TABLES

FOR

DETERMINING TIME TO THE NEAREST MINUTE,

APPLICABLE TO THE

MADRAS PRESIDENCY

AND THE

SOUTHERN PARTS OF BOMBAY;

TO WHICH ARE ADDED

GENERAL TABLES FOR THE SAME PURPOSE

ADAPTED TO THE WHOLE OF BRITISH INDIA;

TOGETHER WITH AN APPENDIX

CONTAINING THE PRINCIPLES OF DIALLING

AND OTHER USEFUL PARTICULARS.

BY WILLIAM GRANT,

ASSIST. REVENUE SURVEYOR D.P.W.

MADRAS:

PRINTED BY J. WRIGHT, AT THE COMMERCIAL

ADVERTISER PRESS,

1848.

TABLES

FOR

DETERMINING TIME TO THE NEAREST MINUTE,

APPLICABLE TO THE

MADRAS PRESIDENCY

AND THE

SOUTHERN PARTS OF BOMBAY;

TO WHICH ARE ADDED

GENERAL TABLES FOR THE SAME PURPOSE

ADAPTED TO THE WHOLE OF BRITISH INDIA;

TOGETHER WITH AN APPENDIX

CONTAINING THE PRINCIPLES OF DIALLING

AND OTHER USEFUL PARTICULARS.

BY WILLIAM GRANT,

ASSIST. REVENUE SURVEYOR D.P.W.

MADRAS:

PRINTED BY J. WRIGHT, AT THE COMMERCIAL

ADVERTISER PRESS,

1848.

PREFACE.

The work now submitted to the judgment of the Public has for its object the determination of time, at day or night, within limits sufficiently accurate for all common purposes, and by means so simple and easy as to be attainable by persons of every description.

The writer was led to this undertaking some years ago by the extreme difficulty which exists in this Country in procuring Sun-dials, or other instruments by which the data necessary for calculating time may be obtained; and although he cannot flatter himself that he has entirely succeeded in his endeavours, he has still reason to believe that as far as universal dials are concerned, the Tables now submitted to public notice, will, in a great measure, supersede the use of them, both in point of accuracy and the facility with which time may be determined.

In a work of this nature, it is not to be expected that the theoretical principles on which it is founded can be rendered very plain and intelligible to those unacquainted with the elements of Astronomy and Mathematics, but the writer has endeavoured to state them as clearly as possible consistently with the nature and limits of the work, and he hopes that the practical and most useful part of the various rules, will be easily understood and applied even by persons of the lowest capacity.

The primary object of the Tables being the regulation of watches, great care has been bestowed in rendering them accurate and free from typographical errors. The writer however, regrets to state that notwithstanding the utmost exertions made in this respect, a few errors of the latter description have crept into the work, which are given in a table of Errata, and may be easily rectified.

W. G.

ERRATA.

Page 7, line 2. Dele the quotation marks.

„ — „ 8 from bottom. For *measuremsnt* read *measurement.*

„ 12, last line. *For* 8h. 30$\frac{1}{3}$m. and 3h. 9$\frac{2}{3}$m. *read* 8h. 33$\frac{2}{3}$m. and 3h. 6$\frac{1}{3}$m. respectively.

" 13, lines 5 and 9. For 2h. 12m. read 2h. 2m.

„ 34, line 7. For *characters* read *character.*

„ 36, „ 4 from bottom. For *on* read *or.*

„ — „ 2 from do. For *latitudes* read *latitude.*

„ 43, „ 18. For *ascending* read *equinoctial,*—the point referred to being the intersection of the Moon's orbit with the equinoctial.

„ 51, in N. B. For *above* Table, read *second* Table.

