THE

SURVEYOR'S COMPANION.

[TELESCOPIC MEASUREMENT.]

BY

WILLIAM SCHMOLZ,

Mathematical Instrument Maker.

SAN FRANCISCO, CAL.:

1882.

Central Print (W. Hengtes'), 4 1 Montgomery St.

A KEY

TO THE

SOLAR REFLECTOR;

WITH A NEW SET OF

PRACTICAL TABLES, &c.

USEFUL IN

SURVEYING, ENGINEERING, &c.

By Wm. SCHMOLZ,

SURVEYING-INSTRUMENT MAKER.

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PREFACE.

The many complaints of surveyors, who night after night failed to observe Polaris, on account of clouds passing over the star, and the frequent request to devise an easy, practical method for the accurate determination of the meridian with a transit instrument during the day-time, led the undersigned to invent a "Solar Reflector," which consists of a simple attachment to the telescope of a surveyor's transit instrument, enabling the operator to find the true meridian by two equal altitudes of the sun.

The telescope of a transit is, in construction, the same as a solar microscope: the sun's rays are received by the object-glass, and the received light proceeds in the true optical axis; at the end of this mathematical line, and in the extension of the direct focus of the telescope lenses, there is the reflector placed to receive the image of the sun.

For the purpose of making practical use of the sun's image on the reflector, tables of correction were calculated by W. J. Lewis, C. E. These tables will be good as long as the sun shines. To make the book more interesting, the most important parts of the "Surveyor's and Engineer's Companion," published in 1859 by Wm. Schmolz, calculated by Dr. R. C. Matthewson, W. J. Lewis, C. E., and G. F. Allardt, C. E.—are republished, with the addition of some new and original tables.

The calculations have been made with great care; every precaution has been taken to avoid typographical errors, by comparing the revised sheets with the original computations or the best authorities; and it is firmly believed that the Rules and Tables will give accurate results.

W. SCHMOLZ.

SAN FRANCISCO, Nov. 1, 1881.

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DESCRIPTION OF

SCHMOLZ'S PATENT SOLAR REFLECTOR.

Fig. 1.

Fig. 2

Fig. 3

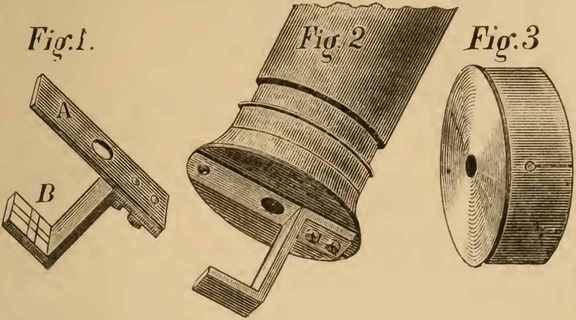


FIG 1 represents the complete attachment. A is a slide, which fits in a dovetailed groove in the eye-piece cap. B is a double-bent piece of brass, firmly fastened to A with two screws. On the inside of B is a graduated silver plate, standing at right angle to the optical axis ; the graduation on the silver plate corresponds to the diameter of the sun's image.

FIG. 2. The reflector is in position for the observation.

FIG. 3 represents the object-glass cap, with a small hole in the center, for the purpose of reducing the sun's diameter and also its bright, strong, glaring light. The advantage gained by the object-glass diaphragm is very decided ; it gives a soft, sharp edge to the image of the sun on the reflector, and prevents injury to the eyesight, as no direct sight at the sun through the telescope is required in taking the double equal altitudes.

The method of finding the true meridian by two equal altitudes of the sun is no new discovery. The Hindoos, Egyptians, Greeks, Arabs, were early acquainted with it, and by the Romans it was employed in laying out cities. Surveyors familiar with the modern computations very seldom use it, on account of the tedious, complicated formulas which are found in Bowditch, page 162; Weissbach, page 322; and those unacquainted with the solution of the problem we refer to the May number, 1878, of the "Engineer of the Pacific."

The advantage of the reflector consists principally in the simple, practical way with which a correct scientific result is obtained. It does not require cross-hair calculation for sun's center-passage, equation of time, elapse of time and co-latitude, zenith distance, azimuth of the sun, error of the collimation, inclination of axis, deviation of instrument in azimuth, difference in longitude, parallax, refraction, Greenwich time, apparent, solar, sidereal and mean time, logarithms, correction for chronometer rate, correction for inequality of level and axis, and, finally and principally, the errors of calculation.

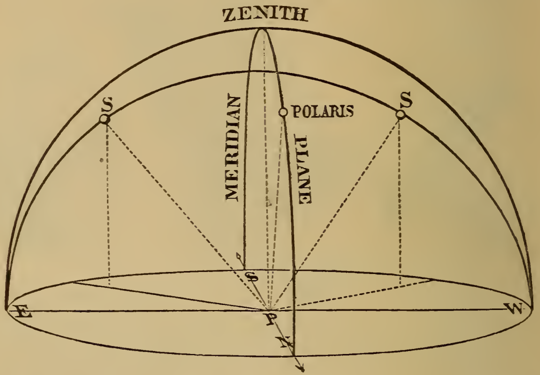
The little magical reflector can be attached to any transit instrument, which is provided with a clamp and tangent screw for the telescope axis.

In desiring to have a solar reflector fitted to a transit, the owner has not to send the complete instrument. All that is required is the cap of the eye-piece and the cap of the object-glass.

By following the annexed instructions, every practical surveyor can convince himself of the accuracy of the assertion that the solar reflector gives a satisfactory result; and any expert will find that a true meridian line established by this method will stand the most critical examination within five seconds of arc.

INSTRUCTIONS.

To determine the true Meridian by two equal Altitudes of the Sun, with "Schmolz's Patent Solar Reflector."



Set up the transit instrument at the place of observation, P ; see that there is no dead motion in the tangent-screws and tripod-legs ; slide the Solar Reflector into the eye-piece cap ; put the cover with the small hole over the object-glass ; clamp the vernier of the horizontal plate to zero ; then level up the instrument, turn it on the lower plate center toward the sun, and raise the telescope till the sun's image appears on the reflector. Clamp the telescope axis and the lower plate center, and bring with the vertical axis tangent screw and with the lower plate tangent screw the image of the sun exactly within the graduated lines of the reflector. Note the time, and make it so that the forenoon observation will correspond nearly in time with one of the columns of the correction table. Be careful that the position of the instrument is not disturbed, and that the vernier of the horizontal plate remains at zero ; because zero is the starting-point for the afternoon observation.

The afternoon observation will be sooner or later, as the case may be, on account of the declination of the sun ; and it is important that the observer should be aware of this, so that he may not put any reliance on exact corresponding meridian distance as to time for the afternoon observation, The second observation, or the double-equal altitude of the sun, is fast or slow: but the observer must not lose confidence in the accuracy of his established true meridian line on account of this irregularity, as the table will afterwards make the necessary correction. Taking it for granted that the instrument has remained undisturbed in the same position during the time since the forenoon observation was taken, and as the time for the afternoon equal altitude of the sun is approaching, the observer has to loosen carefully the horizontal vernier clamp, and slowly turn the instrument on the horizontal circle in the direction the sun has moved. As soon as the sun's image begins to appear on the reflector, the observer has to fasten the clamp of the horizontal vernier, and make the final motion with the horizontal vernier tangent screw alone. The utmost precaution has to be taken not to move the lower clamp and tangent-screw, or the telescope axis tangent screw, as any motion on either of those parts will make the observation worthless.

The sun is moving very fast; two seconds of time can be distinctly seen on the reflector: the observer must therefore be very attentive and quick ; he must follow with the horizontal vernier tangent screw the oblique course of the sun on the reflector till the image is precisely in the same place between the graduated lines as by the former observation. When this is satisfactorily done, then the observer has to find correctly the horizontal angle, and make the necessary corrections for the true meridian line, as shown hereafter.

DIRECTIONS

For the Use of the Table of Corrections.

Find in the ephemeris of the sun the hourly difference of the sun's declination in seconds. for the date of observation; and find in the correction table the number which corresponds to the latitude of the place and to the time of morning observation, multiply the number in the correction-table with the hourly difference of the sun's declination, and the product will be the correction in minutes of arc.

The actual or abstract multiplier to give the result in seconds of arc is sixty times the number given in the table below; but we have divided by sixty, so as to give minutes of arc at once, as not less than a minute of arc can be read on the division of a transit instrument.

Between Dec. 22d and June 22d the sun is moving North, or the north polar distance is decreasing, and the correction found by the multiplier must be SUBSTRACTED from the angle as found on the horizontal plate between the fore and afternoon observations, and the line bisecting the remaining angle will be the true meridian. But between June 22d and Dec .22d, when the sun is moving South or the north polar distance is increasing, ADD the correction to the horizontal angle, as found in the reading of the instrument, and the line bisecting the sum of these two angles will be the true meridian.

TABLE OF CORRECTIONS.

Lat.	8 A. M.	8½ A. M.	9 A. M.	9½ A. M.	10 A. M.	10½ A. M.	11 A. M.	11½ A. M.
32°	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.14
33°	0.18	0.18	0.17	0.16	0.16	0.16	0.15	0.15
34°	0.19	0.18	0.17	0·17	0.16	0.16	0.16	0.15
35°	0.19	0.18	0.17	0.17	0.16	0.16	0.16	0.15
36°	0.19	0·18	0.17	0.17	0.16	0.16	0.16	0.15
37°	0·19	0.18	0.18	0.17	0.17	0.16	0.16	0.16
38°	0.20	0.19	0.18	0.17	0.17	0.17	0.16	0.16
39°	0.20	0.19	0.18	0.18	0.17	0.17	0.17	0.16
40°	0.20	0.19	0.18	0.18	0.17	0.17	0·17	0.16
41°	0.20	0.19	0.19	0.18	0.18	0.17	0.17	0.17
42°	0.21	0.20	0.19	0.18	0.18	0.18	0·17	0.17
43°	0.21	0.20	0.19	0.19	0.18	0.18	0.18	0.17
44°	0.21	0.20	0.20	0.19	0.19	0.18	0.18	0.18
45°	0.22	0.21	0.20	0.19	0.19	0.18	0.18	0.18
46°	0.22	0.21	0.20	0.20	0.19	0.19	0.19	0.18
47°	0.23	0.22	0.21	0.20	0.20	0.19	0.19	0.19
48°	0.23	0.22	0.21	0.20	0.20	0.20	0.19	0.19
49°	0.23	0.22	0.22	0.21	0.20	0.20	0.20	0.19

☞ Substract the product of the multiplication between December 22d and June 22d.

☞ Add the product of the multiplication between June 22d and Dec. 22d.

EXAMPLE I. May 24th, 1881, 8:30 A.M., at San Francisco, in lat. 37 deg. 48 min. north, I took the altitude of the sun's image; and seven hours afterwards, at 3:30 P.M. I had the same altitude. The horizontal angle between the two observations measured 168 deg. 33 min., and the hourly differences in the sun's declination in the ephemeris was 27-46 seconds. The tabular number for lat. 38deg and 8:30 A. M. is 0.19; hence correction is: 27.46 x 0.19 gives 5 minutes; horizontal angle is 168 deg. 33 min., from which deduct 5 min., leaving 168 deg. 28 min., which divided by two gives 84 deg. 14 min. for the true meridian.

EXAMPLE II. Sept. 10th, 1881, at 11 o'clock A.M., at the same place of observation, the horizontal angle measured at 1 P. M. 52 deg 41 min.; the hourly difference in the sun's declination was 56.98 seconds. The tabular number for 38 deg. and 11 A.M, is 0.16; hence correction is: 56.98 x 0.16 gives 9 minutes; horizontal angle is 52 deg 41 min., to which add 9 min., making 52 deg. 50 min., which divided by two gives 26 deg. 25 min. for the true meridian.

After establishing the line on the ground, the whole manipulation is finished.

EPHEMERIS OF THE SUN.

At Greenwich, mean Noon.

Day of Mo.	JANUARY, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of time to be Added to Apparent Time.	FEBRUARY, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of Time to be Added to Apparent Time.
	° ′ ″	″	m. s.	° ′ ″	″	m. s.
1	S. 22 59 37.6	+12.66	3 53.49	S. 17 2 12.5	+42.83	13 51.41
2	22 54 20.1	13.81	4 21.53	16 44 55.2	43.57	13 58.65
3	22 48 35.2	14.94	4 49.19	16 27 20.5	44.30	14 5.06
4	22 42 23.1	+16.07	5 16.46	16 9 28.5	+45.00	14 10.66
5	22 35 44.1	17.20	5 43.30	15 51 19.9	45.70	14 15.45
6	22 28 38.1	18.31	6 9.71	15 32 55.0	46.37	14 19·43
7	22 21 5.6	+19.41	6 35.64	15 14 14.1	+47.04	14 22.62
8	22 13 6.6	20.50	7 1.08	14 55 17.6	47.67	14 25.02
9	22 4 41.6	21.58	7 26.00	14 36 6.1	48.28	14 26.66
10	21 55 50.6	+22.66	7 50.38	14 16 39.8	+48.89	14 27.53
11	21 46 33.9	23.73	8 14.20	13 56 59.3	49.48	14 27.03
12	21 36 51.6	24.78	8 37.45	13 37 4.8	50.04	14 26.98
13	21 26 44.2	+25.82	9 0.09	13 16 56.9	+50.60	14 25.61
14	21 16 12.0	26.85	9 22.10	12 56 36.0	51.13	14 23.50
15	21 5 15.2	27.87	9 43.47	12 36 2.5	51.65	14 20.66
16	20 53 54.1	+28.87	10 4.19	12 15 16.8	+52.14	14 17.11
17	20 42 9.2	29.85	10 24.21	11 54 19.6	52.62	14 12.85
18	20 30 0.6	30.82	10 43.51	11 33 11.1	53.07	14 7.89
19	20 17 28.9	+31·79	11 2.09	11 11 51.7	+53.53	14 2.25
20	20 4 34.2	32.74	11 19.93	10 50 21.8	53.94	13 55.93
21	19 51 17.1	33.67	11 37.01	10 28 42.0	54.36	13 48·95
22	19 37 37.9	+34.59	11 53.31	10 6 52.8	+54.74	13 41·32
23	19 23 36.9	35.48	12 8.82	9 44 54.1	55.11	13 33.05
24	19 9 14.4	36.37	12 23.52	9 22 46.8	55.47	13 24.16
25	18 54 31.0	+37.23	12 37.41	9 0 31.3	+55.81	13 14.65
26	18 39 27.1	38·08	12 50.48	8 38 7.9	56.13	13 4.54
27	18 24 3.0	38.91	13 2.73	8 15 37.0	56.44	12 53.87
28	18 8 19.0	+39.74	13 14.14	7 52 58.9	56.73	12 42.63
29	17 52 15.6	40.54	13 24.70			
30	17 35 53.0	41.33	13 34.43	S. 7 30 14.1	+57.00	12 30.84
31	17 19 11.8	42.08	13 43.34			
32	S. 17 2 12.5	+42.83	13 51.41			

EPHEMERIS OF THE SUN.

At Greenwich, mean Noon.

Day of Mo.	MARCH, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of time to be Added to Apparent Time.	APRIL, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of Time to be Added to / Subtracted from Apparent Time.
	° ′ ″	″	m. s.	° ′ ″	″	m. s.
1	S. 7 30 14.1	+57.00	12 30.84	N. 4 36 50.6	+57.78	3 54.05
2	7 7 22.9	57.25	12 18.55	4 59 54.8	57.57	3 35.90
3	6 44 25.7	57.49	12 5.77	5 22 53.7	57.34	3 17.87
4	6 21 22.8	+57.71	11 52.50	5 45 47.1	+57.11	2 59.99
5	5 58 14.7	57.93	11 38.79	6 8 34.4	56.85	2 42.27
6	5 35 1.7	58.13	11 24.65	6 31 15.5	56.58	2 24.75
7	5 11 44.2	+58.32	11 10.10	6 53 49.9	+56.31	2 7.45
8	4 48 22.5	58.48	11 55.17	7 16 17.4	56.00	1 50.39
9	4 24 57.0	58.64	10 39.88	7 38 37.7	55.69	1 33.59
10	4 1 28.0	+58.77	10 24.25	8 0 50.3	+55.36	1 17.07
11	3 37 55.9	58.89	10 8.31	8 22 54.9	55.03	1 0.83
12	3 14 21.1	58.99	9 52.09	8 44 51.4	54 .67	0 44.91
13	2 50 44.1	+59.09	9 35.59	9 6 39.1	+54.30	0 29.30
14	2 27 5.1	59.15	9 18.82	9 28 17.8	53.91	0 14.03
15	2 3 24.6	59.21	9 1.81	9 49 47.2	53.52	0 0.89
16	1 39 42.9	+59.24	8 44.60	10 11 6.8	+53.11	0 15.44
17	1 16 0.5	59.28	8 27.21	10 32 16.4	52.69	0 29.60
18	0 52 17.8	59.28	8 9.63	10 53 15.6	52.24	0 43.36
19	0 28 35.1	+59.28	7 51.87	11 14 4.1	+51.78	0 56.74
20	S. 0 4 52.7	59.25	7 33.96	11 34 41.4	51.31	1 9.72
21	N. 0 18 49.0	59.21	7 15.93	11 55 7.3	50.83	1 22.29
22	0 42 29.5	+59.15	6 57.79	12 15 21.4	+50.33	1 34·42
23	1 6 8.5	59.09	6 39.55	12 35 23.4	49.81	1 46.10
24	1 29 45.4	59.00	6 21.23	12 55 13.0	49.29	1 57.33
25	1 53 20.1	+58.90	6 2.84	13 14 49.8	+48.76	2 8.11
26	2 16 52.2	58.77	5 44.40	13 34 13.4	48.20	2 18.42
27	2 40 21.4	58.65	5 25.95	13 53 23.6	47.63	2 28.26
28	3 3 47.3	+58.50	5 7.49	14 12 20.1	+47.07	2 37.61
29	3 27 9.4	58.35	4 49.05	14 31 2.6	46.48	2 46.47
30	3 50 27.5	58.17	4 30.65	14 49 30.8	45.87	2 54.82
31	4 13 41.4	57.98	4 12.31	N. 15 7 44.3	+45.25	3 2.65
32	N. 4 36 50.6	+57.78	3 54.05			

EPHEMERIS OF THE SUN.

At Greenwich, mean Noon.

