easy, by a perfectly methodical action involving very little labour, to keep the battery in good and constant action, according to the circumstances of each case.

When, as in laboratory work, or in arrangements for lecture-illustrations, there may be long intervals of time during which the battery is not used, it will be convenient to cease adding sulphate of copper when there is no immediate prospect of action being required, and to cease pouring in water when little or no colour of sulphate of copper is seen in the solution below. The battery is then in a state in which it may be left untouched for months or years. All that will be necessary to set it in action again will be to fill it up with water to replace what has evaporated in the interval, and stir the liquid in the upper part of the jar slightly, until the upper specific-gravity bead is floated to near the top by sulphate of zinc, and then to place a measured amount of sulphate of copper in the funnel at the top of the charging-tube.

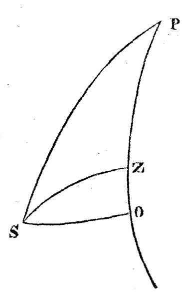
VI. "On the Determination of a Ship's Place from Observations of Altitude." By Sir William Thomson. Received Feb. 6, 1871.

The ingenious and excellent idea of calculating the longitude from two different assumed latitudes with one altitude, marking off on a chart the points thus found, drawing a line through them, and concluding that the ship was somewhere on that line at the time of the observation, is due to Captain T. H. Sumner *. It is now well known to practical navigators. It is described in good books on navigation, as, for instance, Raper's (§§ 1009–1014). Were it not for the additional trouble of calculating a second triangle, this method ought to be universally used, instead of the ordinary practice of calculating a single position, with the most probable latitude taken as if it were the true latitude. I believe, however, that even when in a channel, or off a coast trending north-east and south-west, or north-west and south-east, where Sumner's method is obviously of great practical value, some navigators do not take advantage of it; although no doubt the most skilful use it habitually in all circumstances in which it is advantageous. I learned it first in 1858, from Captain Moriarty, R.N., on board H.M.S. 'Agamemnon.' He used it regularly in the Atlantic Telegraph expeditions of that year and of 1865 and 1866, not merely at the more critical times, but in connexion with each day's sights. Instead of solving two triangles, as directed by Captain Sumner, the same result may be obviously obtained by

* 'A new and accurate method of finding a Ship's Position at Sea,' by Capt. T. H. Sumner. Boston, 1843. "In 1843, Commander Sullivan, R.N., not having heard of "this work, found the line of equal altitude on entering the River Plate; and identifying "the ship's place on it in 12 fathoms by means of the chart, shaped his course up the "river. The idea may thus have suggested itself to others; but the credit of having "reduced it to a method and made it public belongs to Capt. Sumner." (Raper's Navigation, edition 1857.)

finding a second angle (Z) of the one triangle (P Z S) ordinarily solved (P being the earth's pole, Z the ship's zenith, and S the sun or star). The angle ordinarily calculated is P, the hour-angle. By calculating Z, the sun's azimuth also, from the same triangle, the locus on which the ship must be is of course found by drawing on the chart, through the point which would be the ship's place were the assumed latitude exactly correct, a line inclined to the east and west at an angle equal to Z. But, as Captain Moriarty pointed out to me, the calculation of the second angle would involve about as much work as solving for P a second triangle with a slightly different latitude; and Capt. Sumner's own method has practical advantages in affording a check on the accuracy of the calculation by repetition with varied data.

A little experience at sea suggests that it would be very desirable to dispense with the morning and evening spherical triangles altogether, and to abolish calculation as far as possible in the ordinary day's work. When we consider the thousands of triangles daily calculated among all the ships at sea, we might be led for a moment to imagine that every one has been already solved, and that each new calculation is merely a repetition of one already made; but this would be a prodigious error; for nothing short of accuracy to the nearest minute in the use of the data would thoroughly suffice for practical purposes. Now, there are 5400 minutes in 90°, and therefore there are 5400^3 or 157,464,000,000 triangles to be solved each for a single angle. This, at 1000 fresh triangles per day, would occupy above 400,000 years. Even with an artifice, such as that to be described below, for utilizing solutions of triangles with their sides integral numbers of degrees, the number to be solved (being 90^3 or 729,000) would be too great, and the tabulation of the solutions would be too complicated (on account of the trouble of entering for the three sides) to be convenient for practice; and Tables of this kind which have been actually calculated and published (as, for instance, Lynn's Horary Tables *) have not come into general use.



It has occurred to me, however, that by dividing the problem into the solution of two right-angled triangles, it may be practically worked out so as to give the ship's place as accurately as it can be deduced from the observations, without any calculation at all, by aid of a table of the solution of the 8100 right-angled spherical triangles of which the legs are integral numbers of degrees.

Let O be the point in which the arc of a great circle less than 90° through S, perpendicular to P Z, meets P Z or P Z produced.