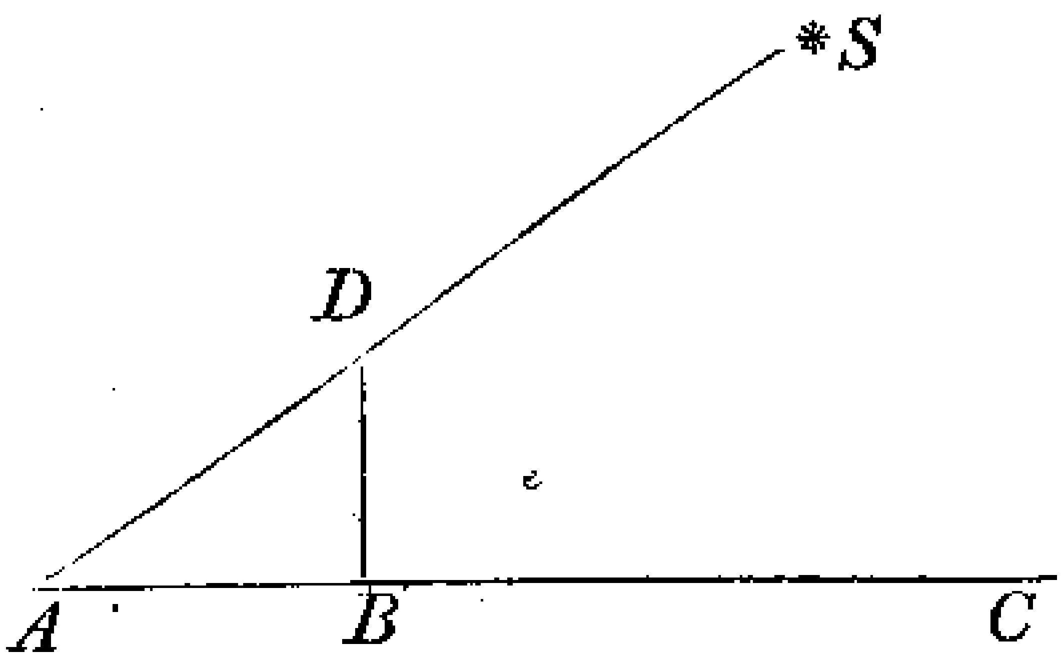
„ 79. Alter the list of places so as to correspond with that at page 81.

„ 96. Opposite to 3f. 6in., in column headed Mar. 23 to Mar. 25, for 27 read 37.

CONSTRUCTION AND USE OF THE TABLES.

The astronomical problem for the determination of Time requires, as is well known, three elements for its solution, viz. the latitude of a place, and the declination and altitude of the celestial body which is the object of our observation. Two of these elements, viz. the latitude and declination, are always known; the former, by being an invariable quantity, and the latter, either by its being constant, or variable within certain limits, or by its being capable of determination by calculation. The third element, viz. the altitude can be deduced from observation only, and the simplest method of doing this, is by the following process which is sufficiently correct for most ordinary purposes.

Let ABC be a horizontal plane, and S the place of the Sun or Moon, then, holding a rod DB perpendicularly on the level surface at B,



it is obvious that its shadow will be projected to the point A, which is in the same line with D and S. But ABD being a right-angled triangle, BD is the tangent of the angle BAD to radius AB; whence $\frac{BD}{AB}$; is the trigonometrical tangent of the angle BAD, which represents the altitude of the luminary S. Hence the altitude may be easily ascertained.

Now let A represent the altitude of any celestial body thus determined, D its declination, and L the latitude of the place where the observation is made ; then, since the co-latitude of the place and the polar and zenith distances of the luminary, form a spherical triangle, having the angle which represents the distance of the object from the meridian, opposite to the zenith distance, we have,

$$\text{Cos. Mer. Dis.} = \frac{\text{cos. Zen. Dis.} - \text{cos. Co-lat.} \times \text{cos. Pol. Dis.}}{\text{sin. Co-lat.} \times \text{sin. Pol. Dis.}}$$