Day of Mo.	MAY, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of time to be Subtracted from Apparent Time.	JUNE, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of Time to be Subtracted from / Added to Apparent Time.
	° ′ ″	″	m. s.	° ′ ″	″	m. s.
1	N.15 7 44.3	+45.25	3 2.65	N.22 4 56.5	+20.26	2 27.67
2	15 25 42.9	44.63	3 9.94	22 12 51.1	19.29	2 18.55
3	15 43 26.2	43.98	3 16.69	22 20 22.5	18.32	2 9.04
4	16 0 54.0	+43.32	3 22.88	22 27 30.5	+17.34	1 59.16
5	16 18 5.9	42.66	3 28.50	22 34 14.9	16.35	1 48.91
6	16 35 1.7	41.99	3 33.55	22 40 35.6	15.36	1 38.32
7	16 51 41.1	+41.29	3 38.02	22 46 3.32	+14.37	1 27.41
8	17 8 3.6	40.58	3 41.91	22 52 5.6	13.37	1 16.19
9	17 24 9.1	39.87	3 45.22	22 57 14.5	12·36	1 4.67
10	17 39 57.1	+39.14	3 47.93	23 1 59.2	+11.35	0 52.88
11	17 55 27.6	38.40	3 50.03	23 6 19.5	10.33	0 40.85
12	18 10 40.2	37.64	3 51.54	23 10 15.4	9.31	0 28.59
13	18 25 34.5	+36.88	3 52.46	23 13 46.9	+ 8.30	0 16.13
14	18 40 10.3	36.10	3 52.79	23 16 53.8	7.27	0 3.51
15	18 54 27.1	35.30	3 52.53	23 19 36.0	6.24	0 9.26
16	19 8 24.9	+34.49	3 51.70	23 21 53.5	+ 5.21	0 22.15
17	19 22 3.2	33.68	3 50.30	23 23 46.4	4.18	0 35.14
18	19 35 22.0	32.86	3 48.33	23 25 14.5	3.15	0 48.20
19	19 48 20.7	+32.02	3 45.82	23 26 17.8	+ 2.12	1 1.28
20	20 00 59.2	31.17	3 42.77	23 26 56.3	1.09	1 14.37
21	20 13 17.1	30.32	3 39.17	23 27 10.0	+ 0.05	1 27.44
22	20 25 14.4	+29.45	3 35.04	23 26 58.9	− 0.98	1 40.47
23	20 36 50.7	28.56	3 30.42	23 26 23.0	2.01	1 53.44
24	20 48 5.8	27.67	3 25.31	23 25 22.4	3.04	2 6.29
25	20 58 59.4	+26.77	3 19.70	23 23 57.1	− 4.07	2 19.04
26	21 9 31.5	25.87	3 13.61	23 22 7.1	5.10	2 31.65
27	21 19 41.6	24.95	3 7.06	23 19 52.5	6.12	2 44.10
28	21 29 29.6	+24.03	3 0.06	23 17 13.4	− 7.15	2 56.37
29	21 38 55.3	23.10	2 52.61	23 14 9.8	8.17	3 8.45
30	21 47 58.4	22.16	2 44.72	23 10 41·6	9.19	3 20.31
31	21 56 38.9	21.21	2 36.40	N.23 6 49.0	−10.20	3 31.93
32	N.22 4 56.5	+20.26	2 27.67			

EPHEMERIS OF THE SUN.

At Greenwich, mean Noon.

Day of Mo.	JULY, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of time to be Added to Apparent Time.	AUGUST, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of Time to be Added to / Subtracted from Apparent Time.
	° ′ ″	″	m. s.	° ′ ″	″	m. s.
1	N. 23 6 49.0	−10.20	3 31.93	N. 17 59 46.8	−37.86	6 4.61
2	23 2 32.3	11.21	3 43.30	17 44 29.3	38.60	6 0.67
3	22 57 51.4	12.21	3 54.39	17 28 54.4	39.31	5 56.13
4	22 52 46.4	−13.21	4 5.19	17 13 2.4	−40.02	5 51.00
5	22 47 17.5	14.20	4 15.71	16 56 53.5	40.71	5 45.29
6	22 41 24.8	15.19	4 25.90	16 40 28.1	41.40	5 39.01
7	22 35 8.4	−16.17	4 35.75	16 23 46.4	−42.06	5 32.14
8	22 28 28.5	17.14	4 45.25	16 6 48.8	42.72	5 24.70
9	22 21 25.3	18.11	4 54.38	15 49 35.5	43.37	5 16.70
10	22 13 58.8	−19.08	5 3.11	15 32 7.1	−44.00	5 8.15
11	22 6 9.2	20.03	5 11.42	15 14 23.7	44.61	4 59.03
12	21 57 56.9	20.97	5 19.31	14 56 25.6	45.22	4 49.36
13	21 49 22.0	−21.91	5 26.76	14 38 13.1	−45.81	4 39.14
14	21 40 24.7	22.84	5 33.73	14 19 46.7	46.39	4 28.38
15	21 31 5.0	23.77	5 40.22	14 1 6.5	46.95	4 17.08
16	21 21 23.5	−24.68	5 46.22	13 42 12.9	−47.51	4 5.25
17	21 11 20.2	25.58	5 51.71	13 23 6.3	48.03	3 52.89
18	21 0 55.3	26.47	5 56.66	13 3 47.1	48.55	3 40.01
19	20 50 9.0	−27.35	6 1.06	12 44 15.5	−49.05	3 26.61
20	20 39 1.8	28.23	6 4.90	12 24 32.0	49.56	3 12.72
21	20 27 33.9	29.09	6 8.17	12 4 36.8	50.04	2 58.34
22	20 15 45.5	−29.94	6 10.86	11 44 30.1	−50.51	2 43.48
23	20 3 36.7	30.78	6 12.96	11 24 12.3	50.96	2 28.16
24	19 51 7.9	31.61	6 14.45	11 3 43.8	51.41	2 12.38
25	19 38 19.3	−32.43	6 15.35	10 43 4.9	−51.84	1 56.17
26	19 25 11.1	33.23	6 15.64	10 22 15.8	52.25	1 39.55
27	19 11 43.6	34.03	6 15.31	10 1 16.8	52.66	1 22.52
28	18 57 57.2	−34.81	6 14.38	9 40 8.3	−53.05	1 5.11
29	18 43 52.1	35.59	6 12.85	9 18 50.4	53.43	0 47.34
30	18 29 28.5	36.35	6 10.71	8 57 23.5	53.79	0 29.23
31	18 14 46.6	37.11	6 7.96	8 35 48.1	54.15	0 10.80
32	N. 17 59 46.8	−37.86	6 4.61	N. 8 14 4.4	−54.49	0 7.93

EPHEMERIS OF THE SUN.

At Greenwich mean Noon.

Day of Mo.	SEPTEMBER, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of time to be Subtracted from Apparent Time.	OCTOBER, 1882. Apparent Declination.	Diff. for 1 Hour.	Equation of Time to be Subtracted from Apparent Time.
	° ′ ″	″	m. s.	° ′ ″	″	m. s.
1	N. 8 14 4.4	−54.49	0 7.93	S. 3 15 0.9	−58.23	10 21.10
2	7 52 12.7	54.82	0 26.94	3 38 17.7	58.15	10 40.09
3	7 30 13.3	55.14	0 46.21	4 1 32.1	58.05	10 58.76
4	7 8 6.4	−55.44	1 5.74	4 24 43.9	−57.92	11 17.09
5	6 45 52.5	55.73	1 25.50	4 47 52.4	57.78	11 35.04
6	6 23 31.7	56.01	1 45.48	5 10 57.5	57.63	11 52.60
7	6 1 4.5	−56.27	2 5.63	5 33 58.6	−57.46	12 9.74
8	5 38 31.2	56.51	2 25.95	5 56 55.7	57.27	12 26.45
9	5 15 52.3	56.75	2 46.42	6 19 48.2	57.08	12 42.73
10	4 53 7.9	−56.96	3 7.03	6 42 35.7	−56.87	12 58.55
11	4 30 18.5	57.15	3 27.75	7 5 17.9	56.64	13 13.88
12	4 7 24.4	57.34	3 48.58	7 27 54.2	56.39	13 28.72
13	3 44 26.0	−57.52	4 9.50	7 50 24.5	−56.12	13 43.05
14	3 21 23.5	57.68	4 30.51	8 12 48.1	55.83	13 56.86
15	2 58 17.4	57.82	4 51.57	8 35 4.8	55.54	14 10.14
16	2 35 7.9	−57.96	5 12.68	8 57 14.1	−55.22	14 22.86
17	2 11 55.5	58.07	5 33.81	9 19 15.8	54.89	14 35.02
18	1 48 40.4	58.17	5 54.95	9 41 9.3	54.56	14 46.60
19	1 25 23.2	−58.26	6 16.08	10 2 54.3	−54.19	14 57.59
20	1 2 4.0	58.33	6 37.19	10 24 30.4	53.81	15 7.95
21	0 38 43.3	58.39	6 58.23	10 45 57.2	53.42	15 17.69
22	N. 0 15 21.2	−58.43	7 19.21	11 7 14.3	−53.00	15 26.79
23	S. 0 8 1.8	58.47	7 40.09	11 28 21.3	52.57	15 35.23
24	0 31 25.5	58.49	8 0.87	11 49 18.0	52.13	15 42.99
25	0 54 49.4	−58.49	8 21.51	12 10 3.8	−51.67	15 50.06
26	1 18 13.4	58.49	8 41.99	12 30 38.3	51.19	15 56.41
27	1 41 36.8	58.46	9 2.27	12 51 1.3	50.71	16 2.02
28	2 4 59.7	−58.42	9 22.35	13 11 12.4	−50.20	16 6.88
29	2 28 21.5	58.37	9 42.20	13 31 11.1	49.68	16 10.98
30	2 51 42.1	58.30	10 1.79	13 50 57.0	49.13	16 14.31
31	S. 3 15 0.9	−58.23	10 21.10	14 10 29.6	48.57	16 16.85
				S. 14 29 48.8	−48.00	16 18.58

EPHEMERIS OF THE SUN.

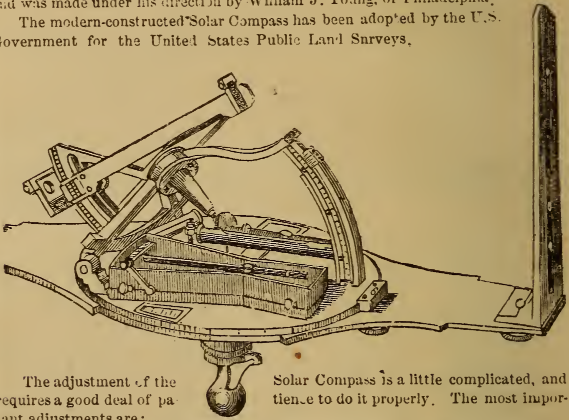
At Greenwich mean Noon.

	NOVEMBER, 1882.			DECEMBER, 1882.		
Day of Mo.	Apparent Declination.	Diff. for 1 Hour.	Equation of time to be Subtracted from Apparent Time.	Apparent Declination.	Diff. for 1 Hour.	Equation of Time to be Subtracted from / Added to Apparent Time.
	° ′ ″	″	m. s.	° ′ ″	″	m. s.
1	S. 14 29 48.8	−48.00	16 18.58	S. 21 50 50.5	−23.13	10 45.94
2	14 48 54.0	47.42	16 19.48	21 59 53.1	22.07	10 22.96
3	15 7 44.9	46.82	16 19.55	22 8 30.3	21.01	9 59.34
4	15 26 20.9	−46.19	16 18.79	22 16 41.8	−19.93	9 35.11
5	15 44 41.8	45.54	16 17.19	22 24 27.4	18.85	9 10.29
6	16 2 46.9	44.89	16 14.74	22 31 46.7	17.75	8 44.88
7	16 20 36.1	−44.21	16 11.43	22 38 39.7	−16.65	8 18.96
8	16 38 8.9	43.51	16 7.27	22 45 6.1	15.53	7 52.55
9	16 55 24.8	42.80	16 2.26	22 51 5.5	14.40	7 25.65
10	17 12 23.3	−42.07	15 56.40	22 56 37.9	−13.27	6 58.32
11	17 29 4.3	41.32	15 49.68	23 1 43.1	12.13	6 30.59
12	17 45 27.1	40.57	15 42.12	23 6 20.8	10.98	6 2.47
13	18 1 31.4	−39.78	15 33.71	23 10 31.0	− 9.83	5 34.03
14	18 17 16.7	38.98	15 24.47	23 14 13.5	8.67	5 5.30
15	18 32 42.8	38.16	15 14.40	23 17 28.2	7.51	4 36.30
16	18 47 49.0	−37.34	15 3.50	23 20 14.9	− 6.36	4 7.06
17	19 2 35.1	36.49	14 51.78	23 22 33.6	5.18	3 37.64
18	19 17 0.9	35.64	14 39.25	23 24 24.2	4.01	3 8.06
19	19 31 5.9	−34.76	14 25.91	23 25 46.6	− 2.84	2 38.35
20	19 44 49.6	33.86	14 11.77	23 26 40.8	1.67	2 8.54
21	19 58 11.6	32.96	13 56.84	23 27 6.7	0.49	1 38.68
22	20 11 11.8	−32.03	23 41.13	23 27 4.4	+ 0.69	1 8.78
23	20 23 49.8	31.08	13 24.63	23 26 33.7	1.87	0 38.89
24	20 36 5.0	39.14	13 7.36	23 25 34.8	3.05	0 9.04
25	20 47 57.3	−29.17	12 49.34	23 24 7.6	+ 4.23	0 20.75
26	20 59 26.2	28.20	12 30.57	23 22 12.1	5.40	0 50.44
27	21 10 31.5	27.21	12 11.06	23 19 48.4	6.57	1 20.02
28	21 21 12.9	−26.21	11 50.83	23 16 56.6	+ 7.75	1 49.45
29	21 31 30.6	25.20	11 29.89	23 13 36.8	8.91	2 18.71
30	21 41 22.7	24.17	11 8.25	23 9 49.0	10.07	2 47.77
31	S. 21 50 50.5	−23.13	10 45.94	23 5 33.3	11.23	3 16.57
				S. 23 0 49.9	+12.39	3 45.11

Burt's Solar Compass.

Was invented in 1835, by William A. Burt, U. S. Dep.-Surveyor, and was made under his direction by William J. Young, of Philadelphia.

The modern-constructed Solar Compass has been adopted by the U.S. Government for the United States Public Land Surveys.



The adjustment of the Solar Compass is a little complicated, and requires a good deal of patience to do it properly. The most important adjustments are:

1. That the level bubbles remain in position by reversing the plates horizontally.
2. That the equatorial lines and solar lenses are parallel to each other.
3. That the polar axis is at right angle with the axis of the latitude arc.
4. That the index error of the declination arc is corrected.
5. That the index error of the latitude arc is adjusted.
6. That the index error of the hour arc is ascertained
7. That the lines of the sights are perpendicular
8. That the sights of the compass coincide with the true meridian.
9. That the compass needle is sensitive
10. That the variation arc for needle is set to correspond to a true meridian line.

When all these corrections are accurately made, a final practical trial is effected by two morning and afternoon observations If they give the same result on an established true meridian line, then the instrument is in adjustment.

For more particulars we refer to the "Key of Burt's Solar Compass."

Meridian Distances West from Greenwich.

Longitude.	Diff. in Time.		Longitude.	Diff. in Time.		Longitude.	Diff. in Time.	
°	h.	m.	°	h	m.	°	h.	m.
101	6	44	111	7	24	121	8	04
102	6	48	112	7	28	122	8	08
103	6	52	113	7	32	123	8	12
104	6	56	114	7	36	124	8	16
105	7	00	115	7	40	125	8	20
106	7	04	116	7	44	126	8	24
107	7	08	117	7	48	127	8	28
108	7	12	118	7	52	128	8	32
109	7	16	119	7	56	129	8	36
110	7	20	120	8	00	130	8	40

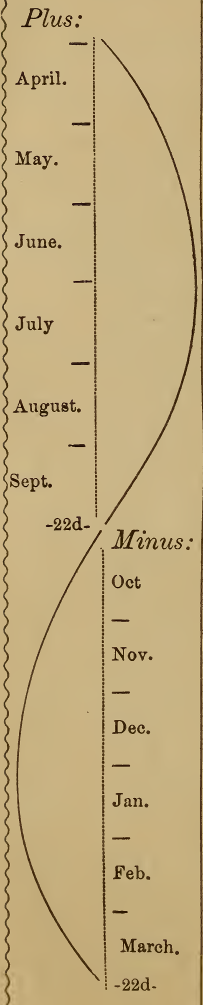
FIXED STARS.

Mean places of Fifty Principal Fixed Stars, for January 1st, 1882.