If the data were S P, P Z, and the hour-angle P, the solution of the right-angled triangle S P O would give P O and S O. Subtracting P Z

* Horary Tables for finding the time by inspection &c., by Thomas Lynn, late Commander in the sea-service of the East-India Company. London, 1827, 4to.

b.	a=51°.		a=52°.		a=53°.		a=54°.		a=55°.		a=56°.		a=57°.		a=58°.		b.
	co-hyp.	A.	co-hyp.	A.	co-hyp.	A.	co-hyp.	A.	co-hyp.	A.	co-hyp.	A.	co-hyp.	A.	co-hyp.	A.	
1°	39° 0′	89° 11′	38° 0′	89° 13′	37° 0′	89° 15′	36° 0′	89° 16′	35° 0′	89° 18′	34° 0′	89° 20′	33° 0′	89° 21′	32° 0′	89° 23′	1°
2	38 58	88 23	37 58	88 26	36 58	88 30	35 59	88 33	34 59	88 36	33 59	88 39	32 59	88 42	31 59	88 45	2
3	38 56	87 34	37 56	87 40	36 56	87 44	35 57	87 49	34 57	87 54	33 57	87 59	32 57	88 3	31 57	88 8	3
4	38 53	86 46	37 53	86 53	36 54	86 59	35 54	87 6	34 54	87 12	33 54	87 18	32 55	87 24	31 55	87 30	4
5	38 49	85 58	37 50	86 6	36 50	86 15	35 50	86 23	34 51	86 30	33 51	86 38	32 52	86 46	31 52	86 53	5
6	38 45	85 10	37 45	85 20	36 46	85 30	35 46	85 39	34 47	85 49	33 47	85 58	32 48	86 7	31 48	86 16	6
7	38 39	84 22	37 40	84 34	36 41	84 45	35 41	84 56	34 42	85 7	33 42	85 18	32 43	85 29	31 44	85 39	7
8	38 33	83 34	37 34	83 48	36 35	84 1	35 36	84 14	34 37	84 26	33 37	84 38	32 38	84 50	31 39	85 2	8
9	38 26	82 47	37 27	83 2	36 28	83 17	35 29	83 31	34 30	83 45	33 32	83 59	32 33	84 12	31 34	84 25	9
10	38 18	82 0	37 19	82 17	36 21	82 33	35 22	82 49	34 24	83 4	33 25	83 19	32 26	83 34	31 27	83 48	10
11	38 9	81 13	37 11	81 31	36 13	81 49	35 14	82 6	34 16	82 23	33 18	82 40	32 19	82 56	31 21	83 12	11
12	38 0	80 27	37 2	80 46	36 4	81 6	35 6	81 25	34 8	81 43	33 10	82 1	32 11	82 19	31 13	82 36	12
13	37 49	79 41	36 52	80 2	35 54	80 23	34 56	80 43	33 59	81 3	33 1	81 22	32 3	81 41	31 5	82 0	13
14	37 38	78 55	36 41	79 18	35 44	79 40	34 46	80 2	33 49	80 23	32 52	80 44	31 54	81 4	30 57	81 24	14
15	37 26	78 10	36 29	78 34	35 33	78 58	34 36	79 21	33 39	79 44	32 42	80 6	31 44	80 28	30 47	80 49	15
16	37 13	77 25	36 17	77 51	35 21	78 16	34 24	78 41	33 28	79 5	32 31	79 28	31 34	79 51	30 37	80 14	16
17	37 0	76 41	36 4	77 8	35 8	77 35	34 12	78 0	33 16	78 26	32 20	78 51	31 23	79 15	30 27	79 39	17
18	36 46	75 57	35 50	76 26	34 55	76 54	33 59	77 21	33 4	77 47	32 8	78 14	31 12	78 39	30 16	79 4	18
19	36 31	75 14	35 36	75 44	34 41	76 13	33 46	76 42	32 51	77 9	31 55	77 37	31 0	78 4	30 4	78 30	19
20	36 15	74 31	35 21	75 2	34 26	75 33	33 32	76 3	32 37	76 32	31 42	77 1	30 47	77 29	29 52	77 56	20
21	35 59	73 49	35 5	74 21	34 11	74 53	33 17	75 24	32 23	75 55	31 28	76 25	30 34	76 54	29 39	77 23	21
22	35 42	73 7	34 48	73 41	33 55	74 14	33 1	74 46	32 8	75 18	31 14	75 49	30 20	76 20	29 26	76 50	22
23	35 24	72 27	34 31	73 1	33 38	73 36	32 45	74 9	31 52	74 42	30 59	75 14	30 5	75 46	29 12	76 17	23
24	35 6	71 46	34 13	72 22	33 21	72 58	32 29	73 32	31 36	74 6	30 43	74 40	29 50	75 12	28 57	75 44	24
25	34 47	71 6	33 55	71 44	33 3	72 20	32 11	72 56	31 19	73 31	30 27	74 5	29 35	74 39	28 42	75 12	25