Or, substituting h for the meridional distance in angular measure, and P for the Polar distance,

$$\cos. h = \frac{\sin. A - \sin. L. \cos. P}{\cos. L. \sin. P};$$

$$\text{But } 2 \sin.^2 \frac{h}{2} = 1 - \cos. h.$$

$$\therefore \quad 2 \sin.^2 \frac{h}{2} = 1 - \frac{\sin. A - \sin. L. \cos. P}{\cos. L. \sin. P}$$

$$= \frac{\cos. L. \sin. P + \sin. L. \cos. P - \sin. A}{\cos. L. \sin. P}$$

$$= \frac{\sin. (P+L) - \sin. A}{\cos. L. \sin. P}$$

$$= \frac{2}{\cos. L. \sin. P} \left\{ \cos. \tfrac{1}{2}(P+L+A). \sin. \tfrac{1}{2}(P+L-A) \right\}.$$

and in logarithms,

$$2 \log. \sin. \frac{h}{2} = 20 + \log. \cos. \tfrac{1}{2}(P+L+A)$$

$$+ \log. \sin \tfrac{1}{2}(P+L-A) - \log. \cos. L. - \log. \sin. P.$$

2. The above is the formula usually given in astronomical works for the determination of h, but the operations it

involves are tedious, and bring out the results with a precision altogether superfluous for the purposes intended by the accompanying Tables. We shall therefore proceed to investigate another formula, which, though wanting in general utility, is, nevertheless, in our particular case, of more easy application, and equally correct in its results.

Reverting to the expression,

$$\cos. h = \frac{\sin. A - \sin. L. \cos. P}{\cos. L. \sin. P};$$

and, dividing the numerator by the denominator, we have,

$$\cos. h = \sin. A. \sec. L. \text{cosec}. P - \tan L. \text{cotan}. P,$$

Or, substituting for P, its equivalent $90° \mp D$,

$$\cos. h = \sin. A. \sec. L. \sec. D \mp \tan. L. \tan. D,$$

where the upper or lower sign is to be used, according as the declination and latitude are of the same or different names.

3. This is the formula by which the accompanying Tables have been computed; and although it is not adapted to logarithmic calculation, yet by the aid of subsidiary Tables showing the values of its terms for every degree of latitude and declination, it will be found to afford facilities of calculation, not easily attainable by any other formula.

4. The original computations by means of the above expression for cos. h, were made for every degree of latitude and declination, and for the altitudes corresponding to every second term of the tabulated shadow. The results of these computations were obtained to the nearest *tenth* of a minute, and interpolated with *second differences*; and when any of the intermediate quantities did not appear to be sufficiently accurate, they were rectified by independent calculation.

5. The apparent altitudes, deduced from the measured

shadow were corrected for *refraction,* before the formula was applied, but the effect of *parallax* has been disregarded, not only because it varies with every celestial body, but also because it is of a perceptible amount only in the case of the Moon, and it will be shown hereafter how the shadow measured in Moonlight, should be corrected, to obtain that which corresponds to the true altitude of the planet.

6. The manner in which the results of the preceding calculations, and the elements necessary for their determination, have been arranged in the accompanying Tables, is so obvious, as to require only a very brief explanation.

7. Each table, it will be seen, contains two double-pages having the latitude for which it is computed marked at the top, and the principal places to which it is applicable at the bottom of the pages. Although from the circumstance of the Tables being intended expressly for the southern part of India, we have inserted therein only such places as are to be found in the Madras and Bombay Presidencies, yet it is obvious that the table may be used at any place in the northern hemisphere of the globe situated on the same parallel of latitude; and likewise in the southern hemisphere, by merely changing the word north for south, and south for north, and altering the other parts of the table accordingly.

8. In the first vertical column of each double-page, is given the length of the shadow of a rod of 4 feet from 1f. 6in. to 20 feet, which comprehends all altitudes, from 11° 19' to 69° 27'.

9. The third argument, viz. the declination is inserted in the lowest horizontal column of the Tables, accompanied by one of the suffixes + or −, the former of which denotes north, and the latter south, declinations. Corresponding to these de-

clinations, and in the first and second horizontal columns,(1) are inserted the two periods (2) of the year, during which each vertical column may be used, in ordinary cases, for the determination of time by the Sun. The two days by which these periods are limited, answer respectively to the Solar declinations which form the means between every tabulated degree, and the next preceding and succeeding one. Hence the days which correspond exactly to the declinations inserted in the lowest horizontal column, are situated nearly in the centre of the above periods, in those cases where the declinations are in arithmetical progression, while in others, their situation corresponds to the situation of the declinations between the means to which the limiting days answer. Thus, in the two periods which answer to 5° South declination, the limiting days March 9th. and October 5th, answer to the declination nearest to 4½° on the side of the above declination, and the days March 7th, and October 7th, answer in like manner, to the declination nearest to 5½°. Again as the period in the first horizontal column contains 3 days, and the declination 5° is equally distant from the next preceding and succeeding declination, the day answering to it, is nearly in the centre of the above period, and is therefore about the 8th. of March.