Name of Star.	Mag	Right ascension. h.	m.	s.	Annual Variation.	s.	Declination. °	′	″	Annual Variation. ″
α Andromedæ	2	0	2	17.39	+	3.090	+28	26	20.0	+ 19.89
β Cassiopeæ	2	0	2	53.22	"	3.170	" 58	29	55.0	" 19.[illegible]5
t Ceti	3	0	13	24.80	"	3.053	− 9	28	42.2	" 19.96
α Cassipeæ (var.)	2	0	33	49.08	"	3.370	+55	53	23.7	" 19.79
β Ceti	2	0	37	39.98	"	3.015	−18	38	4.6	" 19·81
β Andromedæ	2	1	3	7.68	"	3.342	+[illegible]4	59	40.4	" 19.18
α Urs. Min. (Polaris).	2	1	15	30.03	"	21.965	" 88	40	46.9	" 18.98
θ′ Ceti	3	1	18	7.51	"	2.997	− 8	47	33.5	" 18.08
γ Andromedæ	2	1	56	39.55	"	3.655	+41	45	45.7	" 17.46
α Ceti	2	2	56	6.70	"	3.1[illegible]9	" 3	37	3[illegible]	" 14.33
ε Eridani	3	3	27	22.27	"	2.823	− 9	51	30.2	" 12·42
η Tauri	3	3	40	28.26	"	3.556	+23	44	20.5	" 11.41
γ Eridani	3	3	52	31.48	"	2.798	−13	50	42.6	" 10.47
α Tauri (Aldebaran).	1	4	29	9.02	"	3.436	+16	16	14.8	" 7.55
α Aurigæ (Capella)	1	5	7	58.40	"	4.424	" 45	52	34.3	" 4.08
β Orionis (Rigel)	1	5	8	52.03	"	2.831	− 8	20	20.8	" 4.43
β Tauri	2	5	18	49.98	"	3.789	+28	30	22.4	" 3.40
ε Orionis	2	5	30	13.56	"	3.042	− 1	16	42.6	" 2.60
β Aurigæ	2	5	50	52.44	"	4·403	+44	56	0.5	" 0.79
γ Geminorum	2	6	30	53.70	"	3,468	" 16	29	55.0	− 2.74
α Canis Maj. (Sirius	1	6	39	56.91	"	2.644	−16	33	19.1	" 4.68
δ Canis Majoris	2	7	3	35.61	"	2.438	" 26	12	24.1	" 5.48
α2 Geminor'm (Castor	2	7	27	4.22	"	3.839	+32	8	45.4	" 7.52
α Canis Min. (Procyon	1	7	33	7.47	"	3.144	" 5	31	34.6	" 8.96
15 Argus (l)	3	8	2	31.14	"	2.554	−23	57	53.8	" 10.17
α Hydræ	2	9	21	47.33	"	2.949	" 8	8	52.3	" 15.43
α Leonis (Regulus	1	10	2	5.22	"	3.201	+12	32	36.1	" 17.46
α Ursæ Majoris	2	10	56	26.14	"	3.754	" 62	23	15.9	" 19.[illegible]5
δ Crateris	3	11	13	26.53	"	2.996	−14	8	24.9	" 19.46
γ Ursæ Majoris	2	11	47	37.20	"	3.185	+54	21	2.7	" 20.03
β Corvi	2	12	28	11.42	"	3.140	−22	44	38.5	" 19.97
α Virginis (Spica	1	13	18	58.64	"	3.153	" 10	32	42.1	" 18.91
η Urs. Maj. (Alioth	2	13	42	53.44	"	2.372	+49	54	9.1	" 18.09
α Bootis (Arcturus	1	14	10	16.78	"	2.735	" 19	47	50.2	" 18.90
α2 Libræ	2	14	44	21.09	"	3.308	−15	33	2.1	" 15.19
β Ursæ Minoris	2	14	51	3.70	−	0.2[illegible]9	+74	38	15.8	" 14.72
β Libræ	2	15	10	39.48	+	3.221	− 8	56	47.8	" 13.54
α Serpentis	2	15	38	27.33	"	2.951	+ 6	47	51.7	" 11.58
α Scorpii (Antares	1	16	22	10·41	"	3.669	−26	10	7.7	" 8·34
β Herculis	2	16	25	8.86	"	2.577	21	44	51.6	" 8·08
η Ophiuchi	3	17	3	36.65	"	3.436	−15	34	39.1	" 4.78
α Ophiuchi	2	17	29	27.44	"	2.783	+12	38	49.0	" 2.90
λ Sagittarii	3	18	20	41.30	"	3.703	−25	29	7.7	+ 1.60
α Lyræ (Vega	1	18	32	56.62	"	2.031	+38	40	28.1	" 3.15
α Sagittarii	2	18	47	56.89	"	3.722	−26	26	30.6	" 4.09
α Aquilae (Altair	1	19	45	1.57	"	2.928	+ 8	33	27.4	" 9.24
α Cygni	2	20	37	24.58	"	2.044	" 44	51	32.9	" 12.71
β Aquarii	3	21	25	20.80	"	3.162	− 6	5	22.6	" 15.64
ε Pegasii	2	21	38	23.45	"	2.917	+ 9	20	4·5	" 16.[illegible]4
α Pis. Aus. (Fomalh't	1	22	51	7.63	"	3.326	−30	14	50.2	" 18.98
α Pegasi (Markab	2	22	58	5[illegible].02	"	2.984	+14	34	14.0	" 19.29

TABLE

Of Refractions in Declination for Solar-Compasses and Solar-Transits.



By Sun's Declinations North,
From March 22d to Sept. 22d, *add:*

For Lati.	Hours from Merid.	Sun's Declinations in Nautical Alm. + 20°	+ 15°	+ 10°	+ 5°
		′ ″	′ ″	′ ″	′ ″
30°	1.	10	15	21	27
"	2.	14	19	25	31
"	3.	20	26	32	39
"	4.	32	39	46	52
35°	1.	15	21	27	33
"	2.	20	25	32	38
"	3.	26	33	39	47
"	4.	39	47	56	1 06
40°	1.	21	27	33	40
"	2.	25	32	39	46
"	3.	33	40	48	57
"	4.	47	55	1 05	1 18
45°	1.	27	33	40	48
"	2.	32	39	46	52
"	3.	40	47	56	1 06
"	4.	54	1 02	1 14	1 32
50°	1.	33	40	48	57
	2.	38	46	55	1 06
"	3.	47	56	1 06	1 20
"	4.	1 00	1 45	2 00	3 00

By Sun's Declinations South,
From Sept. 22d to March 22d, *substract:*

For Lati.	Hours from Merid.	Sun's Declinations in Nautical Alm. − 5°	− 10°	− 15°	− 20°
		′ ″	′ ″	′ ″	′ ″
30°	1.	40	48	56	1 00
"	2.	46	54	1 10	1 18
"	3.	55	1 06	1 18	1 36
"	4.	1 19	1 35	1 57	2 29
35°	1.	48	57	1 06	1 20
"	2.	55	1 04	1 18	1 34
"	3.	1 06	1 20	1 40	2 00
"	4.	1 40	2 00	2 30	3 30
40°	1.	1 00	1 08	1 30	1 40
"	2.	1 08	1 20	1 36	2 00
"	3.	1 20	1 40	2 00	2 40
"	4.	2 00	2 30	3 20	5 00
45°	1.	1 08	1 30	1 40	2 00
"	2.	1 20	1 40	2 00	2 50
"	3.	1 40	2 00	2 36	3 30
"	4.	2 20	3 00	4 40	8 00
50°	1.	1 30	1 40	2 00	2 40
"	2.	1 36	2 00	2 30	3 15
"	3.	2 30	2 45	3 30	5 00
"	4.	3 00	4 30	7 00	15 00

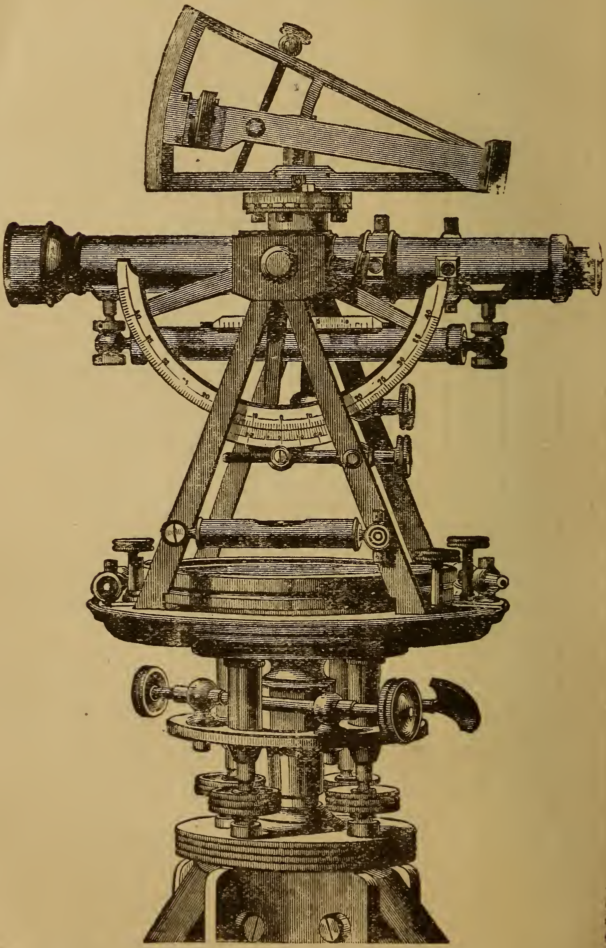
TABLE.

Of the increase or decrease of the Sun's Declination for hourly Differences, from 5 seconds to 60 seconds, and from three to twelve hours of time.

dif.	3 h.		4 h.		5 h.		6 h.		7 h.		8 h.		9 h.		10 h.		11 h.		12 h.	
″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″
5		15		20		25		30		35		40		45		50		55	1	00
6		18		24		30		36		42		48		54	1	00	1	06	1	12
7		21		28		35		42		49		56	1	03	1	10	1	17	1	24
8		24		32		40		48		56	1	04	1	12	1	20	1	28	1	36
9		27		36		45		54	1	03	1	12	1	21	1	30	1	39	1	48
10		30		40		50	1	00	1	10	1	20	1	30	1	40	1	50	2	00
11		33		44		55	1	06	1	17	1	28	1	39	1	50	2	01	2	12
12		36		48	1	00	1	12	1	24	1	36	1	48	2	00	2	12	2	24
13		39		52	1	05	1	18	1	31	1	44	1	57	2	10	2	23	2	36
14		42		56	1	10	1	24	1	38	1	52	2	06	2	20	2	34	2	48
15		45	1	00	1	15	1	30	1	45	2	00	2	15	2	30	2	45	3	00
16		48	1	04	1	20	1	36	1	52	2	08	2	24	2	40	2	56	3	12
17		51	1	08	1	25	1	42	1	59	2	16	2	33	2	50	3	07	3	24
18		54	1	12	1	30	1	48	2	06	2	24	2	42	3	00	3	18	3	36
19		57	1	16	1	35	1	54	2	13	2	32	2	51	3	10	3	29	3	48
20	1	00	1	20	1	40	2	00	2	20	2	40	3	00	3	20	3	40	4	00
21	1	03	1	24	1	45	2	06	2	27	2	48	3	09	3	30	3	51	4	12
22	1	06	1	28	1	50	2	12	2	34	2	56	3	18	3	40	4	02	4	24
23	1	09	1	32	1	55	2	18	2	41	3	04	3	27	3	50	4	13	4	36
24	1	12	1	36	2	00	2	24	2	48	3	12	3	36	4	00	4	24	4	48
25	1	15	1	40	2	05	2	30	2	55	3	20	3	45	4	10	4	35	5	00
26	1	18	1	44	2	10	2	36	3	02	3	28	3	54	4	20	4	46	5	12
27	1	21	1	48	2	15	2	42	3	09	3	36	4	03	4	30	4	57	5	24
28	1	24	1	52	2	20	2	48	3	16	3	44	4	12	4	40	5	08	5	36
29	1	27	1	56	2	25	2	54	3	23	3	52	4	21	4	50	5	19	5	48
30	1	30	2	00	2	30	3	00	3	30	4	00	4	30	5	00	5	30	6	00
31	1	33	2	04	2	35	3	06	3	37	4	08	4	39	5	10	5	41	6	12
32	1	36	2	08	2	40	3	12	3	44	4	16	4	48	5	20	5	52	6	24
33	1	39	2	12	2	45	3	18	3	51	4	24	4	57	5	30	6	03	6	36
34	1	42	2	16	2	50	3	24	3	58	4	32	5	06	5	40	6	14	6	48
35	1	45	2	20	2	55	3	30	4	05	4	40	5	15	5	50	6	25	7	00
36	1	48	2	24	3	00	3	36	4	12	4	48	5	24	6	00	6	36	7	12
37	1	51	2	28	3	05	3	42	4	19	4	56	5	33	6	10	6	47	7	24
38	1	54	2	32	3	10	3	48	4	26	5	04	5	42	6	20	6	58	7	36
39	1	57	2	36	3	15	3	54	4	33	5	12	5	51	6	30	7	09	7	48
40	2	00	2	40	3	20	4	00	4	40	5	20	6	00	6	40	7	20	8	00
41	2	03	2	44	3	25	4	06	4	47	5	28	6	09	6	50	7	31	8	12
42	2	06	2	48	3	30	4	12	4	54	5	36	6	18	7	00	7	42	8	24
43	2	09	2	52	3	35	4	18	5	01	5	44	6	27	7	10	7	53	8	36
44	2	12	2	56	3	40	4	24	5	08	5	52	6	36	7	20	8	04	8	48
45	2	15	3	00	3	45	4	30	5	15	6	00	6	45	7	30	8	15	9	00
46	2	18	3	04	3	50	4	36	5	22	6	08	6	54	7	40	8	26	9	12
47	2	21	3	08	3	55	4	42	5	29	6	16	7	03	7	50	8	37	9	24
48	2	24	3	12	4	00	4	48	5	36	6	24	7	12	8	00	8	48	9	36
49	2	27	3	16	4	05	4	54	5	43	6	32	7	21	8	10	8	59	9	48
50	2	30	3	20	4	10	5	00	5	50	6	40	7	30	8	20	9	10	10	00
51	2	33	3	24	4	15	5	06	5	57	6	48	7	39	8	30	9	21	10	12
52	2	36	3	28	4	20	5	12	6	04	6	56	7	48	8	40	9	32	10	24
53	2	39	3	32	4	25	5	18	6	11	7	04	7	57	8	50	9	43	10	36
54	2	42	3	36	4	30	5	24	6	18	7	12	8	06	9	00	9	54	10	48
55	2	45	3	40	4	35	5	30	6	25	7	20	8	15	9	10	10	05	11	00
56	2	48	3	44	4	40	5	36	6	32	7	28	8	24	9	20	10	16	11	12
57	2	51	3	48	4	45	5	42	6	39	7	36	8	33	9	30	10	27	11	24
58	2	54	3	52	4	50	5	48	6	46	7	44	8	42	9	40	10	38	11	36
59	2	57	3	56	4	55	5	54	6	53	7	52	8	51	9	50	10	49	11	48
60	3	00	4	00	5	00	6	00	7	00	8	00	9	00	10	00	11	00	12	00

INVENTED BY WM. SCHMOLZ.

Patent No. 72687. Dated December 24th, 1867.



Present owners of the Patent, W & L. E. GURLEY, Troy, N. Y.

(FROM THE "ALTA CALIFORNIA," JAN. 4th, 1868.)

"For many years Wm. Schmolz devoted his leisure hours to the special study of the Solar Compass, and the more he became acquainted with the principles of the instrument, the higher he appreciated the invention of W. S. BURT.

"The advantages which the solar apparatus possesses over all other instruments constructed for the U. S. Public Land Surveys are undisputed, it is a complete instrument; and still there is a defect existing in the compass sights, which makes the instrument unreliable in mountainous regions to establish a line correctly. Many attempts which have been made to attach a telescope to a Solar Compass never amounted to a decided success. Seeing the impossibility of attaching a telescope to a 'Solar,' Mr. Schmolz made some experiments in placing a declination arc on a Transit, and found that the trial observations gave a satisfactory result; and being convinced of the originality of his construction, he applied for a United States patent, which was granted to him last week.

"We suppose that the reader is already familiar with the principles of the Solar Compass, as well as with the construction of the Transit; so that in this case it is easy for us to describe the invention, as the only piece around which the invention turns is merely a small spindle attached to the top in the middle, and perpendicular to the telescope axis and the optical axis of an ordinary Transit. This center spindle is called the 'Polar Axis,' to which an hour arc and a declination arc, &c., are attached.

"For new beginners it will be an interesting study to get acquainted with the five movements which a Solar Transit has: I. The Declination; II. The Equatorial; III. The Vertical; IV. The Horizontal; V. The Meridian. If these movements are well understood, then the principal attention has to be directed to the increase or decrease of Declination, Meridian Distance, and Refraction.

"The adjustment of Schmolz's Solar Transit is a combination of two distinct instruments: I. THE TRANSIT.

"1. That the levels remain in position by repeatedly reversing.

"2. That the cross hairs are in perfect collimation.

"3. That the telescope describes a perpendicular line.

"4. That the telescope level is parallel to the optical axis.

"5. That the vernier of the elevation arc is at zero.

"6. That the compass needle is sensitive, and is well adjusted.

"7. That the index error of the compass needle is ascertained on a true meridian.

"II. THE SOLAR APPARATUS Adjustment is precisely the same as that of the Solar Compass.

"With several friends we have seen the progress of the instrument, and were very much pleased when the portable astronomical observatory was finished. We witnessed yesterday the experimental observations, and were astonished at the precision with which meridian lines, variation of the compass needle, time of the day, latitude and longitude, were repeatedly established."

***

SAN FRANCISCO, Jan. 4th, 1882.

Several Solar Transits have been constructed and patented since the above patent was issued; but none has given such entire satisfaction, or is manufactured so extensively, or is so generally in practical use, as the one described. The jealousy of some Philadelphia makers has led them to disparage the instrument; but in a few years,, when the term of the patent will have expired, they will be the first to adopt Schmolz's construction.

W. S.

TABLE.

AZIMUTHS OF POLARIS,

At the time of greatest elongation, from the year 1881 to 1900, and from latitude 30deg. to 49deg. north.

COMPUTED BY W. J. LEWIS, C. E.

For W. Schmolz, San Francisco, Cal.

year.	L. 30°		L. 31°		L. 32°		L. 33°		L. 34°		L. 35°		L. 36°		L. 37°		L. 38°		L. 39°		year.
	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	
1881.	1	32	1	33	1	34	1	35	1	36	1	37	1	38	1	40	1	41	1	42	1881.
1882.	1	31	1	32	1	33	1	34	1	36	1	37	1	38	1	39	1	41	1	42	1882.
1883.	1	31	1	32	1	33	1	34	1	35	1	36	1	38	1	39	1	40	1	42	1883.
1884.	1	31	1	32	1	33	1	34	1	35	1	36	1	37	1	38	1	40	1	41	1884.
1885.	1	30	1	31	1	32	1	33	1	34	1	36	1	37	1	38	1	39	1	41	1885.
1886.	1	30	1	31	1	32	1	33	1	34	1	35	1	36	1	38	1	39	1	40	1886.
1887.	1	30	1	31	1	32	1	33	1	34	1	35	1	36	1	37	1	39	1	40	1887.
1888.	1	29	1	30	1	31	1	32	1	33	1	34	1	36	1	37	1	38	1	39	1888.
1889.	1	29	1	30	1	31	1	32	1	33	1	34	1	35	1	36	1	38	1	39	1889.
1890.	1	29	1	29	1	30	1	31	1	32	1	34	1	35	1	36	1	37	1	39	1890.
1891.	1	28	1	29	1	30	1	31	1	32	1	33	1	34	1	36	1	37	1	38	1891.
1892.	1	28	1	29	1	30	1	31	1	32	1	33	1	34	1	35	1	37	1	38	1892.
1893.	1	27	1	28	1	29	1	30	1	31	1	32	1	34	1	35	1	36	1	37	1893.
1894.	1	27	1	28	1	29	1	30	1	31	1	32	1	33	1	34	1	36	1	37	1894.
1895.	1	27	1	28	1	29	1	30	1	31	1	32	1	33	1	34	1	35	1	37	1895.
1896.	1	26	1	27	1	28	1	29	1	30	1	31	1	32	1	34	1	35	1	36	1896.
1897.	1	26	1	27	1	28	1	29	1	30	1	31	1	32	1	33	1	35	1	36	1897.
1898.	1	26	1	27	1	27	1	29	1	29	1	31	1	32	1	33	1	34	1	35	1898.
1899.	1	25	1	26	1	27	1	28	1	29	1	30	1	31	1	32	1	34	1	35	1899.
1900.	1	25	1	26	1	27	1	28	1	29	1	30	1	31	1	32	1	33	1	34	1900.