26	34 27	70 27	33 36	71 6	32 45	71 43	31 53	72 20	31 2	72 56	30 10	73 32	29 19	74 7	28 27	74 41	26
27	34 6	69 49	33 16	70 28	32 26	71 7	31 35	71 45	30 44	72 22	29 53	72 58	29 2	73 34	28 10	74 10	27
28	33 45	69 11	32 56	69 52	32 6	70 31	31 16	71 10	30 26	71 48	29 35	72 26	28 45	73 3	27 54	73 39	28
29	33 24	68 34	32 35	69 15	31 46	69 56	30 56	70 36	30 7	71 15	29 17	71 54	28 27	72 31	27 37	73 9	29
30	33 2	67 57	32 13	68 40	31 25	69 21	30 36	70 2	29 47	70 42	28 58	71 22	28 9	72 1	27 19	72 39	30
31	32 39	67 22	31 51	68 5	31 3	68 47	30 15	69 29	29 27	70 10	28 38	70 51	27 50	71 30	27 1	72 10	31
32	32 15	66 46	31 28	67 31	30 41	68 14	29 54	68 57	29 6	69 39	28 19	70 20	27 30	71 1	26 42	71 41	32
33	31 51	66 12	31 5	66 57	30 19	67 41	29 32	68 25	28 45	69 8	27 58	69 50	27 11	70 31	26 23	71 12	33
34	31 27	65 38	30 41	66 24	29 56	67 9	29 10	67 53	28 24	68 37	27 37	69 20	26 50	70 3	26 4	70 44	34
35	31 2	65 5	30 17	65 52	29 32	66 38	28 47	67 23	28 1	68 7	27 16	68 51	26 30	69 34	25 44	70 17	35
36	30 36	64 33	29 52	65 20	29 8	66 7	28 24	66 53	27 39	67 38	26 54	68 22	26 9	69 6	25 23	69 50	36
37	30 10	64 1	29 27	64 49	28 44	65 36	28 0	66 23	27 16	67 9	26 32	67 54	25 47	68 39	25 2	69 23	37
38	29 44	63 30	29 1	64 19	28 19	65 7	27 36	65 54	26 52	66 41	26 9	67 27	25 25	68 12	24 41	68 57	38
39	29 17	63 0	28 35	63 49	27 53	64 38	27 11	65 26	26 28	66 13	25 45	67 0	25 2	67 46	24 19	68 32	39
40	28 49	62 30	28 8	63 20	27 27	64 9	26 46	64 58	26 4	65 46	25 22	66 34	24 40	67 21	23 57	68 7	40
41	28 21	62 1	27 41	62 52	27 1	63 42	26 20	64 31	25 39	65 20	24 58	66 8	24 16	66 55	23 34	67 43	41
42	27 53	61 33	27 14	62 24	26 34	63 15	25 54	64 4	25 14	64 54	24 33	65 43	23 52	66 31	23 11	67 19	42
43	27 24	61 5	26 46	61 57	26 7	62 48	25 28	63 39	24 48	64 28	24 8	65 18	23 28	66 7	22 48	66 55	43
44	26 55	60 38	26 17	61 31	25 39	62 22	25 1	63 13	24 22	64 4	23 43	64 54	23 4	65 43	22 24	66 32	44
45	26 25	60 12	25 48	61 5	25 11	61 57	24 34	62 48	23 56	63 40	23 17	64 30	22 39	65 20	22 0	66 10	45
46	25 55	59 47	25 19	60 40	24 43	61 32	24 6	62 24	23 29	63 16	22 51	64 7	22 14	64 58	21 36	65 48	46
47	25 25	59 22	24 50	60 15	24 14	61 8	23 38	62 1	23 2	62 53	22 25	63 45	21 48	64 36	21 11	65 26	47
48	24 54	58 58	24 20	59 52	23 45	60 45	23 10	61 38	22 34	62 31	21 58	63 23	21 22	64 14	20 46	65 5	48
49	24 23	58 34	23 49	59 28	23 15	60 22	22 41	61 16	22 6	62 9	21 31	63 1	20 56	63 53	20 21	64 45	49
50	23 52	58 11	23 19	59 6	22 45	60 0	22 12	60 54	21 38	61 47	21 4	62 40	20 30	63 33	19 55	64 25	50
51	23 20	57 49	22 48	58 44	22 15	59 39	21 43	60 33	21 10	61 27	20 36	62 20	20 3	63 13	19 29	64 6	51
52	22 48	57 27	22 16	58 23	21 45	59 18	21 13	60 12	20 41	61 7	20 8	62 1	19 35	62 54	19 2	63 47	52
53	22 15	57 7	21 45	58 2	21 14	58 58	20 43	59 53	20 12	60 47	19 40	61 41	19 8	62 35	18 36	63 29	53
54	21 43	56 46	21 13	57 42	20 43	58 38	20 13	59 33	19 42	60 28	19 11	61 23	18 40	62 17	18 9	63 11	54
55	21 10	56 27	20 41	57 23	20 12	58 19	19 42	59 14	19 12	60 10	18 42	61 5	18 12	61 59	17 42	62 54	55
56	20 36	56 8	20 8	57 4	19 40	58 0	19 11	58 56	18 42	59 52	18 13	60 47	17 44	61 42	17 14	62 37	56