So, in the two periods which correspond to 11° North declination in the table for 15° N. latitude, the days April 17th. and August 27th. answer to 10°, and the days April 25th. and August 20th. answer to 13°, on the side of 11°; and, as the declination in question is situated nearer to 9°

(1) By the "first" horizontal column is meant that at the top of the Tables, and by the "second," the upper of the two horizontal columns at the foot of each Table.

(2) The periods are thus represented, Dec. 22 to Dec. 29; which means from Dec. 22d. to Dec. 29th.

than to 15°, the differences being in the proportion of 1 : 2, the days answering to it, are approximately the 20th of April, and the 24th of August.

10. In the body of each Table, are inserted the intervals in hours and minutes, between noon and the time of the observation of the shadow; the hours being marked on the left hand side, and the minutes on the right hand side of each vertical column. To avoid a multiplicity of figures, the *hours* have been omitted wherever their repetition would be unnecessary; and it is to be observed that in all such cases, the number of hours marked immediately *above* or *below* the vacant places, is understood. Thus, in the second vertical column of the Table for 15° North latitude, and in correspondence to $8^{f.}$ $4^{in.}$ in the first page, we find only 31 minutes, which stands for 3^h 31^m; and in the third vertical column of the same page opposite to $5^{f.}$ $2^{in.}$ we find 27 minutes, standing for 2^h 27^m.

11. Since the quantities inserted in the body of the Tables, represent the intervals between noon and the time of the observation of the shadow, it is evident that when the observation is made in the *afternoon*, the above quantities represent at once the time of the day; and that when it is made in the *forenoon*, they must be subtracted from 12 hours to obtain the time in ordinary reckoning—Thus, in the table for 13° North latitude, corresponding to $9^{f.}$ $4^{in.}$, we find in the second vertical column of the first page, the quantity 3^h 49^m. This would represent 49 minutes after 3 o'clock, if the observation of the shadow were made in the afternoon; but 3^h 49^m *to* 12 o'clock, if in the forenoon. In the latter case, therefore, the time would be 12^h less 3^h 49^m, or 8^h 11^m A. M. in ordinary reckoning. It is evident that in

order to avoid the compound subtraction, we might simply say, " 49 minutes *to* 9 o'clock ; the 9 o'clock in this case being obtained by mentally subtracting the tabulated hour 3 from 12 hours.

12. From the nature of the calculation by which the results embodied in the Tables, are obtained, it is evident that these results are strictly correct only to the latitudes marked at the top of the Tables, the declinations inserted in the lowest horizontal column, and the altitudes corresponding to the shadow in the first vertical column. These conditions, it is obvious, can but seldom exist together. Hence it becomes necessary to show, how the results in question may be modified so as to answer every possible change which can take place, in either one, or all, of the elements upon which they depend.

13. Before, however, we proceed to this part of the subject, it is important to observe, that as the elements of declination and latitude are generally known before hand, the accuracy of the result obtained in any practical case, depends materially upon a correct measurement of the shadow, which should therefore be performed with great care. The ground selected for this purpose should be the most level that can be obtained ; the rod(1) which is to be 4 feet long,(2) should be held between the thumb and forefinger, and be suspended above the ground for a few seconds until it rests in a perpendicular position by virtue of its own gravity. It should

(1) The rod should be cylindrical, being about one inch in diameter ; and should be made of teak, or some other heavy wood to resist the effects of slight currents of air. For facility of measuremsnt, it should also be graduated with feet and inches.

(2) We have fixed upon 4 feet, as the most convenient length for practical purposes, but it is obvious that the rod may be of any length whatever, though to render its shadow a proper argument for the Tables, it would be necessary to reduce it to the corresponding shadow of a rod of 4 feet, either by proportion, or by measuring it with a scale, of which the linear unit is the 48th part of the rod.

then be gently lowered, and at the instant it touches the ground, the shadow should be noted and measured.