	L. 40°		L. 41°		L. 42°		L. 43°		L. 44°		L. 45°		L. 46°		L. 47°		L. 48°		L. 49°		
	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	
1881.	1	44	1	45	1	47	1	49	1	51	1	52	1	54	1	57	1	59	2	01	1881.
1882.	1	43	1	45	1	47	1	48	1	50	1	52	1	54	1	56	1	58	2	01	1882.
1883.	1	43	1	45	1	46	1	48	1	50	1	52	1	54	1	56	1	58	2	00	1883.
1884.	1	43	1	44	1	46	1	47	1	49	1	51	1	53	1	55	1	57	2	00	1884.
1885.	1	42	1	44	1	45	1	47	1	49	1	51	1	53	1	55	1	57	1	59	1885.
1886.	1	42	1	43	1	45	1	47	1	48	1	50	1	52	1	54	1	56	1	59	1886.
1887.	1	41	1	43	1	44	1	46	1	48	1	50	1	52	1	54	1	56	1	58	1887.
1888.	1	41	1	42	1	44	1	46	1	47	1	49	1	51	1	53	1	56	1	58	1888.
1889.	1	41	1	42	1	44	1	45	1	47	1	49	1	51	1	53	1	55	1	57	1889.
1890.	1	40	1	42	1	43	1	45	1	47	1	48	1	50	1	52	1	55	1	57	1890.
1891.	1	40	1	41	1	43	1	44	1	46	1	48	1	50	1	52	1	54	1	56	1891.
1892.	1	39	1	41	1	42	1	44	1	46	1	48	1	50	1	52	1	54	1	56	1892.
1893.	1	39	1	40	1	42	1	44	1	45	1	47	1	49	1	51	1	53	1	55	1893.
1894.	1	38	1	40	1	41	1	43	1	45	1	47	1	49	1	51	1	53	1	55	1894.
1895.	1	38	1	40	1	41	1	43	1	44	1	46	1	48	1	50	1	52	1	54	1895.
1896.	1	38	1	39	1	41	1	42	1	44	1	46	1	48	1	50	1	52	1	54	1896.
1897.	1	37	1	39	1	40	1	42	1	44	1	45	1	47	1	49	1	51	1	54	1897.
1898.	1	37	1	38	1	40	1	41	1	43	1	45	1	47	1	49	1	51	1	53	1898.
1899.	1	36	1	38	1	39	1	41	1	43	1	44	1	46	1	48	1	50	1	53	1899.
1900.	1	36	1	37	1	39	1	41	1	42	1	44	1	46	1	48	1	50	1	52	1900.

The following Tables give the greatest Eastern and Western Elongation of the North Star (Polaris), in common clock time, for every third day in the year when the star is visible.

EASTERN ELONGATION.

Day of Month	April.	May.	June.	July.	August.	September.
	h. min.	h. min.	h. min.	h. min.	h. min.	h. min.
1	6 39 A.M	4 41 A.M	2 39 A.M	0 41 A.M	10 35 P.M	8 32 P.M
4	6 27 "	4 29 "	2 28 "	0 30 "	10 23 "	8 20 "
7	6 15 "	4 17 "	2 16 "	0 18 "	10 12 "	8 08 "
10	6 03 "	4 05 "	2 04 "	0 06 "	10 00 "	7 56 "
13	5 52 "	3 53 "	1 52 "	11 49 P.M	9 48 "	7 45 "
16	5 40 "	3 41 "	1 40 "	11 37 "	9 36 "	7 33 "
19	5 28 "	3 30 "	1 28 "	11 25 "	9 24 "	7 21 "
22	5 16 "	3 18 "	1 17 "	11 14 "	9 12 "	7 09 "
25	5 04 "	3 06 "	1 05 "	11 02 "	9 01 "	6 57 "
28	4 52 "	2 54 "	0 53 "	10 50 "	8 49 "	6 46 "
31	——	2 42 "	——	10 38 "	8 37 "	——

WESTERN ELONGATION.

Day of Month	October.	November.	December.	January.	February.	March.
	h. min.	h. min.	h. min.	h. min.	h. min.	h. min.
1	6 27 A.M	4 24 A.M	2 26 A.M	0 27 A.M	10 21 P.M	8 31 P.M
4	6 15 "	4 13 "	2 14 "	0 15 "	10 09 "	8 18 "
7	6 03 "	4 01 "	2 02 "	12 00 P.M	9 58 "	8 06 "
10	5 51 "	3 49 "	1 51 "	11 48 "	9 46 "	7 55 "
13	5 39 "	3 37 "	1 39 "	11 36 "	9 34 "	7 44 "
16	5 27 "	3 25 "	1 27 "	11 24 "	9 22 "	7 32 "
19	5 16 "	3 13 "	1 16 "	11 12 "	9 10 "	7 20 "
22	5 04 "	3 02 "	1 04 "	11 01 "	8 59 "	7 08 "
25	4 52 "	2 50 "	0 52 "	10 49 "	8 47 "	6 56 "
28	4 40 "	2 38 "	0 41 "	10 36 "	8 35 "	6 44 "
31	4 28 "	——	0 30 "	10 25 "	——	6 33 "

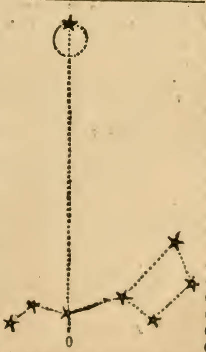
An approximation to the true meridian might be obtained by sighting on the Pole Star at the instant when it is on the same vertical plane with Alioth. The North Star is exactly in the true meridian 26 minutes in time after it has been in the same vertical plane with Alioth, and may be sighted after that interval of time with perfect accuracy.

On the first day of January, 1882, the right ascension of Polaris will be: 1 h. 15 m. 30 sec., and of Alioth 13 h. 42 m. 53 sec. When therefore Polaris arrives at the meridian, Alioth will be 27 m. 23 sec. to the East.

Hence when Alioth is directly under Polaris, or in the same vertical plane, the pole is to the West of this plumb line, ranging from 10 min. 38 sec. in arc in lat. 30 deg. north to 14 min. 2 sec. in lat. 49 deg. north.

The azimuth for every second degree of latitude is shown in the following table:

Lat.	m. s.	Lat.	m. s.	Lat.	m. s.
28°	10 27	36°	11 23	44°	12 48
30°	10 38	38°	11 41	46°	13 15
32°	10 51	40°	12 01	48°	13 46
34°	11 06	42°	12 23	49°	14 02



EXPLANATION OF THE TABLES.

Tables I and II.

Table I gives the length of a degree of latitude, in chains, for every minute of latitude between 29 and 49 degrees, calculated by the Formula $Dm = 5523.8724 - 27.7425 \cos 2l + .0592 \cos 4l$, in which Dm represents a degree of the meridian, and l, the middle latitude.

Table II gives the length of a degree of longitude, in chains, for every minute of latitude between 29 and 49 degrees, calculated by the formula $Dp = 5537.7439 \cos l - 4.6337 \cos 3l + .0058 \cos 5l$, in which Dp represents a degree of the parallel and l, the latitude.

These tables are useful for converting linear into angular, and angular into linear measure, as well as for determining the convergencies and divergencies of the meridians, on the spheroidal surface of the earth.

PROBLEMS AND EXAMPLES.

1. *Given the latitudes of any two places on the same meridian, to find the distance between them.*

RULE.—Find, from Table I, the length of a degree of the meridian at each latitude, and take half their sum for the mean length of a degree. Then say, as 60 minutes is to the difference of latitude, so is the mean length of a degree to the distance required.

The latitude of the Monte Diablo Base Line, is 37 deg. 52 min. 47 sec., and that of the 1st Standard North, 38 deg. 18 min. 53 sec.; what is the meridional distance between them?

chains. chains.
As 60 min.: 26 min. 6 sec.: : 5517.205 : 2400 the distance required.

2. *Given the distance between any two places on the same meridian, and the latitude of one of them to find their difference of latitude.*

RULE.—Find, from Table I, the length of a degree of the meridian, in the given latitude, and also in that differing from it, by the meridional distance, converted into an arc at the rate of 52 seconds per mile, and take half their sum for the mean length of a degree. Then say, as the mean length of a degree is to the meridional distance, so is 60 minutes to the difference of latitude required.

The latitude of the Monte Diablo Base Line, is 37 deg. 52 min. 47 sec.; what is the latitde of the 1st Standard North, the meridional distance being 30 miles?

chains. chains.
As 5517.205 : 2400 : : 60 min. : 26 min. 6 sec, the difference of latitude required.

3. *Given the longitudes of any two places, on the same parallel, in a given latitude, to find the distance between them.*

RULE.—Find, from Table II, the length of a degree of longitude in the given latitude: and say, as 60 minutes is to the difference of longitude, so is the length of the degree of longitude to the distance required.

The longitude of Monte Diablo Meridian is 121 deg. 54 min. 49 sec., and that of Range 1 East, 121 deg. 21 min. 53 sec.; what is the distance between them, on the Base Line, in latitude 37 deg. 52 min. 47 sec.?

chains chains
As 60 min. : 32 min. 56 sec. :: 4372.51 : 2400, the distance required.

4. *Given the distance between any two places on the same parallel, in a given latitude, to find their difference of longitude.*

RULE.—Find from Table II, the length of degree of longitude in the given latitude; and say, as the length of the degree of longitude is to the given distance, so is 60 minutes to the difference of longitude.

The longitude of the Monte Diablo Meridian, is 121 deg. 54 min. 40 sec.: what is the difference of longitude to Range 5 East. the distance on the Base Line, in latitude 37 deg. 52 min. 47 sec., being 30 miles?

chains. chains.
As 4373.51: 2400: : 60 min.: 32 min. 56 sec, the difference of longitude required.

5. *Given the distance between two meridians, on any parallel, in a given latitude, to find the convergency of the meridians for any distance north of that parallel.*

RULE.—Find the length of a degree of longitude, at each latitude, by the foregoing rules; and say, as the greater of the two lengths is to their difference, so is the given distance to the convergency required.

The distance between Ranges 1 and 2 on the 1st Standard South, is 6 miles, what is the convergency of the two range lines at the 2d Standard North, the meridional distance being 30 miles?

chains. chains. chains. chains.
As 4346.66 : 26.07 : : 480 : 2.88, the convergency required.

6. *Given the distance between two meridians, on any parallel in a given latitude, to find the divergency of the meridians for any distance south of that parallel.*

RULE.—Find the length of a degree of longitude, at each latitude, by the foregoing rules; and say, as the less of the two lengths is to their difference, so is the given distance to the divergency required.

The distance between Ranges 1 and 2, on the 1st Standard South, is 6 miles; what is the divergency of the two range lines at the 2d Standard South, the meridional distance being 24 miles?

chains. chains. chains. chains.
As 4393.00 : 20.34 : : 480 : 2.22, the divergency required.

Table III.

This table gives the divergency of the Parallel of Latitude from the Prime Vertical,* or perpendicular to the meridian, on the spheroidal surface of the earth at every second degree of latitude, from 28 to 48 degrees, for any number of miles from 1 to 36; and is useful in running a parallel of latitude by fore and back sighting.

*The length of a degree of the Prime Vertical may be calculated by the Formula $Dv = 5551.6748 - 18.6536 \cos 2l + .0940 \cos 4l$; in which Dv represents a degree of the Prime Vertical, in chains, and l the latitude.

EXAMPLE.

If a line commenced on the parallel of 37 degrees north latitude, be extended east or west, 27½ miles, by fore and back sighting, what distance will its terminus be south of that parallel?

	chains.
The table gives for 27 miles in latitude 37 deg. ..	5.52
" " 28 " " ..	5.94
The mean of which is........................	.5.73 the distance required.

TABLE. I.

Length of a Degree of Latitude.

′	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	′
	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	
0	5509·15	5509·97	5510·82	5511·67	5512·55	5513·44	5514·34	5515·25	5516·18	5517·11	0
1	09·16	09·99	10·83	11·69	12·56	13·45	14·35	15·27	16·19	17·13	1
2	09·17	10·00	10·84	11·70	12·58	13·47	14·37	15·28	16·21	17·14	2
3	09·19	10·01	10·86	11·72	12·59	13·48	14·38	15·30	16·22	17·16	3
4	09·20	10·03	10·87	11·73	12·61	13·50	14·40	15·31	16·24	17·17	4
5	09·21	10·04	10·89	11·75	12·62	13·51	14·42	15·33	16·25	17·19	5
6	09·23	10·06	10·90	11·76	12·64	13·53	14·43	15·34	16·27	17·20	6
7	09·24	10·07	10·91	11·78	12·65	13·54	14·45	15·36	16·28	17·22	7
8	09·25	10·08	10·93	11·79	12·67	13·56	14·46	15·38	16·30	17·23	8
9	09·27	10·10	10·94	11·81	12·68	13·57	14·48	15·39	16·32	17·25	9
10	09·28	10·11	10·96	11·82	12·70	13·59	14·49	15·41	16·33	17·27	10
11	09·30	10·13	10·97	11·83	12·71	13·60	14·51	15·42	16·35	17·28	11
12	09·31	10·14	10·99	11·85	12·73	13·62	14·52	15·44	16·36	17·30	12
13	09·32	10·15	11·00	11·86	12·74	13·63	14·54	15·45	16·38	17·31	13
14	09·34	10·17	11·01	11·88	12·76	13·65	14·55	15·47	16·39	17·33	14
15	09·35	10·18	11·03	11·89	12·77	13·66	14·57	15·48	16·41	17·34	15
16	09·36	10·19	11·04	11·91	12·79	13·68	14·58	15·50	16·42	17·36	16
17	09·38	10·21	11·06	11·92	12·80	13·69	14·60	15·51	16·44	17·38	17
18	09·39	10·22	11·07	11·94	12·81	13·71	14·61	15·53	16·46	17·39	18
19	09·41	10·24	11·09	11·95	12·83	13·72	14·63	15·54	16·47	17·41	19
20	09·42	10·25	11·10	11·96	12·84	13·74	14·64	15·56	16·49	17·42	20
21	09·43	10·26	11·11	11·98	12·86	13·75	14·66	15·57	16·50	17·44	21
22	09·45	10·28	11·13	11·99	12·87	13·77	14·67	15·59	16·52	17·45	22
23	09·46	10·29	11·14	12·01	12·89	13·78	14·69	15·61	16·53	17·47	23
24	09·47	10·31	11·16	12·02	12·90	13·80	14·70	15·62	16·55	17·49	24
25	09·49	10·32	11·17	12·04	12·92	13·81	14·72	15·64	16·56	17·50	25
26	09·50	10·33	11·19	12·05	12·93	13·83	14·73	15·65	16·58	17·52	26
27	09·51	10·35	11·20	12·07	12·95	13·84	14·75	15·67	16·60	17·53	27
28	09·53	10·36	11·21	12·08	12·96	13·86	14·76	15·68	16·61	17·55	28
29	09·54	10·38	11·23	12·10	12·98	13·87	14·78	15·70	16·63	17·56	29
30	09·56	10·39	11·24	12·11	12·99	13·89	14·79	15·71	16·64	17·58	30
31	09·57	10·41	11·26	12·12	13·01	13·90	14·81	15·73	16·66	17·60	31
32	09·58	10·42	11·27	12·14	13·02	13·92	14·82	15·74	16·67	17·61	32
33	09·60	10·44	11·29	12·15	13·04	13·93	14·84	15·76	16·69	17·63	33
34	09·61	10·45	11·30	12·17	13·05	13·95	14·86	15·77	16·70	17·64	34
35	09·63	10·46	11·31	12·18	13·07	13·96	14·87	15·79	16·72	17·66	35
36	09·64	10·48	11·33	12·20	13·08	13·98	14·89	15·81	16·74	17·67	36
37	09·65	10·49	11·34	12·21	13·10	13·99	14·90	15·82	16·75	17·69	37
38	09·67	10·50	11·36	12·22	13·11	14·01	14·92	15·84	16·77	17·71	38
39	09·68	10·52	11·37	12·24	13·13	14·02	14·93	15·85	16·78	17·72	39
40	09·69	10·53	11·39	12·26	13·14	14·04	14·95	15·87	16·80	17·74	40
41	09·71	10·55	11·40	12·27	13·16	14·05	14·96	15·88	16·81	17·75	41
42	09·72	10·56	11·42	12·29	13·17	14·07	14·98	15·90	16·83	17·77	42
43	09·74	10·57	11·43	12·30	13·18	14·08	14·99	15·91	16·84	17·78	43
44	09·75	10·59	11·44	12·31	13·20	14·10	15·01	15·93	16·86	17·80	44
45	09·76	10·60	11·46	12·33	13·21	14·11	15·02	15·94	16·88	17·82	45
46	09·78	10·62	11·47	12·34	13·23	14·13	15·04	15·96	16·89	17·83	46
47	09·79	10·63	11·49	12·36	13·24	14·14	15·05	15·98	16·91	17·85	47
48	09·80	10·65	11·50	12·37	13·26	14·16	15·07	15·99	16·92	17·86	48
49	09·82	10·66	11·52	12·39	13·27	14·17	15·08	16·01	16·94	17·88	49
50	09·83	10·67	11·53	12·40	13·29	14·19	15·10	16·02	16·95	17·89	50
51	09·85	10·69	11·54	12·42	13·30	14·20	15·11	16·04	16·97	17·91	51
52	09·86	10·70	11·56	12·43	13·32	14·22	15·13	16·05	16·98	17·93	52
53	09·87	10·72	11·57	12·45	13·33	14·23	15·15	16·07	17·00	17·94	53
54	09·89	10·73	11·59	12·46	13·35	14·25	15·16	16·08	17·02	17·96	54
55	09·90	10·74	11·60	12·48	13·36	14·26	15·18	16·10	17·03	17·97	55
56	09·92	10·76	11·62	12·49	13·38	14·28	15·19	16·11	17·05	17·99	56
57	09·93	10·77	11·63	12·51	13·39	14·29	15·21	16·13	17·06	18·00	57
58	09·94	10·79	11·65	12·52	13·41	14·31	15·22	16·15	17·08	18·02	58
59	09·96	10·80	11·66	12·53	13·42	14·32	15·24	16·16	17·09	18·04	59
60	09·97	10·82	11·67	12·55	13·44	14·34	15·25	16·18	17·11	18·05	60

TABLE I.

Length of a Degree of Latitude.