57	20 3	55 49	19 36	56 46	19 8	57 43	18 40	58 39	18 12	59 35	17 44	60 30	17 15	61 26	16 46	62 21	57
58	19 29	55 31	19 2	56 28	18 36	57 25	18 9	58 22	17 42	59 18	17 14	60 14	16 46	61 9	16 19	62 5	58
59	18 55	55 14	18 29	56 11	18 3	57 8	17 37	58 5	17 11	59 2	16 44	59 58	16 17	60 54	15 50	61 50	59
60	18 20	54 57	17 56	55 55	17 31	56 52	17 5	57 49	16 40	58 46	16 14	59 43	15 48	60 39	15 22	61 35	60
61	17 46	54 42	17 22	55 39	16 58	56 37	16 33	57 34	16 9	58 31	15 44	59 28	15 19	60 24	14 53	61 21	61
62	17 11	54 26	16 48	55 24	16 25	56 22	16 1	57 19	15 37	58 16	15 13	59 13	14 49	60 10	14 24	61 7	62
63	16 36	54 11	16 14	55 9	15 51	56 7	15 29	57 5	15 6	58 2	14 42	59 0	14 19	59 57	13 55	60 54	63
64	16 1	53 57	15 39	54 55	15 18	55 53	14 56	56 51	14 34	57 49	14 11	58 46	13 49	59 44	13 26	60 41	64
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66	14 50	53 30	14 30	54 29	14 10	55 27	13 50	56 26	13 29	57 24	13 9	58 22	12 48	59 19	12 27	60 17	66
67	14 14	53 18	13 55	54 17	13 36	55 15	13 17	56 14	12 57	57 12	12 37	58 10	12 17	59 8	11 57	60 6	67
68	13 38	53 6	13 20	54 5	12 2	55 4	12 43	56 2	12 24	57 0	12 6	57 59	11 46	58 57	11 27	59 55	68
69	13 2	52 55	12 45	53 54	12 27	54 52	12 10	55 51	11 52	56 50	11 34	57 48	11 15	58 46	10 57	59 45	69
70	12 26	52 44	12 9	53 43	11 53	54 42	11 36	55 41	11 19	56 39	11 2	57 38	10 44	58 36	10 27	59 35	70
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73	10 36	52 15	10 22	53 14	10 8	54 13	9 54	55 13	9 39	56 12	9 25	57 11	9 10	58 9	8 55	59 8	73
74	9 59	52 6	9 46	53 6	9 33	54 5	9 19	55 4	9 6	56 3	8 52	57 2	8 38	58 2	8 24	59 1	74
75	9 22	51 58	9 10	52 58	8 58	53 57	8 45	54 56	8 32	55 56	8 19	56 55	8 6	57 54	7 53	58 53	75
76	8 45	51 51	8 34	52 50	8 22	53 50	8 11	54 49	7 59	55 48	7 46	56 48	7 34	57 47	7 22	58 46	76
77	8 7	51 44	7 58	52 43	7 47	53 43	7 36	54 42	7 25	55 42	7 14	56 41	7 2	57 41	6 51	58 40	77
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79	6 54	51 31	6 45	52 31	6 36	53 31	6 26	54 30	6 17	55 30	6 8	56 29	5 58	57 29	5 48	58 29	79
80	6 16	51 26	6 8	52 26	6 0	53 25	5 51	54 25	5 43	55 25	5 34	56 24	5 26	57 24	5 17	58 24	80
81	5 39	51 21	5 32	52 21	5 24	53 20	5 17	54 20	5 9	55 20	5 1	56 20	4 53	57 19	4 45	58 19	81
82	5 1	51 16	4 55	52 16	4 48	53 16	4 42	54 16	4 35	55 16	4 28	56 16	4 21	57 15	4 14	58 15	82
83	4 24	51 13	4 18	52 12	4 12	53 12	4 6	54 12	4 0	55 12	3 55	56 12	3 48	57 12	3 42	58 12	83
84	3 46	51 9	3 41	52 9	3 36	53 9	3 31	54 9	3 26	55 9	3 21	56 9	3 16	57 9	3 11	58 9	84
85	3 9	51 6	3 5	52 6	3 0	53 6	2 56	54 6	2 52	55 6	2 48	56 6	2 43	57 6	2 39	58 6	85
86	2 31	51 4	2 28	52 4	2 24	53 4	2 21	54 4	2 18	55 4	2 14	56 4	2 11	57 4	2 7	58 4	86
87	1 53	51 2	1 51	52 2	1 48	53 2	1 46	54 2	1 43	55 2	1 41	56 2	1 38	57 2	1 35	58 2	87
88	1 16	51 1	1 14	52 1	1 12	53 1	1 11	54 1	1 9	55 1	1 7	56 1	1 5	57 1	1 4	58 1	88
89	0 38	51 0	0 37	52 0	0 36	53 0	0 35	54 0	0 34	55 0	0 34	56 0	0 33	57 0	0 32	58 0	89
90	0 0	51 0	0 0	52 0	0 0	53 0	0 0	54 0	0 0	55 0	0 0	56 0	0 0	57 0	0 0	58 0	90

