3	1	109 45 2/3	92 45 2/3	
12	0 12 51	75 54 1/2	65 30	40 59 55 ̄	205 24 2/3	2	110 50 1/3	94 34 1/3	
12	0 29 30	75 54 1/2	65 30	43 36 28 ̄	210 52 2/3	1 & 2	117 12 2/3	93 39 2/3	
19	2 13 00	76 30	72 35	45 59 50 ̄	240 32	1 & 2	138 23	102 09	
19	2 33 00	76 30	72 35	47 27 10 ̄	246 53 1/2	2	143 37 1/2	103 16	
19	2 33 00	76 30	72 35	47 33 40 ̄	245 58 1/2	1	144 03 1/2	101 55	
22	9 00 00	76 32 2/3	76 52 1/2	36 54 40 ̄	348 56	1	241 00	107 56	
25	8 27 10	76 08 3/4	78 21	40 32 30 ̄	341 05 1/2	2	230 07	110 58 1/2	
25	8 27 10	76 08 1/2	78 21	40 14 05 ̄	341 17 1/2	1	230 58	110 19 1/2	
25	10 03 00	76 08 1/2	78 21	30 06 47 ̄	4 05	1	254 56	109 09	
25	10 08 00	76 08 1/2	78 21	28 25 25 ̄	5 43 1/2	3	256 18	109 25 1/2	
Sept. 11	8 30 00	70 35 1/2	66 55 1/2	13 27 30 L.	330 44	1 & 2	244 06	86 38	Observed by the silk line, the line of light not being perceptible owing to the weather. Dip of horizon allowed for 51 feet 7 in. measured. Compasses used alternately.
11	8 36 00	70 35 1/2	66 55 1/2	12 59 47 L.	332 58 2/3	2	245 36	87 22 2/3	
11	8 40 00	70 35 1/2	66 55 1/2	12 39 33 L.	333 19 1/3	1	246 41	86 38 1/3	

In the column of "observed altitude," ̄ signifies the lower, and ̄ the upper limb of the sun, the altitude being taken by reflection; L, the lower limb by the natural horizon.

Results of azimuths observed on board the Isabella, with WALKER'S azimuth compass, placed amidships in front of the companion.

1818.	Latitude.	Longitude.	Ship's head.	Variation.	Remarks.	
June	3	65° 38'	54° 24'	NW. by W.	67° 10'	True variation observed on the ice 75° 30'.
	4	65 47	54 44	N.	66 22	
	4	65 47	54 44	W.	77 34	
	4	65 46	54 44	E. S. E.	47 54	
	5	65 47	54 22	N.W.	76 47	
	5	65 47	54 22	N.	67 32	
	7	65 50	55 0	NE. by E.	49 57	
	27	74 02	54 13	E.	64 56	
	27	74 02	54 13	S. E.	67 07	
	27	74 02	54 13	S.	76 27	
	27	74 02	54 13	S.W.	84 38	
	27	74 02	54 13	W.	93 16	
	27	74 02	54 13	N.W.	90 20	
	27	74 02	54 13	N.	77 44	
27	74 02	54 13	N.E.	70 30		
Aug.	29	74 44	77 50	W.N.W.	128 35	True variation observed on the ice 86° 53'.
30	74 21	78 0	N. by E.	104 28		
Sep.	3	73 55	73 47	N. by W. $\frac{1}{2}$ W.	108 55	
	4	73 23	75 58	E. by S. $\frac{1}{2}$ S.	85 04	
	5	72 34	74 06	S.E.	74 22	
	5	72 34	74 06	S. $\frac{1}{4}$ W.	90 32	
	5	72 34	74 06	S. S. E.	78 50	
	11	70 37	66 58	N.W.	98 42	
	11	70 37	66 58	N.W. by W.	100 08	
	11	70 37	66 58	W.N.W.	100 56	
	11	70 37	66 58	W. by N.	99 36	
	16	68 40	64 0	N. by E.	73 56	
	16	68 40	64 0	S.E. by E. $\frac{1}{2}$ E.	59 07	
	29	64 53	62 10	N.N.W.	71 21	
29	65 02	62 10	S.W.	75 40		
Oct.	14	59 30	36 07	E. S. E.	39 04	
	14	59 30	36 07	N.W. by N.	52 55	