′	39°	40°	41°	42°	43°	44°	45°	46°	47°	48°	′
	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	
0	5518·05	5519·00	5519·96	5520·92	5521·88	5522·85	5523·81	5524·78	5525·75	5526·72	0
1	18·07	19·02	19·97	20·93	21·90	22·86	23·83	24·80	25·77	26·73	1
2	18·08	19·03	19·99	20·95	21·91	22·88	23·85	24·82	25·78	26·75	2
3	18·10	19·05	20·00	20·96	21·93	22·89	23·86	24·83	25·80	26·76	3
4	18·11	19·06	20·02	20·98	21·94	22·91	23·88	24·85	25·82	26·78	4
5	18·13	19·08	20·04	21·00	21·96	22·93	23·90	24·86	25·83	26·80	5
6	18·15	19·10	20·05	21·01	21·98	22·94	23·91	24·88	25·85	26·81	6
7	18·16	19·11	20·07	21·03	21·99	22·96	23·93	24·90	25·86	26·83	7
8	18·18	19·13	20·08	21·04	22·01	22·98	23·94	24·91	25·88	26·84	8
9	18·19	19·14	20·10	21·06	22·02	22·99	23·96	24·93	25·90	26·86	9
10	18·21	19·16	20·12	21·08	22·04	23·01	23·98	24·94	25·91	26·88	10
11	18·22	19·18	20·13	21·09	22·06	23·02	23·99	24·96	25·93	26·89	11
12	18·24	19·19	20·15	21·11	22·07	23·04	24·01	24·98	25·94	26·91	12
13	18·26	19·21	20·16	21·12	22·09	23·06	24·02	24·99	25·96	26·92	13
14	18·27	19·22	20·18	21·14	22·11	23·07	24·04	25·01	25·98	26·94	14
15	18·29	19·24	20·20	21·16	22·12	23·09	24·06	25·03	25·99	26·96	15
16	18·30	19·25	20·21	21·17	22·14	23·10	24·07	25·04	26·01	26·97	16
17	18·32	19·27	20·23	21·19	22·15	23·12	24·09	25·06	26·02	26·99	17
18	18·34	19·29	20·24	21·20	22·17	23·14	24·11	25·07	26·04	27·00	18
19	18·35	19·30	20·26	21·22	22·19	23·15	24·12	25·09	26·06	27·02	19
20	18·37	19·32	20·28	21·24	22·20	23·17	24·14	25·11	26·07	27·04	20
21	18·38	19·33	20·29	21·25	22·22	23·19	24·15	25·12	26·09	27·05	21
22	18·40	19·35	20·31	21·27	22·23	23·20	24·17	25·14	26·10	27·07	22
23	18·41	19·37	20·32	21·29	22·25	23·22	24·19	25·15	26·12	27·09	23
24	18·43	19·38	20·34	21·30	22·27	23·23	24·20	25·17	26·14	27·10	24
25	18·45	19·40	20·36	21·32	22·28	23·25	24·22	25·19	26·15	27·12	25
26	18·46	19·41	20·37	21·33	22·30	23·27	24·23	25·20	26·17	27·13	26
27	18·48	19·43	20·39	21·35	22·31	23·28	24·25	25·22	26·19	27·15	27
28	18·49	19·45	20·40	21·36	22·33	23·30	24·27	25·23	26·20	27·17	28
29	18·51	19·46	20·42	21·38	22·35	23·31	24·28	25·25	26·22	27·18	29
30	18·53	19·48	20·44	21·40	22·36	23·33	24·30	25·27	26·23	27·20	30
31	18·54	19·49	20·45	21·41	22·38	23·35	24·32	25·28	26·25	27·21	31
32	18·56	19·51	20·47	21·43	22·40	23·36	24·33	25·30	26·27	27·23	32
33	18·57	19·53	20·48	21·45	22·41	23·38	24·35	25·32	26·28	27·25	33
34	18·59	19·54	20·50	21·46	22·43	23·40	24·36	25·33	26·30	27·26	34
35	18·60	19·56	20·52	21·48	22·44	23·41	24·38	25·35	26·31	27·28	35
36	18·62	19·57	20·53	21·49	22·46	23·43	24·40	25·36	26·33	27·29	36
37	18·64	19·59	20·55	21·51	22·48	23·44	24·41	25·38	26·35	27·31	37
38	18·65	19·60	20·56	21·53	22·49	23·46	24·43	25·40	26·36	27·33	38
39	18·67	19·62	20·58	21·54	22·51	23·48	24·44	25·41	26·38	27·34	39
40	18·68	19·64	20·60	21·56	22·52	23·49	24·46	25·43	26·39	27·36	40
41	18·70	19·65	20·61	21·57	22·54	23·51	24·48	25·44	26·41	27·37	41
42	18·72	19·67	20·63	21·59	22·56	23·52	24·49	25·46	26·43	27·39	42
43	18·73	19·68	20·64	21·61	22·57	23·54	24·51	25·48	26·44	27·41	43
44	18·75	19·70	20·66	21·62	22·59	23·56	24·52	25·49	26·46	27·42	44
45	18·76	19·72	20·68	21·64	22·60	23·57	24·54	25·51	26·47	27·44	45
46	18·78	19·73	20·69	21·65	22·62	23·59	24·56	25·52	26·49	27·45	46
47	18·79	19·75	20·71	21·67	22·64	23·60	24·57	25·54	26·51	27·47	47
48	18·81	19·76	20·72	21·69	22·65	23·62	24·59	25·56	26·52	27·49	48
49	18·83	19·78	20·74	21·70	22·67	23·64	24·61	25·57	26·54	27·50	49
50	18·84	19·80	20·76	21·72	22·69	23·65	24·62	25·59	26·56	27·52	50
51	18·86	19·81	20·77	21·74	22·70	23·67	24·64	25·61	26·57	27·53	51
52	18·87	19·83	20·79	21·75	22·72	23·69	24·65	25·62	26·59	27·55	52
53	18·89	19·84	20·80	21·77	22·73	23·70	24·67	25·64	26·60	27·57	53
54	18·91	19·86	20·82	21·78	22·75	23·72	24·69	25·65	26·62	27·58	54
55	18·92	19·88	20·84	21·80	22·77	23·73	24·70	25·67	26·64	27·60	55
56	18·94	19·89	20·85	21·82	22·78	23·75	24·72	25·69	26·65	27·61	56
57	18·95	19·91	20·87	21·83	22·80	23·77	24·73	25·70	26·67	27·63	57
58	18·97	19·92	20·88	21·85	22·81	23·78	24·75	25·72	26·68	27·65	58
59	18·98	19·94	20·90	21·86	22·83	23·80	24·77	25·73	26·70	27·66	59
60	19·00	19·96	20·92	21·88	22·85	23·81	24·78	25·75	26·72	27·68	60

TABLE. II.

Length of a Degree of Longitude.

′	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	′
	chains.	chains.	chains.	chains.	chains	chains.	chains.	chains.	chains.	chains.	
0	4843·17	4795·32	4747·01	4690·75	4645·06	4591·96	4537·45	4481·56	4424·29	4365·68	0
1	42·40	95·02	46·19	95·90	44·19	91·06	36·53	80·61	23·33	64·69	1
2	41·62	94·22	45·36	95·05	43·32	90·16	35·61	79·67	22·36	63·70	2
3	40·84	93·42	44·53	94·20	42·44	89·26	34·69	78·73	21·40	62·72	3
4	40·06	92·61	43·71	93·35	41·57	88·37	33·77	77·78	20·43	61·73	4
5	39·28	91·81	42·88	92·50	40·69	87·47	32·84	76·84	19·46	60·74	5
6	38·50	91·01	42·05	91·65	39·82	86·57	31·92	75·89	18·49	59·75	6
7	37·72	90·20	41·22	90·80	38·94	85·67	31·00	74·95	17·53	58·76	7
8	36·94	89·40	40·39	89·94	38·06	84·77	30·08	74·00	16·56	57·77	8
9	36·16	88·59	39·56	89·09	37·19	83·87	29·15	73·05	15·59	56·77	9
10	35·38	87·79	38·73	88·24	36·31	82·97	28·23	72·11	14·62	55·78	10
11	34·60	86·98	37·90	87·38	35·43	82·07	27·30	71·16	13·65	54·79	11
12	33·82	86·18	37·07	86·53	34·55	81·17	26·38	70·21	12·68	53·80	12
13	33·04	85·37	36·24	85·67	33·68	80·26	25·46	69·26	11·71	52·81	13
14	32·26	84·56	35·41	84·82	32·80	79·36	24·53	68·32	10·74	51·81	14
15	31·47	83·76	34·58	83·96	31·92	78·46	23·60	67·37	09·77	50·82	15
16	30·69	82·95	33·75	83·11	31·04	77·56	22·68	66·42	08·80	49·83	16
17	29·91	82·14	32·92	82·25	30·16	76·65	21·75	65·47	07·82	48·83	17
18	29·12	81·33	32·08	81·40	29·28	75·75	20·83	64·52	06·85	47·84	18
19	28·34	80·52	31·25	80·54	28·40	74·85	19·90	63·57	05·88	46·84	19
20	27·55	79·71	30·42	79·68	27·52	73·94	18·97	62·62	04·91	45·85	20
21	26·77	78·90	29·58	78·82	26·64	73·04	18·04	61·67	03·93	44·85	21
22	25·98	78·09	28·75	77·97	25·75	72·13	17·11	60·72	02·96	43·85	22
23	25·20	77·28	27·92	77·11	24·87	71·23	16·19	59·77	01·98	42·86	23
24	24·41	76·47	27·08	76·25	23·99	70·32	15·26	58·81	01·01	41·86	24
25	23·62	75·66	26·25	75·39	23·11	69·41	14·33	57·86	00·04	40·86	25
26	22·83	74·85	25·41	74·53	22·22	68·51	13·40	56·91	4399·06	39·87	26
27	22·05	74·04	24·57	73·67	21·34	67·60	12·47	55·96	98·08	38·87	27
28	21·26	73·22	23·74	72·81	20·45	66·69	11·54	55·00	97·11	37·87	28
29	20·47	72·41	22·90	71·95	19·57	65·78	10·61	54·05	96·13	36·87	29
30	19·68	71·60	22·06	71·09	18·69	64·88	09·67	53·09	95·16	35·87	30
31	18·89	70·78	21·22	70·22	17·80	63·97	08·74	52·14	94·18	34·87	31
32	18·10	69·97	20·39	69·36	16·91	63·06	07·81	51·19	93·20	33·87	32
33	17·31	69·16	19·55	68·50	16·03	62·15	06·88	50·23	92·22	32·87	33
34	16·52	68·34	18·71	67·64	15·14	61·24	05·94	49·27	91·25	31·87	34
35	15·73	67·53	17·87	66·77	14·26	60·33	05·01	48·32	90·27	30·87	35
36	14·94	66·71	17·03	65·91	13·37	59·42	04·08	47·36	89·29	29·87	36
37	14·15	65·89	16·19	65·05	12·48	58·51	03·14	46·41	88·31	28·87	37
38	13·35	65·08	15·35	64·18	11·59	57·60	02·21	45·45	87·33	27·87	38
39	12·56	64·26	14·51	63·32	10·70	56·68	01·28	44·49	86·35	26·87	39
40	11·77	63·44	13·67	62·45	09·81	55·77	00·34	43·53	85·37	25·86	40
41	10·98	62·52	12·82	61·59	08·93	54·86	4499·40	42·57	84·39	24·86	41
42	10·18	61·81	11·98	60·72	08·04	53·95	98·47	41·62	83·41	23·86	42
43	09·39	60·99	11·14	59·85	07·15	53·03	97·53	40·66	82·42	22·85	43
44	08·59	60·17	10·30	58·99	06·26	52·12	96·59	39·70	81·44	21·85	44
45	07·80	59·35	09·45	58·12	05·36	51·21	95·66	38·74	80·46	20·85	45
46	07·00	58·53	08·61	57·25	04·47	50·29	94·72	37·78	79·48	19·84	46
47	06·21	57·71	07·76	56·38	03·58	49·38	93·78	36·82	78·49	18·84	47
48	05·41	56·89	06·92	55·51	02·69	48·46	92·84	35·86	77·51	17·83	48
49	04·61	56·07	06·07	54·65	01·80	47·55	91·91	34·89	76·53	16·82	49
50	03·82	55·25	05·23	53·78	00·90	46·63	90·97	33·93	75·54	15·82	50
51	03·02	54·43	04·38	52·91	00·01	45·71	90·03	32·97	74·56	14·81	51
52	02·22	53·60	03·54	52·04	4599·12	44·80	89·09	32·01	73·57	13·80	52
53	01·42	52·78	02·69	51·17	98·22	43·88	88·15	31·04	72·59	12·80	53
54	00·62	51·96	01·84	50·30	97·33	42·96	87·21	30·08	71·60	11·79	54
55	4799·82	51·13	01·00	49·42	96·44	42·04	86·27	29·12	70·62	10·78	55
56	99·02	50·31	00·15	48·55	95·54	41·13	85·32	28·15	69·63	09·77	56
57	98·22	49·49	4699·30	47·68	94·64	40·21	84·38	27·19	68·64	08·76	57
58	97·42	48·66	98·45	46·81	93·75	39·29	83·44	26·22	67·66	07·75	58
59	96·62	47·84	97·60	45·94	92·85	38·37	82·50	25·26	66·67	06·74	59
60	95·82	47·01	96·75	45·06	91·96	37·45	81·56	24·29	65·68	05·73	60

TABLE. II.

Length of a Degree of Longitude.

′	39°	40°	41°	42°	43°	44°	45°	46°	47°	48°	′
	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	
0	4305.73	4244·47	4181·91	4118·06	4052·96	3986·62	3919·05	3850·28	3780·32	3709·22	0
1	04·72	43·44	80·85	16·99	51·87	85·50	17·91	49·12	79·15	08·03	1
2	03·71	42·41	79·80	15·91	50·77	84·38	16·78	47·97	77·98	06·83	2
3	02·70	41·37	78·75	14·84	49·67	83·27	15·64	46·81	76·80	05·63	3
4	01·69	40·34	77 69	13·76	48·58	82·15	14·50	45·65	75·63	04·44	4
5	00·68	39·31	76·64	12·69	47·48	81·03	13·36	44·50	74·45	03·24	5
6	4299·67	38·27	75·58	11·61	46·38	79·91	12·23	43·34	73·27	02·05	6
7	98·65	37·24	74·52	10·53	45·28	78·79	11·09	42·18	72·09	00·85	7
8	97·64	36·20	73·47	09·46	44·19	77·68	09·95	41·02	70·92	3699·65	8
9	96·63	35·17	72·41	08·38	43·09	76·56	08·81	39·86	69·74	98·46	9
10	95·61	34·13	71·36	07·30	41·99	75·44	07·67	38·70	68·56	97·26	10
11	94·60	33·10	70·30	06·22	40·89	74·32	06·53	37·54	67·38	96·06	11
12	93·59	32·06	69·24	05·14	39·79	73·20	05·39	36·38	66·20	94·86	12
13	92·57	31·02	68·18	04·07	38·69	72·08	04·25	35·22	65·02	93·66	13
14	91·56	29·99	67·12	02·99	37·59	70·96	03·11	34·06	63·84	92·46	14
15	90·54	28·95	66·07	01·91	36·49	69·84	01·97	32·90	62·66	91·26	15
16	89·52	27·91	65·01	00·83	35·39	68·72	00·83	31·74	61·48	90·06	16
17	88·51	26·87	63·95	4099·75	34·29	67·59	3899·69	30·58	60·30	88·86	17
18	87·49	25·84	62·89	98·67	33·19	66·47	98·54	29·42	59·12	87·66	18
19	86·48	24·80	61·83	97·58	32·09	65·35	97·40	28·26	57·94	86·46	19
20	85·46	23·76	60·77	96·50	30·98	64·23	96·26	27·09	56·76	85·26	20
21	84·44	22·72	59·71	95·42	29·88	63·11	95·12	25·93	55·57	84·06	21
22	83·42	21·68	58·65	94·34	28·78	61·98	93·97	24·77	54·39	82·86	22
23	82·40	20·64	57·58	93·26	27·67	60·86	92·83	23·60	53·21	81·66	23
24	81·39	19·60	56·52	92·17	26·57	59·73	91·68	22·44	52·02	80·46	24
25	80·37	18·56	55·46	91·09	25·47	58·61	90·54	21·28	50·84	79·25	25
26	79·35	17·52	54·40	90·01	24·36	57·49	89·40	20·11	49·66	78·05	26
27	78·33	16·48	53·44	88·92	23·26	56·36	88·25	18·95	48·47	76·85	27
28	77·31	15·43	52·27	87·84	22·15	55·24	87·11	17·78	47·29	75·64	28
29	76·29	14·39	51·21	86·75	21·05	54·11	85·96	16·62	46·10	74·44	29
30	75·27	13·35	50·14	85·67	19·94	52·98	84·81	15·45	44·92	73·24	30
31	74·24	12·31	49·08	84·58	18·84	51·86	83·67	14·29	43·73	72·03	31
32	73·22	11·26	48·02	83·50	17·73	50·73	82·52	13·12	42·55	70·83	32
33	72·20	10·22	46·95	82·41	16·62	49·60	81·37	11·95	41·30	69·62	33
34	71·18	09·18	45·89	81·33	15·52	48·48	80·23	10·79	40·18	68·42	34
35	70·16	08·13	44·82	80·24	14·41	47·35	79·08	09·62	38·99	67·21	35
36	69·13	07·09	43·75	79·15	13·30	46·22	77·93	08·45	37·80	66·01	36
37	68·11	06·04	42·69	78·07	12·19	45·09	76·78	07·28	36·62	64·80	37
38	67·09	05·00	41·62	76·98	11·09	43·96	75·63	06·11	35·43	63·59	38
39	66·06	03·95	40·55	75·89	09·98	42·83	74·48	04·95	34·24	62·39	39
40	65·04	02·90	39·49	74·80	08·87	41·71	73·34	03·78	33·05	61·18	40
41	64·01	01·86	38·42	73·71	07·76	40·58	72·19	02·61	31·86	59·97	41
42	62·99	00·81	37·35	72·62	06·65	39·45	71·04	01·44	30·67	58·76	42
43	61·96	4199·76	36·28	71·53	05·54	38·32	69·89	00·27	29·48	57·56	43
44	60·93	98·72	35·21	70·44	04·43	37·18	68·74	3799·10	28·30	56·35	44
45	59·91	97·67	34·14	69·35	03·32	36·05	67·58	97·93	27·11	55·14	45
46	58.88	96·62	33·08	68·26	02·21	34·92	66·43	96·76	25·92	53·93	46
47	57·85	95·57	32·01	67·17	01·10	33·79	65·28	95·59	24·73	52·72	47
48	56·83	94·52	30·93	66·08	3999·98	32·66	64·13	94·41	23·53	51·51	48
49	55·80	93·47	29·86	64·99	98·87	31·53	62·98	93·24	22·34	50·30	49
50	54·77	92·42	28·79	63·90	97·76	30·39	61·82	92·07	21·15	49·09	50
51	53·74	91·37	27·72	62·81	96·65	29·26	60·67	90·90	19·96	47·88	51
52	52·71	90·32	26·65	61·71	95·53	28·13	59·52	89·72	18·77	46·67	52
53	51·68	89·27	25·58	60·62	94·42	26·99	58·36	88·55	17·58	45·46	53
54	50·66	88·22	24·51	59·53	93·31	25·86	57·21	87·38	16·38	44·25	54
55	49·63	87·17	23·43	58·43	92·19	24·73	56·06	86·20	15·19	43·03	55
56	48·59	86·12	22·36	57·34	91·08	23·59	54·90	85·03	14·00	41·82	56
57	47·56	85·07	21·29	56·25	89·96	22·46	53·75	83·86	12·80	40·61	57
58	46·53	84·02	20·21	55·15	88·85	21·32	52·59	82·68	11·61	39·40	58
59	45·50	82·96	19.14	54·06	87·73	20·19	51·44	81·51	10·41	38·18	59
60	44·47	81·91	18·06	52·96	86·62	19·05	50·28	80·33	09·22	36·97	60

DIVERGENCY OF THE PARALLEL OF LATITUDE AND THE PRIME VERTICAL.