from P O, we have Z O; and this, with S O in the triangle S Z O, gives the zenith distance, S Z, and the azimuth, S Z O, of the body observed.

Suppose, now, that the solution of the right-angled spherical triangle S P O for P O and S O to the nearest integral numbers of degrees could suffice. Further, suppose P Z to be the integral number of degrees closest to the estimated co-latitude, then Z O will be also an integral number of degrees. Thus the two right-angled spherical triangles S P O and S Z O have each arcs of integral numbers of degrees for legs. Now I find that the two steps which I have just indicated can be so managed as to give, with all attainable accuracy, the whole information deducible from them regarding the ship's place. Thus the necessity for calculating the solutions of spherical triangles in the ordinary day's work at sea is altogether done away with, provided a convenient Table of the solutions of the 8100 triangles is available. I have accordingly, with the cooperation of Mr. E. Roberts, of the 'Nautical Almanac' Office, put the calculation in hand; and I hope soon to be able to publish a Table of solutions of right-angled spherical triangles, showing co-hypotenuse* and one angle, to the nearest minute, for every pair of values of the legs from 0° to 90°. The rule to be presently given for using the Tables will be readily understood when it is considered that the data for the two triangles are their co-hypotenuses, the difference between a leg of one and a leg of the other, and the condition that the other leg is common to the two triangles. The Table is arranged with all the 90 values for one leg (b) in a vertical column, at the head of which is written the value of the other leg (a). Although this value is really not wanted for the particular nautical problem in question, there are other applications of the Table for which it may be useful. On the same level with the value of b, in the column corresponding to a, the Table shows the value of the co-hypotenuse and of the angle A opposite to the leg a. I take first the case in which latitude and declination are of the same name, the latitude is greater than the declination, and the azimuth (reckoned from south or north, according as the sun crosses the meridian to the south or north of the zenith of the ship's place) is less than 90°. The hypotenuses, legs, and angles P and Z of the two right-angled triangles of the preceding diagram are each of them positive and less than 90°, and the two co-hypotenuses are the sun's declination and altitude respectively. We have then the following rule:—

(1) Estimate the latitude to the nearest integral number of degrees by dead reckoning.

(2) Look from one vertical column to another, until one is found in which co-hypotenuses approximately agreeing with the declination and altitude are found opposite to values of b which differ by the complement of the assumed latitude.

(3) The exact values of the co-hypotenuse and the angle A corresponding

* It is more convenient that the complements of the hypotenuses should be shown than the hypotenuses, as the trouble of taking the complements of the declination and the observed altitude is so saved.

to these values of b are to be taken as approximate declination, hour-angle, altitude, and azimuth.

(4) Either in the same or in a contiguous vertical column find similarly another set of four approximate values, the two sets being such that one of the declinations is a little less and the other a little greater than the true declination.

(5) On the assumed parallel of latitude mark off the points for which the actual hour-angles at the time of observation were exactly equal to the approximate hour-angles thus taken from the Table. With these points as centres, and with radii equal (miles for minutes) to the differences of the approximate altitude from the observed altitude, describe circles. By aid of a parallel ruler and protractor *, draw tangents to these circles, inclined to the parallel of latitude, at angles equal to the approximate azimuths taken from the Table. These angles, if taken on the side of the parallel away from the sun, must be measured from the easterly direction, or the westerly direction, according as the observation was made before or after noon. The tangent must be taken on the side of the circle towards the sun, or from the sun, according as the observed altitude was greater or less than the approximate altitude taken from the Tables in each case. The two tangents thus drawn will be found very nearly parallel. Draw a line dividing the space between them into parts proportional to the differences of the true declination, from the two approximate values taken from the Tables. *The ship's place at the time of the observation was somewhere on the line thus found.*

To facilitate the execution of clause (2) of the rule, a narrow slip of card should be prepared with numbers 0 to 90 printed or written upon it at equal intervals, in a vertical column, equal to the intervals in the vertical column of the Table, 0 being at the top and 90 at the bottom of the column as in the Table. Place number 90 of the card abreast of a value of co-hypotenuse in the Table approximately equal to the declination, and look for the other co-hypotenuse abreast of the number on the card equal to the assumed latitude. Shift the card from column to column according to this condition until the co-hypotenuse abreast of the number on the card equal to the assumed latitude is found to agree approximately enough with the observed altitude.