Dist	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	Dist
mile	chns	chns	chns	chns	chns	chns	chns	chns	chns	chns.	chns.	mile
1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1
2	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	2
3	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.10	3
4	0.09	0.09	0.10	0.11	0.12	0.13	0.13	0.14	0.16	0.17	0.18	4
5	0.13	0.14	0.16	0.17	0.18	0.20	0.21	0.23	0·24	0.26	0.28	5
6	0.19	0.21	0.23	0.24	0.26	0.28	0.30	0.33	0.35	0.37	0.40	6
7	0.26	0.28	0.31	0.33	0.36	0.38	0.41	0.44	0.48	0.51	0.55	7
8	0.34	0.37	0.40	0.43	0.47	0.50	0.54	0.58	0.62	0.67	0.71	8
9	0.43	0.47	0.51	0·55	0.59	0.64	0.68	0.73	0.79	0.84	0.90	9
10	0.53	0.58	0.63	0.68	0.73	0.78	0.84	0.90	0.97	1.04	1.11	10
11	0.65	0.70	0.76	0.82	0.88	0.95	1.02	1.09	1.17	1.26	1.35	11
12	0.77	0.83	0.90	0.97	1.05	1.13	1.21	1.30	1.40	1.50	1.61	12
13	0 90	0.98	1.06	1.14	1.23	1·33	1.42	1.53	1.64	1.76	1.88	13
14	1.05	1.14	1.23	1.33	1.43	1.54	1.65	1.77	1.90	2.04	2.19	14
15	1.20	1.30	1.41	1.52	1.64	1.76	1.90	2.03	2.18	2.34	2.51	15
16	1.36	1.48	1.60	1.73	1.87	2.01	2.16	2.32	2.48	2.66	2.85	16
17	1.54	1.67	1.81	1.96	2.11	2.27	2.44	2.61	2.80	3.00	3.22	17
18	1.73	1.88	2.03	2.19	2.36	2.54	2.73	2.93	3.14	3.37	3.61	18
19	1.92	2.09	2.26	2.44	2.63	2.83	3.04	3.26	3.50	3.75	4.03	19
20	2.13	2.32	2.51	2.71	2.92	3·14	3.37	3.62	3.88	4.16	4.46	20
21	2.35	2.55	2.76	2.98	3.22	3.46	3.72	3.99	4.28	4.59	4.92	21
22	2.58	2.80	3.03	3.28	3.53	3·80	4.08	4.38	4.69	5.03	5.40	22
23	2.82	3.06	3.32	3.58	3.86	4.15	4.46	4.78	5.13	5.50	5.90	23
24	3.07	3.34	3.61	3·90	4·20	4.52	4.85	5.21	5.59	5.99	6.42	24
25	3.33	3.62	3.92	4.23	4.56	4.90	5.27	5.65	6.06	6.50	6.97	25
26	3.60	3.91	4.24	4.57	4.93	5.30	5.70	6.11	6.56	7.03	7.54	26
27	3·89	4.22	4.57	4.93	5·32	5.72	6.14	6.59	7.07	7.58	8.13	27
28	4.18	4.54	4.91	5·31	5.72	6.15	6.61	7.09	7.60	8.15	8.74	28
29	4.48	4.87	5.27	5.69	6.13	6.60	7.09	7.61	8.16	8.74	9.38	29
30	4.80	5.21	5.64	6.09	6.56	7.06	7.58	8.14	8.73	9.36	10.04	30
31	5.12	5.57	6.02	6.50	7.01	7.54	8.10	8.69	9.32	9.99	10.72	31
32	5.46	5.93	6.42	6.93	7.47	8.03	8.63	9.26	9.93	10.65	11.42	32
33	5.81	6.31	6.83	7.37	7.94	8.54	9.18	9.85	10.56	11.32	12.14	33
34	6.16	6.69	7.25	7.82	8.43	9.07	9.74	10.45	11.21	12.02	12.89	34
35	6.53	7.09	7.68	8.29	8·93	9.61	10.32	11.08	11.88	12.74	13.66	35
36	6.91	7.51	8.12	8.77	9.45	10.16	10.92	11.72	12.57	13.47	14.45	36

TABLE showing the Difference of Latitude and Departure in running 80 chains, at any course from 1 to 60 minutes.

Min's	Links.	Min's	Links.	Min's	Links.	Min's	Links.	Min's	Links.	Min's	Links.
1	2⅓	11	25⅔	21	49	31	72⅓	41	95⅔	51	119
2	4⅔	12	28	22	51⅓	32	74⅔	42	98	52	121⅓
3	7	13	30⅓	23	53⅔	33	77	43	100⅓	53	123⅔
4	9⅓	14	32⅔	24	56	34	79⅓	44	102⅔	54	126
5	11⅔	15	35	25	58⅓	35	81⅔	45	105	55	128⅓
6	14	16	37⅓	26	60⅔	36	84	46	107⅓	56	130⅔
7	16⅓	17	39⅔	27	63	37	86⅓	47	109⅔	57	133
8	18⅔	18	42	28	65⅓	38	88⅔	48	112	58	135⅓
9	21	19	44⅓	29	67⅔	39	91	49	114⅓	59	137⅔
10	23⅓	20	46⅔	30	70	40	93⅓	50	116⅔	60	140

TABLE for reducing Chains to Feet, and Feet to Chains.

Chains or Links.	Feet.	Chains or Links.	Feet.	Chains or Links.	Feet.	Chains or Links.	Feet.	Chains or Links.	Feet.
1	66	21	1386	41	2706	61	4026	81	5346
2	132	22	1452	42	2772	62	4092	82	5412
3	198	23	1518	43	2838	63	4158	83	5478
4	264	24	1584	44	2904	64	4224	84	5544
5	330	25	1650	45	2970	65	4290	85	5610
6	396	26	1716	46	3036	66	4356	86	5676
7	462	27	1782	47	3102	67	4422	87	5742
8	528	28	1848	48	3168	68	4488	88	5808
9	594	29	1914	49	3234	69	4554	89	5874
10	660	30	1980	50	3300	70	4620	90	5940
11	726	31	2046	51	3366	71	4686	91	6006
12	792	32	2112	52	3432	72	4752	92	6072
13	858	33	2178	53	3498	73	4818	93	6138
14	924	34	2244	54	3564	74	4884	94	6204
15	990	35	2310	55	3630	75	4950	95	6270
16	1056	36	2376	56	3696	76	5016	96	6336
17	1122	37	2442	57	3762	77	5082	97	6402
18	1188	38	2508	58	3828	78	5148	98	6468
19	1254	39	2574	59	3894	79	5214	99	6534
20	1320	40	2640	60	3960	80	5280	100	6600

TABLE of Acres required per Mile, and per 100 Feet, for different widths.

width. Feet.	Acres per Mile.	Acres per 100 feet.	width. Feet.	Acres per Mile.	Acres per 100 feet.	width. Feet.	Acres per Mile.	Acres per 100 feet.
1	.121	.002	23	2.79	.053	45	5.45	.103
2	.242	.005	24	2.91	.055	46	5.58	.106
3	.364	.007	24¾	3.00	.057	47	5.70	.108
4	.485	.009	25	3.03	.058	48	5.82	.110
5	·606	.011	26	3.15	.060	49	5.94	.112
6	.727	.014	27	3.27	.062	49½	6.00	.114
7	.848	.016	28	3.39	.064	50	6.06	.115
8	.970	.018	29	3.52	.067	51	6.18	.117
8¼	1.00	.019	30	3.64	.069	52	6.30	.119
9	1.09	.021	31	3.76	.071	53	6.42	.122
10	1.21	.023	32	3.88	.073	54	6.55	.124
11	1.33	.025	33	4.00	.076	55	6.67	.126
12	1.46	.028	34	4.12	.078	56	6.79	.129
13	1.58	.030	35	4.24	.080	57	6.91	.131
14	1.70	.032	36	4.36	.083	57¾	7.00	.133
15	1.82	.034	37	4.48	.085	58	7.03	.134
16	1.94	.037	38	4.61	.087	59	7.15	.135
16½	2.00	.038	39	4.73	.090	60	7.27	.138
17	2.06	.039	40	4.85	.092	61	7.39	.140
18	2.18	.041	41	4.97	.094	62	7.52	.142
19	2.30	.044	41¼	5.00	.095	63	7.64	.145
20	2.42	.046	42	5.09	.096	64	7.76	.147
21	2.55	.048	43	5.21	.099	65	7.88	.149
22	2·67	.051	44	5.33	.101	66	8.00	.151

APPROXIMATE RULES CONVENIENT IN PRACTICE.

I. For Correcting Random Lines.*

1. *Given the error of latitude or departure for any distance, to find the error of the course.*

Rule.—Three-sevenths of the error of latitude or departure, per mile, in links, will be the error of the course, in minutes.

EXAMPLE.

What is the error of the course for an error of 210 links of latitude or departure, in 6 miles?

Here the error, per mile, is 35 links, three-sevenths of which is 15 minutes, the error required.

2. *Given the error of the course, to find the corresponding error of latitude or departure for any distance.*

Rule.—Seven-thirds of the error of the course, in minutes, will be the error of latitude or departure, per mile, in links.

EXAMPLE.

What is the error of latitude or departure, in 6 miles, for an error of 15 minutes in the course?

Here seven thirds of 15 is 35 links, the error per mile, or 210 links in 6 miles, the error required,

II. For Running a Parallel of Latitude.†

Given the distance run, east or west, on a great circle, to find the divergency from the parallel of latitude.

Rule.—Multiply the square of the distance in miles, by the natural tangent of the latitude, and the product will be the divergency, in links.

EXAMPLE.

After running 6 miles, east or west, on the arc of a great circle, from latitude 38 degrees, what will be the meridional distance south of the parallel?

Here we have $.781 \times 6^2 = 28$ links, the divergency required

TRIGONOMETRICAL SERIES

$$\text{Sin } A = A - \frac{A^3}{2.3} + \frac{A^5}{2.3.4.5} - \frac{A^7}{2.3.4.5.6.7} + \text{etc.}$$

$$\text{Cos } A = 1 - \frac{A^2}{2} + \frac{A^4}{2.3.4} - \frac{A^6}{2.3.4.5.6} + \text{etc.}$$

$$\text{Tan } A = A + \frac{A^3}{3} + \frac{2A^5}{3.5} + \frac{17A^7}{3^2.5.7} + \text{etc}$$

$$\text{Cot } A = \frac{1}{A} - \frac{A}{3} - \frac{A^3}{3^2.5} - \frac{2A^5}{3^3\,5.7} - \text{etc.}$$

$$\text{Arc } A = \sin A + \frac{\sin^3 A}{2.3} + \frac{3\sin^5 A}{2.4.5} + \frac{3.5\sin^7 A}{2.4.6.7} + \text{etc.}$$

$$\text{Arc } A = \tan A - \frac{1}{3}\tan^3 A + \frac{1}{5}\tan^5 A - \frac{1}{7}\tan^7 A + \text{etc.}$$

* This approximation is true to the nearest minute for all angles up to 3 deg.; and to the nearest quarter of a degree for all angles up to 11¼ degrees.

† This approximation may be considered practically correct for any distance not exceeding 30 miles.

Rules for Solving all Cases of Plane Trigonometry.

Case 1.

Given all the Angles and One Side, to find the other Side.

Rule.—As sine of the angle opposite the given side, is to sine of the angle opposite the required side, so is the given side to the required side.

Case 2.

Given two Sides and an Angle opposite one of them, to find the other Angles and Side.

Rule.—As the side opposite the given angle, is to the other given side, so is sine of the angle opposite the former, to sine of the angle opposite the latter.

Case 3.

Given two Sides and the included Angle, to find the other Angles and Side.

Rule.—Subtract the given angle from 180 degrees and the remainder will be the sum of the two unknown angles; then say, as the sum of the two given sides is to their difference, so is tangent of half sum of unknown angles, to tangent of half their difference. Add this half difference of the unknown angles to their half sum for the angle opposite the greater side, and subtract it from the half sum for the angle opposite the less side.

Case 4.

Given the Three Sides to find the Angles.

Rule—Upon the longest side let fall a perpendicular from the opposite angle. This perpendicular will divide the base into two segments and the triangle into two right-angled triangles; then say, as the given base is to the sum of the two other sides, so is the difference of those sides, to the difference of the segments of the base. To half the base add half the difference of the segments for the greater segment, and subtract it from half the base for the less side; then proceed as in Case 2.

Rule 2.—Add together the arith. comp. of the logarithms of the two sides, containing the required angle, the log. of the half sum of the three sides and the log. of the difference of the half sum and the side opposite the required angle. The half sum of these four logarithms will be the logarithmic cosine of half the required angle.

For Finding the Diameter of a Tree.

Rule.—Annex a cipher to the number of links around the tree, and one fourth of the result will be the diameter, in inches.

EXAMPLE.

What is the diameter of a tree whose circumference is 16 links?

Here we have $\frac{1}{4}$ of 160 = 40 inches, the diameter required.

TABLE FOR RUNNING ON SLOPES.

In the following table the first column shows the angle, the second the number of links to be added to a chain on the slopes, to make 1 chain horizontal measurement.

Angle.	Cor. in links	Angle.	Cor. in links	Angle.	Cor. in links	Angle.	Cor. in links
°		°		°		°	
4	0.24	11	1.88	18	5.14	25	10.54
5	0.38	12	2.24	19	5.76	26	11.26
6	0.55	13	2.63	20	6.42	27	12.24
7	0.76	14	3.06	21	7.11	28	13.37
8	0.98	15	3.53	22	7.85	29	14.34
9	1.24	16	4.02	23	8.64	30	15.47
10	1.55	17	4.56	24	9.47	35	22.07

Position of the Principal Lines of the United States Surveys in the State of California.

MONTE DIABLO Merid., Mt. Diablo. Lat. 37° 52′ 47″, Long. 121° 54′ 49″ W.

Parallel.	Latitude.			Distance.	Longitude per Range.			Converg.
	°	′	″	Miles.	°	′	″	Chains.
Monte Diablo	37	52	47	0	0	0	35.2	0.00
I Standard North	38	18	53	30	0	6	37.5	2.84
II " "	38	44	58	60	0	6	39.9	2.88
III " "	39	11	4	90	0	6	42.4	2.93
IV " "	39	37	10	120	0	6	44.9	2.97
V " "	40	3	15	150	0	6	47.5	3.02
VI " "	40	29	21	180	0	6	50.1	2.06
VII " "	40	55	26	210	0	6	52.8	3.11
VIII " "	41	21	31	240	0	6	55.5	3.16
IX " "	41	47	54	270	0	6	58.3	3.21
Oregon Boundary	42	0	0	284	0	6	59.6	1.48
I Standard South	37	31	54	24	0	6	33.4	2.25
II " "	37	11	1	48	0	6	31.6	2.22
III " "	36	50	8	72	0	6	29.8	2.19
IV " "	36	29	14	96	0	6	28.0	2.17
V " "	36	8	21	120	0	6	26.3	2.14
VI " "	35	47	28	144	0	6	24.6	2.11
VII " "	35	26	35	168	0	6	22.9	2.09
VIII " "	35	5	41	192	0	6	21.3	2.06
IX " "	34	44	48	216	0	6	19.7	2.03
X " "	34	23	55	240	0	6	18.1	2.00

HUMBOLDT MERID., Mt. Pierce, Lat. 40° 24′ 56″, Long. 124° 07′ 03″ W.

Parallel.	Latitude.			Distance.	Longitude per Range.			Converg.
	°	′	″	Miles.	′	′	″	Chains.
Mount Pierce	40	24	56	0	0	6	49.6	0.00
I Standard North	40	51	1	30	0	6	52.3	3.09
II " "	41	17	6	60	0	6	55.0	3.15
III " "	41	43	12	90	0	6	57.9	3.20
Oregon Boundary	42	0	0	109.32	0	6	59.6	2.09
								Diverg.
I Standard South	40	4	4	24	0	6	47.5	2.48

SAN BERNARDINO Merid.. Mt. San Bern. Lat. 34° 07′ 25″, Long. 116° 56′ W.

Parallel.	Latitude.			Distance.	Longitude per Range.			Converg.
	°	′	″	Miles.	°	′	″	Chains.
Mount San Bernardino	34	7	25	0	0	6	16.9	0.00
I Standard North	34	33	32	30	0	6	18.8	2.47
II " "	34	59	39	60	0	6	20.8	2.51
III " "	35	25	46	90	0	6	22.8	2.56
IV " "	35	51	53	120	0	6	24.9	2.60
V " "	36	18	0	150	0	6	27.1	2.64
VI " "	36	44	6	180	0	6	29.2	2.68
								Diverg.
I Standard South	33	46	31	24	0	6	15.3	1.95
II " "	33	25	38	48	0	6	13.8	1.93
III " "	33	4	34	72	0	6	12.3	1.90
IV " "	32	43	50	96	0	6	10.9	1.87
V " "	32	22	56	120	0	6	9.5	1.85

Position of the Principal Lines of the United States Surveys in the

STATE of NEVADA.

The principal Base and Standard Parallels in this State are precisely the same as those of California. All the townships are numbered from the Monte Diablo meridian and base line. The Fourth Standard Parallel base line commences at the California and Nevada State lines, run by A. W. von Schmidt, at the line between Ranges 17 and 18, and extends to the Utah boundary line, in Range 70.

There are four Guide Meridians, viz.:

CARSON GUIDE MERIDIAN, running north from the Fourth Standard North, between Ranges 20 and 21 E. M. D. M.

HUMBOLDT RIVER GUIDE MERIDIAN, running north from the Fourth Standard North, between ranges 35 and 36 E. M. D. M.

REESE RIVER GUIDE MERIDIAN, running south from the Fourth Standard North, between Ranges 42 and 43 E. M. D. M.

RUBY VALLEY GUIDE MERIDIAN, running N. and S. from the Fourth Standard Parallel North, between Ranges 55 and 56 of the Monte Diablo meridian.

Position of the Principal Lines of the United States Surveys in

UTAH TERRITORY.

Initial Point, Salt Lake Base and Meridian.

Latitude, 40° 46′ 08″ North; Longitude 111° 53′ 47″ West.

Surveys North of the Base Line.

Parallel.	Latitude.			Distance.	Longitude. per Range.			Converg.
	°	′	″	Miles.	°	′	″	Chains.
Initial Point	40	46	08	0	0	6	51.8	0 0
I Standard North	41	07	00	24	0	6	53.9	2.51
II " "	41	27	52	48	0	6	56.1	2.54
III " "	41	48	44	72	0	6	58.4	2.58
Oregon Line	42	00	00	84.95	0	6	59.6	1.40

Surveys South of the Base Line.

	°	′	″	Miles.	°	′	″	Chains.
Initial Point	40	46	08	0	0	6	51.8	0 0
I Standard South	40	20	03	30	0	6	49.1	3.09
II " "	39	53	57	60	0	6	45.6	3.05
III " "	39	27	51	90	0	6	44.0	2.99
IV " "	39	01	46	120	0	6	41.5	2.95
V " "	38	35	40	150	0	6	39.1	2.91
VI " "	38	09	34	180	0	6	36.7	2.86
VII " "	37	43	28	210	0	6	34.3	2.82
VIII " "	37	17	22	240	0	6	32.1	2.78
Arizona Line	37	00	00	259.95	0	6	30.1	2.37

COLORADO BASE LINE,

Latitude of Initial Point, 33 deg. 51 min.;....Longitude, 114 deg. 29 min.

Meridian runs north 12 miles to Lat. 34 deg. 1 min. 27 sec.

Convergency, 0,97 chains.

Position of the Principal Lines of the U. S. Surv. in ARIZONA TER.
Initial Point, junct. of Salt & Gila rivers. Lat. 33° 22′ 57″, Long. 112° 15′ 46″

Surveys north of Gila and Salt River Base Line.

Parallel.	Latitude.			Distance.	Longitude per Range.			Converg.
	°	′	″	Miles.	°	′	″	Chains.
Initial Point	33	22	57	0	0	6	13.6	0 0
I Standard North	33	43	51	24	0	6	15.1	1.92
II " "	34	04	45	48	0	6	16.6	1.95
III " "	34	25	38	72	0	6	18.2	1.97
IV " "	34	46	32	96	0	6	19.8	2.00
V " "	35	07	25	120	0	6	21.4	2.02
VI " "	35	28	18	144	0	6	23.0	2.05
VII " "	35	49	12	168	0	6	24.7	2.08
VIII " "	36	10	05	192	0	6	26.4	2.10
IX " "	36	30	58	216	0	6	28.1	2.13
X " "	36	51	52	240	0	6	29.9	2.16
North Boundary	37	00	00	249.35	0	6	30.6	0.85

Surveys south of Gila and Salt River Base Line.

Parallel.	Latitude.			Distance.	Longitude per Range.			Converg.
	°	′	″	Miles.	°	′	″	Chains.
Initial Point	33	22	57	0	0	6	13.6	0 0
I Standard South	32	56	50	30	0	6	11.8	2·37
II " "	32	30	42	60	0	6	10.0	2.33
III " "	32	04	35	90	0	6	8.2	2.29
IV " "	31	38	27	120	0	6	6.5	2.26

Initial Point of Williametta Meridian, WASHINGTON TERRITORY.
Base Line, Lat. 45° 31′ 13″ North, Long. 122° 30′ 26″ W.

Parallel.	Latitude.			Distance.	Longitude per Range.			Converg.
	°	′	″	Miles.	°	′	″	Chains.
Initial Point	45	31	13	0	0	7	25.0	0 0
I Standard North	45	52	04	24	0	7	27.7	2.96
II " "	46	12	55	48	0	7	30.6	3.00
III " "	46	33	46	72	0	7	33.4	3.04
IV " "	46	54	37	96	0	7	36.3	3.07
V " "	47	15	28	120	0	7	39.3	3.11
VI " "	47	36	19	144	0	7	42.4	3.15
VII " "	47	57	09	168	0	7	45.4	3.19
VIII " "	48	18	00	192	0	7	48.6	3.23
IX " "	48	38	51	216	0	7	51.8	3.27
X " "	48	59	41	240	0	7	55.1	3.30

Position of the Principal Lines of the U.S. Surveys in MONTANA TER.
Initial Point, intersec. prin. base & mer., lat. 45°46′27 N.; Long. 111°27′14″W

Parallel.	Latitude.			Distance.	Longitude per Range.			Converg.
	°	′	″	Miles.	°	′	″	Chains.
Principal Base	45	46	27	0	0	7	27.8	0 0
I Standard North	46	07	15	24	0	7	28.2	3.01
II " "	46	28	03	48	0	7	28.5	3.03
III " "	46	48	51	72	0	7	28.8	3.06
IV " "	47	09	39	96	0	7	29.2	3.11
V " "	47	30	27	120	0	7	29.6	3.15
VI " "	47	51	15	144	0	7	29.9	3.19
VII " "	48	12	03	168	0	7	30.3	3.22
								Diverg.
I Standard South	45	20	27	30	0	7	27.3	3.71
II " "	44	54	27	60	0	7	27.8	3.67

TABLES.

Position of the Principal Lines of the U. S. Surveys in the STATE OF OREGON.

Initial Point, intersection of Willamette meridian and base line,

Lat. 45° 31′ 13″ North; Long. 122° 30′ 26″ West,

Surveys north of the Willamette Base Line.

Parallel.	Latitude.			Distance	Longitude per Range.			Converg.
	°	′	″	Miles.	°	′	″	Chains.
Willamette Base Line.....	45	31	13	0	0	7	25.0	0 0
I Standard North.....	45	52	04	24	0	7	27.7	2.96
II " "	46	07	42	42	0	7	29.8	2.25

Surveys south of the Willamette Base Line.

	°	′	″	Mlies.	°	′	″	Chains.
Willamette Base Line.....	45	31	13	0	0	7	25.0	0 0
I Standard South.....	45	05	09	30	0	7	21.6	3.62
II " "	44	39	05	60	0	7	18.3	3.59
III " "	44	23	26	78	0	7	16.3	2.15
IV " "	43	57	22	108	0	7	13.1	3.51
V " "	43	36	30	132	0	7	10.6	2.76
VI " "	43	10	26	162	0	7	07.7	3.41
VII " "	42	44	21	192	0	7	04.6	3.38
VIII " "	42	28	42	210	0	7	02.8	2.00
IX " "	42	07	50	234	0	7	00.4	2.63
North Bound. of Calif'a..	42	00	00	243	0	6	59.5	0.99

ACKNOWLEDGEMENTS.

In the Compilation of this little work I am indebted for information to

Honorable THEOD. WAGNER....U.S, Surveyor-Gen'l for California.
" E. S. DAVIS........... " " " Nevada.
" FRED'K SALOMAN... " " " Utah Ter.
" JOHN WASSON........ " " " Arizona Ter.
" WM. McMICKEN...... " " " Washington T
" R. H. MASON.......... " " " Montana Ter

And herewith I tender my sincere thanks for the interest which the above named U.S. Surveyor-Generals have taken in furnishing me so promptly with the required notes of the different principal Initial Points of the United States Public Land Survey on this Coast.

Very respectfully,

W. SCHMOLZ.

TABLES OF GRADES,

Per Mile and per 100 Feet, measured horizontally and corresponding to different Angles of Elevation.

° ′	Feet per mile.	Feet per 100 ft.	° ′	Feet per mile.	Feet per 100 ft.	° ′	Feet per mile.	Feet per 100 ft.	° ′	Feet per mile.	Feet per 100 ft.
	1.	0.01894	0 18	27.64	0.5237		54.	1.02273		81.	1.53409
0 1	1.536	0.02091		28.	0.53030		55.	1.04167	0 53	81.40	1.5419
	2.	0.03788		29.	0.54924	0 36	55.30	1.0472		82.	1.55303
	3.	0.05682	0 19	29.17	0.5528		56.	1.06061	0 54	82.94	1.5710
0 2	3.072	0.0582		30.	0.56818	0 37	56.83	1.0763		83.	1.57197
	4.	0.07576	0 20	30.72	0.5818		57.	1.07955		84.	1.59091
0 3	4.608	0.0873		31.	0.58712		58.	1.09848	0 55	84.47	1.6000
	5.	0.09470		32.	0.60606	0 38	58.37	1.1054		85.	1.60985
	6.	0.11364	0 21	32.26	0.6109		59.	1.11742		86.	1.62879
0 4	6.144	0.1164		33.	0.62500	0 39	59.90	1.1345	0 56	86.01	1.6291
	7.	0.13258	0 22	33.80	0.6400		60.	1.13636		87.	1.64773
0 5	7.680	0.1455		34.	0.64394		61.	1.15530	0 57	87.54	1.6583
	8.	0.15152		35.	0.66288	0 40	61.44	1.1636		88.	1.66666
	9.	0.17045	0 23	35.33	0.6691		62.	1.17424		89.	1.68561
0 6	9.216	0.1746		36.	0.68182	0 41	62.97	1.1927	0 58	89.08	1.6873
	10.	0.18939	0 24	36.86	0.6982		63.	1.19318		90.	1.70455
0 7	10.75	0.2037		37.	0.70076		64.	1.21212	0 59	90.62	1 7164
	11.	0.20833		38.	0.71970	0 42	64.51	1.2218		91.	1.72348
	12.	0.22727	0 25	38.40	0.7273		65.	1.23106		92.	1.74242
0 8	12.29	0.2328		39.	0.73864		66.	1.25000	1 0	92.16	1.7455
	13.	0.24621	0 26	39.94	0.7564	0 43	66.04	1.2509		93.	1.76136
0 9	13.82	0.2619		40.	0.75758		67.	1.26894		94.	1.78030
	14.	0.26515		41.	0.77652	0 44	67.57	1.2800		95.	1.79924
	15.	0.28409	0 27	41.47	0.7855		68.	1.28788	1 2	95.23	1.8038
0 10	15.36	0.2909		42.	0.79545		69.	1.30682		96.	1.81818
	16.	0.30303		43.	0.81439	0 45	69.11	1.3090		97.	1.83712
0 11	16.90	0.3200	0 28	43.01	0.8146		70.	1.32576		98.	1.85606
	17.	0.32197		44.	0.83333	0 46	70.64	1.3381	1 4	98.30	1.8620
	18.	0.34091	0 29	44.54	0.8436		71.	1.34470		99.	1.87500
0 12	18.43	0.3491		45.	0.85227		72.	1.36364		100.	1.89394
	19.	0.35985		46.	0.87121	0 47	72.18	1.3672		101.	1.91288
0 13	19.96	0.3782	0 30	46.08	0.8727		73.	1.38258	1 06	101.4	1.9202
	20.	0.37879		47.	0.89015	0 48	73.72	1.3963		102.	1.93182
	21.	0.39773	0 31	47.62	0.9018		74.	1.40152		103.	1.95076
0 14	21.50	0.4073		48.	0.90909		75.	1.42045		104.	1.96969
	22.	0.41667		49.	0.92803	0 49	75.26	1.4254		147.	2.78409
	23.	0.43561	0 32	49.16	0.9309		76.	1.43939	1 36	147.4	2.7932
0 15	23.04	0.4364		50.	0.94697	0 50	76.80	1.4545		148.	2.80303
	24.	0.45455	0 33	50.69	0.9600		77.	1.45833		149.	2.82197
0 16	24.58	0.4655		51.	0.96591		78.	1.47727		150.	2.84091
	25.	0.47348		52.	0.98485	0 51	78.33	1.4837	1 38	150.5	2.8514
	26.	0.49242	0 34	52.23	0.9891		79.	1.49621		151.	2.85985
0 17	26.11	0.4946		53.	1.00379	0 52	79.87	1.5128		152.	2.87879
	27.	0.51136	0 35	53.76	1.0182		80.	1.51515	1 40	153.6	2.9097

TABLE OF
RADII, MIDDLE ORDINATES, &c., OF CURVES.

CHORD 100 FEET.

☞ The Tangential Angle is always one-half of the Angle of Deflection.

Angle of Deflec.	Radii in feet.	Deflec. distance, in ft.	Tang. dist. in feet.	Mid. Ordin.	Angle of Deflec.	Radii in feet.	Deflec. dist. in feet.	Tang. dist. in feet.	Mid. Ordin.
° ′					° ′				
1	343775	.029	.014	.004	2 6	2729	3.665	1.832	.458
2	171887	.058	.029	.008	" 12	2604	3.839	1.919	.480
4	85944	.116	.058	.014	" 18	2491	4.014	2.007	.502
6	57296	.174	.087	.022	" 24	2387	4.188	2.094	.523
8	42972	.232	.116	.028	" 30	2292	4.363	2.182	.545
10	34378	.291	.145	.036	" 36	2204	4.538	2.269	.567
12	28648	.349	.174	.043	" 42	2122	4.712	2.356	.589
14	24556	.407	.203	.050	" 48	2046	4.886	2.443	.611
16	21485	.465	.232	.058	" 54	1976	5.060	2.530	.632
18	19098	.523	.261	.065	3 0	1910	5.235	2.618	.654
20	17189	.581	.290	.073	" 15	1763	5.666	2.836	.710
22	15627	.639	.319	.080	" 30	1637	6.108	3.054	.764
24	14324	.697	.348	.087	" 45	1528	6.544	3.272	.818
26	13222	.756	.378	.095	4 0	1433	6.980	3.490	.873
28	12278	.814	.407	.102	" 15	1348	7.416	3.708	.927
30	11459	.872	.436	.109	" 30	1274	7.853	3.927	.981
32	10743	.930	.465	.116	" 45	1207	8.289	4.145	1.036
34	10111	.988	.494	.123	5 0	1146	8.722	4.361	1.091
36	9549	1.046	.523	.131	" 15	1092	9.159	4.579	1.146
38	9046	1.104	.552	.138	" 30	1042	9.595	4.798	1.200
40	8594	1.162	.581	.145	" 45	996.8	10.03	5.015	1.255
42	8185	1.221	.610	.152	6 0	955.4	10.47	5.235	1.309
44	7814	1.279	.639	.159	" 15	917.0	10.90	5.450	1.364
46	7474	1.337	.668	.167	" 30	882.0	11·34	5.670	1.419
48	7162	1.395	.697	.174	" 45	849.3	11·78	5.890	1.473
50	6876	1.453	.726	.182	7 0	819.0	12.21	6.105	1.528
52	6611	1.511	.755	.189	" 15	790.8	12.64	6.320	1.582
54	6367	1.569	.784	.197	" 30	764.5	13.08	6.540	1.637
56	6139	1.627	.813	.204	" 45	739.9	13.51	6.755	1.692
58	5928	1.685	.842	.211	8 0	716.8	13.95	6.975	1.746
1 0	5730	1.745	.872	.218	" 15	695.1	14.38	7.190	1.801
" 4	5372	1.860	.930	.232	" 30	674.6	14.81	7.405	1.855
" 8	5056	1.976	.988	.246	" 45	655.5	15.25	7.625	1.910
" 12	4775	2.094	1.047	.261	9 0	637.3	15.68	7.840	1.965
" 16	4524	2.210	1.105	.275	" 15	620.2	16.12	8.060	2.019
" 20	4298	2.326	1.163	.290	" 30	603.8	16.55	8.275	2.074
" 24	4093	2.443	1.221	.306	" 45	588.4	16.99	8.495	2.128
" 28	3907	2.559	1.279	.320	10 0	573.7	17.43	8.715	2.183
" 32	3737	2.676	1.338	.334	" 15	559.7	17.87	8.935	2.238
" 36	3581	2.793	1.396	.349	" 30	546.4	18.30	9.150	2.292
" 40	3438	2.908	1.454	.364	" 45	533.8	18.73	9.365	2.347
" 44	3306	3.025	1.512	.378	11 0	521.7	19.17	9.585	2·401
" 48	3183	3.141	1.570	.393	" 15	510.1	19.61	9.805	2.456
" 52	3069	3.258	1.629	.407	" 30	499.1	20.05	10.03	2.511
" 56	2964	3.374	1.687	.422	" 45	488.5	20.50	10.25	2.566
2 0	2865	3.490	1.745	.436	12 0	478.3	20.94	10.47	2.620

TABLE.

TEMPERATURE OF BOILING WATER

Corresponding to the Height of Barometer and Altitude above Sea Level.

Thermo.	Baro.	Alti.	Thermo.	Baro.	Alti.	Thermo.	Baro.	Alti.
Deg.	inch.	feet.	Deg.	inch.	feet.	Deg.	inch.	feet.
184.0	16.79	15221	194.0	20.82	9579	204.0	25.59	4169
.2	16.86	15112	.2	20.91	9466	.2	25.70	4057
.4	16.93	15003	.4	21.00	9353	.4	25.88	3945
.6	17.00	14895	.6	21.09	9241	.6	25.91	3344
.8	17.08	14772	.8	21.18	9130	.8	26.01	3742
185.0	17.16	14649	195.0	21.26	9031	205.0	26.11	3642
.2	17.23	14543	.2	21.35	8920	.2	26.22	3532
.4	17.31	14421	.4	21.44	8810	.4	26.33	3422
.6	17.38	14315	.6	21.53	8700	.6	26.43	3322
.8	17.46	14195	.8	21·62	8590	.8	26.54	3213
186.0	17.54	14075	196.0	21.71	8481	206.0	26.64	3115
.2	17.62	13956	.2	21.81	8361	.2	26.75	3007
.4	17.70	13837	.4	21.90	8253	.4	26.86	2899
·6	17.78	13718	.6	21·99	8145	·6	26.97	2792
.8	17.86	13601	.8	22.08	8038	.8	27.08	2685
187.0	17.93	13498	197.0	22.17	7932	207.0	27.18	2589
.2	18.00	13396	.2	22.27	7814	.2	27.29	2483
.4	18.08	13280	.4	22.36	7708	.4	27.40	2377
.6	18.16	13164	.6	22.45	7602	.6	27.51	2272
.8	18.24	13049	.8	22.54	7498	.8	27.62	2167
188.0	18.32	12934	198.0	22.64	7381	208.0	27.73	2063
·2	18.40	12820	.2	22.74	7266	.2	27.84	1959
.4	18.48	12706	.4	22.84	7151	.4	27.95	1856
.6	18.56	12593	.6	22.93	7048	.6	28.06	1753
.8	18.64	12480	.8	23.02	6945	.8	28.17	1650
189.0	18.72	12367	199.0	23.11	6843	209.0	28.29	1539
.2	18.80	12256	.2	23.21	6729	.2	28.40	1437
.4	18.88	12144	.4	23.31	6617	.4	28.51	1336
.6	18.96	12033	.6	23.40	6516	.6	28.62	1235
.8	19.04	11923	.8	23.49	6415	.8	28.73	1134
190.0	19.13	11799	200.0	23.59	6304	210.0	28.85	1025
.2	19.21	11690	.2	23.69	6193	.2	28.97	916
.4	19.29	11581	.4	23.79	6082	.4	29.09	808
.6	19.37	11472	.6	23.89	5972	.6	29.20	709
.8	19.45	11364	.8	23.98	5874	.8	29.31	610
191.0	19.54	11243	201.0	24.08	5764	211.0	29.42	512
.2	19.62	11136	.2	24.18	5656	.2	29.54	405
.4	19.70	11029	.4	24.28	5547	.4	29.65	308
.6	19.78	10923	.6	24.38	5440	.6	29.77	202
.8	19.87	10804	.8	24.48	5332	.8	29.88	105
192.0	19.96	10685	202.0	24.58	5225	212.0	30.00	sea level.
.2	20.05	10567	.2	24.68	5119	below	sea	level.
.4	20.14	10450	.4	24.78	5013	.2	30.12	– 104
.6	20.22	10346	.6	24.88	4907	.4	30.24	– 206
.8	20.31	10230	·8	24.98	4802	.6	30.35	– 304
						.8	30·47	– 405
193.0	20.39	10127	203.0	25.08	4697			
.2	20.48	10011	·2	25.18	4593	213.0	30.59	– 512
.4	20.57	9896	.4	25.28	4489	.2	30.71	– 613
.6	20.65	9794	.6	25.38	4386	.4	30.82	– 714
·8	20.73	9693	.8	25.49	4272	.6	30.93	– 813

TABLE.