When the declination and latitude are of contrary names and the azimuth less than 90°, or when they are of the same names, but the declination greater than the latitude, the sum, instead of the difference, of the legs b of the two triangles will be equal to the complement of the assumed latitude; and clause (2) of the rule must be altered accordingly. The slip of card in this case cannot be used; but the following scarcely less easy process is to be practised. Put one point of a pair of compasses on a position in one of the vertical columns of the hypotenuse abreast of

* A circle divided to degrees, and having its centre at the centre of the chart, ought to be printed on every chart. This, rendering in all cases the use of a separate protractor unnecessary, would be useful for many purposes.

that point of the column of values of b corresponding to half the complement of the assumed latitude; this point will be on a level with one of the numbers, or midway between that of two consecutive numbers, according as the assumed latitude is even or odd: then use the compasses to indicate pairs of co-hypotenuses equidistant in the vertical column from the fixed point of the compasses, and try from one column to another until co-hypotenuses approximately agreeing with the observed altitude and the correct declination are found. It is easy to modify the rule so as to suit cases in which the azimuth is an obtuse angle; but it is not worth while to do so at present, as such cases are rarely used in practice.

The following examples will sufficiently illustrate the method of using the Tables:—

(1) On 1870, May 16, afternoon, at 5h. 42m. Greenwich *apparent* time, the Sun's altitude was observed to be 32° 4′: to find the ship's place, the assumed latitude being 54° North.

The Nautical Almanac gives at 1870, May 16, 5h. 42m. Greenwich *apparent* time, the Sun's apparent declination N. 19° 10′. On looking at the annexed Table (which is a portion of the solutions of the 8100 right-angled spherical triangles) under the heading $a = 56°$, and opposite $b = 54°$, the co-hypotenuse (representing the Sun's declination) is 19° 11′, and opposite $b = 18°$ (differing from 54° by the complement of the assumed latitude), the co-hypotenuse (representing the Sun's altitude) is 32° 8′, which are sufficiently near the actual values; we therefore select our sets of values from these columns as follows:—

			Co-hyp.	A.
$a = 56°$	1.	$b = 54°$	19° 11′	61° 23′ = Sun's hour-angle.
		$b = 18$	32 8	78 14 = Sun's azimuth (S. towards W.).
	2.	$b = 55$	18 42	61 5 = Sun's hour-angle.
		$b = 19$	31 55	77 37 = Sun's azimuth (S. towards W.).

from which we have the following:—

Greenwich apparent time (in arc)		85° 30′		85° 30′
Sun's hour-angle	(1)	61 23	(2)	61 5
Diff. = Longitude		24 7 W.		24 25 W.
Sun's altitude (observed)		32° 4′		32° 4′
Sun's altitudes (auxiliary)	(1)	32 8	(2)	31 55
Diff. =		− 4		+ 9
Sun's declination from N. A.		19° 10′		19° 10′
Sun's declinations (auxiliary)	(1)	19 11	(2)	18 42
Diff =		− 1		+ 28

This example is represented graphically in the first diagram annexed. The second set of values could have been selected equally well from the contiguous columns ($a=57°$), which on trial will be found to give an almost identical result.

Again, (2), on 1870, May 16, afternoon, at 5h. 42m. Greenwich *apparent* time, the Sun's altitude was observed to be 30° 30′: to find the ship's place, the assumed latitude being 10° North.

The Sun's declination from N. A. is N. 19° 10′, and the half complement of the assumed latitude 40°. By a few successive trials, $a=56°$ will be found to contain values of co-hypotenuses approximately equal to the Sun's declination and altitude at the time, and which are equidistant from 40°; we therefore select the following sets of values from this column as follows:—

			Co-hyp.	A.
$a=56°$	1.	$b=54°$	19° 11′	61° 23′ = Sun's hour-angle.
		$b=26$	30 10	73 32 = Sun's azimuth (N. towards W.).
	2.	$b=55$	18 42	61 5 = Sun's hour-angle.
		$b=27$	29 53	72 58 = Sun's azimuth (N. towards W.).