THERMOMETERS.

Corresponding Temperatures by the Fahrenheit, Centigrade and Reaumur Scales.

Fahren.	Centi.	Reau.	Fahren.	Centi.	Reau.	Fahren.	Centi.	Reau.
Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
212	100.0	80.0	128	53.3	42.6	44	6.7	5.3
210	98.9	79.1	126.	52.2	41.7	42	5.5	4.4
208	97.8	78.2	124	51.1	40.8	40	4.4	3.5
206	96.7	77.3	122	50.0	40.0	38	3.3	2.6
204	95.6	76.4	120	48.9	39.1	36	2.2	1.7
202	94.4	75.5	118	47.8	38.2	34	1.1	0.8
200	93.3	74.6	116	46.7	37.3	32	0.0	.0
198	92.2	73.7	114	45.6	36.4	30	– 1.1	– 0.8
196	91.1	72.9	112	44.4	35.5	28	2.2	1.7
194	90.0	72.0	110	43.3	34.6	26	3.3	2.6
192	88.9	71.1	108	42.2	33.7	24	4.4	3.5
190	87.8	70.2	106	41.1	32.8	22	5.5	4.4
188	86.7	69.3	104	40.0	32.0	20	– 6.7	– 5.3
186	85.6	68.4	102	38.9	31.1	18	7.7	6.1
184	84.4	67.5	100	37.8	30.2	16	8.9	7.3
182	83.3	66.6	98	36.7	29.3	14	10.0	8.0
180	82.2	65.7	96	35.6	28.4	12	11.1	8.8
178	81.1	64.9	94	34.4	27.5	10	12.2	9.7
176	80.0	64.0	92	33.3	26.6	8	– 13.3	–10.6
174	78.9	63.1	90	32.2	25.7	6	14.4	11.5
172	77.8	62.2	88	31.1	24.8	4	15.5	12.4
170	76.7	61.3	86	30.0	24.0	2	16.7	13.2
167	75.0	60.0	84	28.9	23.1	– 0	17.7	14.1
166	74.4	59.5	82	27.7	22.1	2	18.9	15.1
164	73.3	58.6	80	26.6	21.2	– 4	– 20.0	–16.0
162	72.2	57.7	78	25.5	20.4	6	21.1	16.8
160	71.1	56.8	77	25.0	20.0	8	22.2	17.7
158	70·0	56.0	74	23.3	18.6	10	23.3	18.6
156	68.9	55.1	72	22.2	17.7	12	24.4	19.5
154	67.8	54.2	70	21.1	16.8	14	25.5	20.4
152	66.7	53.3	68	20.0	16.0	16	– 26.7	–21.2
150	65.6	52.4	66	18.9	15.1	18	27.7	22.1
148	64.4	51.5	64	17.7	14.1	20	28.9	23.1
146	63.3	50.6	62	16.6	13.2	22	30.0	24.0
144	62.2	49.7	60	15.5	12.4	24	31.1	24.8
142	61.1	48.8	58	14.4	11.5	26	32.2	25.7
140	60.0	48.0	56	13.3	10.6	- 28	– 33.3	–26.6
138	58.9	47.1	54	12.2	9.7	30	34.4	27.5
136	57.8	46.2	52	11.1	8.8	32	35.6	28.4
134	56.7	45.3	50	10.0	8.0	34	36.7	29.3
132	55.6	44.4	48	8.9	7.3	36	37.8	30.2
130	54.4	43.5	46	7.7	6.1	38	38.9	31.1

Equivalents of Lineal Measures.

Inches.	Links.	Feet.	Varas.	Yards.	Chains.	Miles.	Sp' Lea.	Eng. Lea.
1	0.126263	0.083333	0.029965	0.027778	0.001263	0.000016	0.000006	0.000005
7.92	1	0.66	0.237325	0.22	0.01	0.000125	0.000047	0.000042
12	1.515152	1	0.359583	0.333333	0.015152	0.000189	0.000072	0.000063
33.372	4.213636	2.781	1	0.927	0.042136	0.000527	0.0002	0.000176
36	4.545455	3	1.078749	1	0.045455	0.000568	0.000216	0.000189
792	100	66	23.73247	22	1	0.0125	0.004746	0.004167
63360	8000	5280	1898.598	1760	80	1	0.379720	0.333333
166860	21068.18	13905	5000	4635	210.6818	2.633523	1	0.877841
190080	24000	15840	5695.793	5280	240	3	1.139159	1

Equivalents of Square Measures.

Varas.	Yards.	Chains.	Acres.	Miles.	Sp. League	Eng. Lea.
1	0.859329	0.00177547	0.00017755	0.00000028	0.00000004	0.00000003
1.16369865	1	0.00206612	0.00020661	0.00000032	0.00000005	0.00000004
563.230148	484	1	0.1	0.00015625	0.00002253	0.00001736
5632.30148	4840	10	1	0.0015625	0.00022533	0.00017361
3604672.95	3097600	6400	640	1	0.14418692	0.11111111
25000000	21483225	44386.8285	4438.68285	6.93544195	1	0.77060466
32442056.5	27878400	57600	5760	9	1.29768226	1

French Units of Weights and Measures, &c.

Metre.	Gramme.	Litre.
Measures of Length.	**Weights.**	**Measures of Volume.**
Myriametre....10000 meters	Millier ....1000000 Grammes	Kilolitre ....1000 litres
Kilometre...... 1000 "	Quintal.... 100000 "	Hectolitre......... 100 "
Hectometre.... 100 "	Myriagram' 10000 "	Decalitre.......... 10 "
Dekametre..... 10 "	Kilogram'.. 1000 "	Litre.............. 1 "
Metre.......... 1 "	Hectogram' 100 "	Decilitre ....one-tenth "
Decimetre... one-tenth "	Dekagram'. 10 "	Centillitre....one 100th "
Centimetre...one 100th "	Gramme... 1 "	Millilitre ....one 1000th "
Millimetre..one 1000th "	Decigram'.one-tenth "	1 Fluid Dr'm.,0,0036967 "
1 Kilometre ....3280.833 feet	Centigram.one 100th "	1 Fl. Ounce...0.0295739 "
1 Hectometre....328.083 feet	Milligram'.one 1000th "	1 Fl. Pound.0.35483656 "
Measure of Surface.	**Cubic Weight.**	**Cubic Measure.**
Hectare....10000 Sq. Meters	1 Cubic M...2204.6 lbs. A.D.	1 Cub.M. ..264.17 wine gal.
Hectare..........2.471 acres	1 Cub.Litre, 2.2046 " "	1 Cub. Litre.1.0567 wine gal.
Are.........119.6 Sq. Yards	1 Tonneau..1000000 gr'mmes	1 Cub.Millilitre 0.0154 grains

Equivalents Lineal Measures.

Inches.	Links.	Feet.	Yards.	Chains.	Miles.	Meters.
1	0.126263	0.083333	0.027778	0.001263	0.000016	0.02540005
7.92	1	0.66	0.22	0.01	0.000125	0.20116839
12	1.515152	1	0.333333	0.015152	0.000189	0.3048006
36	4.545455	3	1	0.045455	0.000568	0.9144018
792	100	66	22	1	0.0125	20.1168396
63360	8000	5280	1760	80	1	1609.347168
39.37	4.9710591	3.280899	1.093633	0.0497106	0.0006213	1

Equivalents of Square Measures.

Inches.	Feet.	Yards.	Chains.	Acres.	Meters.
1	0.0069444	0.0007716	0.0000016	0.00000016	0.000645161
144	1	0.333333	0.0002296	0.0000229	0.092903184
1296	9	1	0.00206612	0.00020661	0.836128656
627264	4356	484	1	0.1	404.671063
6272640	43560	4840	10	1	4046.71063
1550.0589477	10.7612982	1.1960331	0.0024711	0.00024711	1

Equivalents of Weights.

Grains.	Scruples.	Drachms.	Oz. Troy.	Oz. A.D.	P'd Troy.	P'd A.D.	Grammes
1	0.05	0.016666	0.002083	0.002285	0.000173	0.000142	0.648004
20	1	0.333333	0.041666	0.045714	0.003472	0.002857	1.296008
60	3	1	0.125	0.139215	0.010416	0.008571	3.888024
480	24	8	1	0.990295	0.083333	0.0685702	31.10419
437.5	21.875	7.18311	1.0098	1	0.075941	0.0625	28.35017
5760	288	96.00	12	13.168	1	0.822857	373.2502
7000	350	116.66	14.5833	16	1.215278	1	453.6028
15.43316	0.771658	0.257219	0.032151	0.035275	0.002679	0.002203	1

Equivalents of Liquid Measures.

Gills.	Pints.	Quarts.	Gallons.	Liters.	Cubic Inches.
1	0.25	0.125	0.03125	0.1182955	7.21875
4	1	0.50	0.125	0.4737821	28.875
8	2	1	0.25	0.9463642	57.75
32	8	4	1	3.7854579	231.
8.4524	2.1131	1.05656	0.2641407	1	61.0165

A standard avoirdupois pound is the weight of 27.7015 cubic inches of distilled water, weighed in air at a temperature of 39.83 Fahrenheit, barometer at 30 inches. A cubic inch of such water weighs 252.6037 grains.

A cubic foot contains 7.48052 gallons liquid measure. A gallon is equal to a cylinder of 7 inches in diameter and 6 inches high.

United States Gold Coins.

Denomination	Standard Weight. Grains.	Standard Weight. Troy Ounces.	Deviation Allowed.	Least Current Weight.
1 Double Eagle	516.00	1.075000	0.5 Grains.	513.42 Grains.
1 Eagle........	258.00	0.537500	0.5 "	256.71 "
1 Half Eagle ..	129.00	0.268750	0.25 "	128.36 "
1 Three Dollar.	77.40	0.161250	0.25 "	77.02 "
1 Quarter Eagle	64.50	0.134375	0.25 "	64.18 "
1 Dollar.......	25.80	0.053750	0.25 "	25.67 "

United States Silver Coins.

Denomination.	Standard Weight. Grains.	Standard Weight. Troy Ounces.	Deviation Allowed.
1 Trade Dollar............	420.00	0.8750000	1.5 Grains.
1 Dollar..................	412.50	0.8593750	1.5 "
1 Half Dollar.............	192.90	0.4018750	1.5 "
1 Quarter Dollar..........	96.45	0.2009375	1.0 "
1 Dime....................	38.58	0.0803750	0.5 "
1 Half Dime...............	19.29	0.0401875	0.5 "

United States Standard Weight for
GOLD AND SILVER COINS.

Gold Coins.		Trade Dollars.		Silver Dollars.		Subsidiary Coins.	
$	Troy Ounces.	$	Troy Ounces.	$	Troy Ounces.	$	Troy Ounces.
20,000.	1075.000	1,000.	875.00	1,000.	859,37500	1,000	803.7500
15,000.	806.250	750.	656.25	750.	644.53125	500	401.8750
10,000.	537.500	500.	437.50	500.	429.68750	250	200.9375
5,000.	268.750	250.	218.75	250.	214.84375	100	80.3750
2,500.	134.375	100.	87.50	100.	85.93750	50	40.1875
1,000.	53.750	50.	43.75	50.	42.96875	10	8.0375

Mexican Weights.

12 granos.....	=	1 tomin.................	Equal..	9.2 grains Troy.
3 tomines ...	=	1 adarme	"	27.7 grains "
2 adarmes...	=	1 ochava or dracma.......	"	55.5 grains "
8 ochavas ...	=	1 onza..................	"	443.8 grains or 0,9245 oz. Troy.
8 onzas......	=	1 marco.................	"	3550.5 grains or 7,396 oz. Troy.
2 marcos	=	1 libra.................	"	7101. grains or 14,7937 oz. Troy.

TABLE

Of value of One Ounce troy, of different fineness.

GOLD.				SILVER.			
Fine.	Dols. Cts.	Fine.	Dols. Cts.	Fine.	Dols. Cts.	Fine.	Dols. Cts.
0	00.00	460	9 50.90	0	00.00	460	59.47
1	02.07	470	9 71.58	1	00.13	470	60.77
2	04·13	480	9 92.25	2	00.26	480	62.06
3	06.20	490	10 12.92	3	00.39	490	63.35
4	08.27	500	10 33.59	4	00.52	500	64.65
5	10.34	510	10 54.26	5	00.65	510	65.94
6	12.40	520	10 74.94	6	00.78	520	67.23
7	14.47	530	10 95.61	7	00.90	530	68·53
8	16.54	540	11 16.28	8	01.03	540	69.82
9	18.60	550	11 36.95	9	01.16	550	71.11
10	20.67	560	11 57.62	10	01.29	560	72.40
20	41.34	570	11 78.29	20	02.59	570	73.69
30	62.02	580	11 98.97	30	03.88	580	74.99
40	82.69	590	12 19.64	40	05.17	590	76.28
50	1 03.36	600	12 40.31	50	06.46	600	77.58
60	1 24.03	610	12 60.98	60	07.76	610	78.87
70	1 44.70	620	12 81.65	70	09.05	620	80.16
80	1 65.37	630	13 02.33	80	10.34	630	81.45
90	1 86.05	640	13 23.00	90	11.64	640	82.75
100	2 06.72	650	13 43.67	100	12.93	650	84.04
110	2 27.39	660	13 64.34	110	14.22	660	85.33
120	2 48.06	670	13 85.01	120	15.52	670	86.63
130	2 68.73	680	14 05.68	130	16.81	680	87.92
140	2 89.41	690	14 26·36	140	18.10	690	89.21
150	3 10.08	700	14 47.03	150	19.39	700	90.51
160	3 30.75	710	14 67.70	160	20.69	710	91.80
170	3 51.42	720	14 88.37	170	21.98	720	93.09
180	3 27.09	730	15 09.04	180	23.27	730	94.38
190	3 92.76	740	15 29.72	190	24.57	740	95.68
200	4 13.44	750	15 50.39	200	25.86	750	96.97
210	4 34.11	760	15 71.06	210	27.15	760	98.26
220	4 54.78	770	15 91.73	220	28.44	770	99.56
230	4 75.45	780	16 12.40	230	29.74	780	1 00.85
240	4 96.12	790	16 33.07	240	31.03	790	1 02.14
250	5 16.80	800	16 53.75	250	32.32	800	1 03.43
260	5 37.47	810	16 74.42	260	33.62	810	1 04.72
270	5 58.14	820	16 95.09	270	34.91	820	1 06.02
280	5 78.81	830	17 15.76	280	36.20	830	1 07.31
290	5 99.48	840	17 36.43	290	37.49	840	1 08.61
300	6 20.16	850	17 57.11	300	38.79	850	1 09.90
310	6 40.83	860	17 77.78	310	40.08	860	1 11.19
320	6 61.50	870	17 98.45	320	41.37	870	1 12.48
330	6 82.17	880	18 19.12	330	42.67	880	1 13.78
340	7 02.84	890	18 39.79	340	43.96	890	1 15.07
350	7 23·51	900	18 60.46	350	45.25	900	1 16.36
360	7 44.19	910	18 81.14	360	46.55	910	1 17.66
370	7 64.86	920	19 01.81	370	47.84	920	1 18.95
380	7 85.53	930	19 22.48	380	49.13	930	1 20.24
390	8 06.20	940	19 43.15	390	50.42	940	1 21.54
400	8 26.87	950	19 63.82	400	51.72	950	1 22.83
410	8 47.55	960	19 84.50	410	53.01	960	1 24.12
420	8 68.22	970	20 05.17	420	54.30	970	1 25.41
430	8 88.89	980	20 25.84	430	55.60	980	1 26.71
440	9 09.56	990	20 46.51	440	56.89	990	1 28.00
450	9 30.23	1000	20 67.13	450	5[illegible].13	1000	1 29.29

A CARD.

Sir :

Should you desire to have a Solar Reflector attached to your transit instrument, the eye-piece cap and the object-glass cap must be forwarded to me. Before taking the eye-piece cap off from the eye-piece, please screw it on tight, and scratch a perpendicular line with a knife over the front face of the cap, and mark the top of the line with a cross, as shown in the annexed engraving.

The price of a Solar Reflector is $20.00.

For the last thirty years the undersigned has been established in San Francisco ; and in that long period of time became personally acquainted with hundreds of surveyors and engineers. A few in that large number will criticise the invention, and may not feel inclined to use the new method till they are more familiar with the motion of our globe, and fully understand and study the astronomical fundamental law, and get acquainted with the principle by which the Reflector produces an accurate result. The more enlightened class of surveyors will readily appreciate the invention after a short examination—and they will have the benefit of getting a good night's rest after their hard day's work, as no observation of Polaris will be necessary to establish the meridian. Besides, by establishing the true meridian in day-time, and directly on the line of their survey, instead of doing it in camp (which may be several miles distant from the field of operation), they will have the assurance of more correct work.

This plain and entirely mechanical apparatus, which solves a complicated astronomical problem so readily and easily, will be in general use in a few years. Those using the Reflector will give the inventor due credit for spending six years of his life to bring this invention to perfection ; besides six months more in publishing the little book, and making daily observations with the Reflector, whenever the weather was favorable, to test the correctness of the tables.

*** Repairs of every description of Surveying instruments executed in a workmanlike manner, at moderate charges, by

Yours respectfully,

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