from which we have the following:—

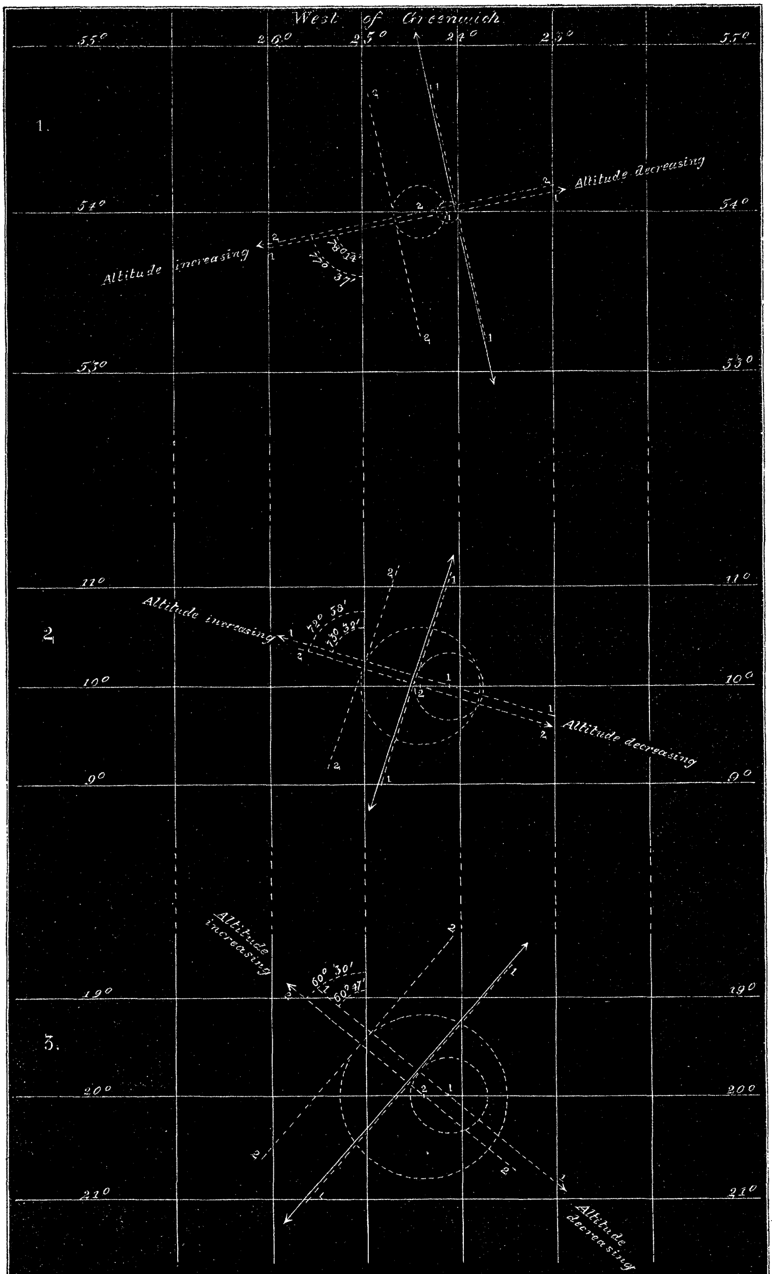
Greenwich apparent time (in arc)		85° 30′		85° 30′
Sun's hour-angle	(1)	61 23	(2)	61 5
Diff. = Longitude		24 7 W.		24 25 W.
Sun's altitude (observed)		30° 30′		30° 30′
Sun's altitudes (auxiliary)	(1)	30 10	(2)	29 53
Diff. =		+ 20		+ 37
Sun's declination from N. A.		19° 10′		19° 10′
Sun's declinations (auxiliary)	(1)	19 11	(2)	18 42
Diff. =		− 1		+ 28

In this case the sun passes the meridian to the north of the ship's zenith, the azimuth, from the Tables being less than 90°, is measured from the north towards the west. In this case also the second set of values might have been taken from $a=57°$, which will be found on trial to give a position nearly identical with the above.

This example is represented in the second diagram annexed.

Again, (3), on 1870, May 16, afternoon, at 5h. 42m. Greenwich *apparent* time, the Sun's altitude was observed to be 18° 35′: to find the ship's place, the assumed latitude being 20° South.

The Sun's declination from N. A. is N. 19° 10′, and the half complement of the assumed latitude is 55°, to be used because the Sun's declination and the assumed latitude are of different names. Proceeding as in the previous


West of Greenwich
26°
25°
24°
23°
55°
54°
53°
1.
Altitude decreasing
Altitude increasing
78° 14'
77° 37'
11°
10°
9°
2.
Altitude increasing
72° 58'
73° 32'
Altitude decreasing
19°
20°
21°
3.
Altitude increasing
60° 30'
60° 47'
Altitude decreasing

example, we find the column $a=56°$ again to contain values of co-hypotenuses approximately equal to the given values; and therefore have :—

			Co-hyp.	A.
$a = 56°$	1.	$b=54°$	19° 11′	61° 23′ = Sun's hour-angle.
		$b=56$	18 13	60 47 = Sun's azimuth (N. towards W.).
	2.	$b=55$	18 42	61 5 = Sun's hour-angle.
		$b=57$	17 44	60 30 = Sun's azimuth (N. towards W.).

which give

Greenwich apparent time (in arc)		85° 30′	85° 30′
Sun's hour-angle	(1)	61 23 ....(2)	61 5
Diff. = Longitude		24 7 W.	24 25 W.
Sun's altitude (observed)		18° 35′	18° 35′
Sun's altitudes (auxiliary)	(1)	18 13 ....(2)	17 44
Diff. =		+ 22	+ 51
Sun's declination from N. A.		19° 10′	19° 10
Sun's declinations (auxiliary)	(1)	19 11 ....(2)	18 42
Diff. =		− 1	+ 28

This example is represented in the third diagram annexed.

January 26, 1871.

General Sir EDWARD SABINE, K.C.B., President, in the Chair.

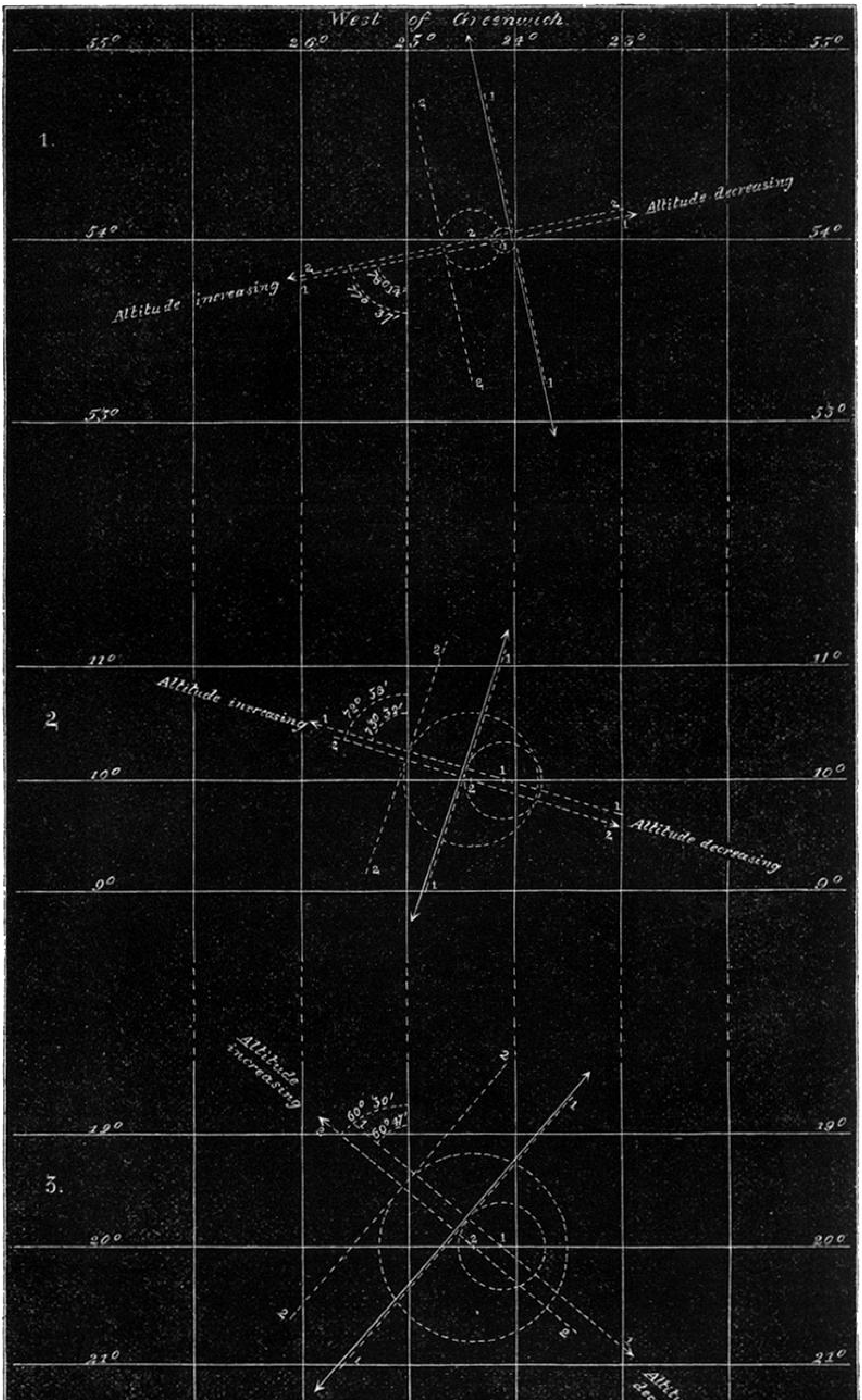
The following communications were read :—

I. "On the Mineral Constituents of Meteorites." By NEVIL STORY MASKELYNE, M.A., F.R.S., Professor of Mineralogy, Oxford, and Keeper of the Mineral Department, British Museum. Received November 3, 1870.

(Abstract.)

In the memoir now offered to the Society the author gives the results of his investigation of the meteorites of Breitenbach and of Shalka. A preliminary notice of two of the minerals occurring in the former, which is of the Siderolite class, was read before the Society in March, 1869 (Proc. R. S. vol. xvii. p. 370).

After entering upon the probable history of the Breitenbach Siderolite, and endeavouring to identify it with certain other Siderolites that have been found, or have been recorded as found, in the region extending from


West of Greenwich
26°
25°
24°
23°
55°
54°
53°
1.
Altitude decreasing
Altitude increasing
80°14'
77° 37'
11°
10°
9°
2
Altitude increasing
72° 58'
73° 32'
Altitude decreasing
Altitude increasing
60° 30'
60° 47'
19°
20°
21°
3.
Altitude decreasing