14. On holding a rod in sunlight, it will be perceived that a circular penumbra is formed at the extremity of its shadow. This is caused by the rays which proceed from the upper and lower limbs of the sun and intersect one another at the top of the rod, the dark edge representing the position of those which proceed from the upper limb. When the sky is clear, and the sun considerably above the horizon, the extent of this shadow is not great, and the limits of it are so clearly defined that the distance of its centre from the foot of the rod may be easily measured to obtain the shadow which corresponds to the centre of the sun; but as this orb descends, the penumbra increases rapidly, attaining to about 12 inches when the dark shadow measures 20 feet, and its boundaries become so faint and indistinct, as to render it difficult to trace them clearly. Under these circumstances, the length of the dark shadow must be increased by a quantity, obtained by calculation and inserted in the subjoined table; and it is to be carefully borne in mind that this correction is always supposed to be made, before the result of any measurement can be applied practically.

TABLE.

Length of dark shadow.	Correction	Length of dark shadow.	Correction.	Length of dark shadow.	Correction.	Length of dark shadow.	Correction.
Feet.	In.	Feet.	In.	Feet.	In.	Feet.	In.
1	+0.2	6	+0.8	11	+1.9	16	+3.9
2	0.3	7	0.9	12	2.2	17	4.4
3	0.3	8	1.1	13	2.6	18	4.9
4	0.4	9	1.3	14	3.0	19	5.4
5	0.6	10	1.6	15	3.4	20	5.9

Rule I.

15. Having thus obtained the length of the shadow, look for it in the first column of the Table, which is headed by the latitude of the place, or by the degree nearest to it; then, in a line with that shadow, and in the vertical column adapted to the given day will be found the *true* or *apparent* interval between noon and the time of the observation.

Example 1.

In the forenoon of the 8th. of March, in latitude 15° N. I measured the shadow of a rod of 4 feet, and found it to be $3^{f.}\ 6^{in.}$. Required the time.

Turning over to the Table which has the 15th. degree of North latitude marked at the top, we find, in the horizontal line corresponding to $3^{f.}\ 6^{in.}$, and in the vertical column headed by the period March 7th. to March 9th, which includes the given day, the quantity $2^h\ 25^m$ for the interval between noon and the time of the observation; consequently, the time required is 25 minutes to 10 o'clock, or $9^h\ 35^m$ A. M. Had the observation been made in the afternoon, the time would have been simply $2^h\ 25^m$,(1) or 25 minutes past two.

Example 2.

At Madras, on the 17th. of November, I measured the shadow of a three-feet rod, and found it to be exactly $2\frac{1}{2}$ feet. Required the time.

Since the shadows of different rods taken at the same instant, are proportional to their lengths,

we have, $3 : 4 :: \frac{2\frac{1}{2} \times 4}{3} = 3\frac{1}{3}$ feet $= 3^{f.}\ 4^{in.}$, for the cor-

(1.) Both these times, and in fact, all the results of the succeeding examples until art. 19, require to be corrected by the Equation of time. The amount responding length of a four-feet rod. Therefore, turning to the table which has the 13th. degree of North latitude marked at the top, we find, in a line with $3^{f.}$ $4^{in.}$, and in the column containing the given day in the second horizontal column, the quantity 1^h 36^m, for the interval between noon and the time of the observation. Hence, the required time is either 36 minutes (1) to 11 o'clock A. M., or 1^h 36^m P. M.

Rule II.

16. When the length of the shadow(2) is not found exactly in the Tables, towards the latter part of which it increases successively by several inches, take the difference of the intervals corresponding to the next less and next greater tabular inch ; and find the proportional part of it due to the situation of the given shadow. Apply this correction to either of the above times, as the case may require, and the true interval will be obtained.

Example.

In the afternoon of the 11th. of December in latitude 16° North, I found the shadow to be $10^{f.}$ $4^{in.}$, when my watch indicated 51 minutes past 3 o'clock. Required the error of the watch.

The intervals corresponding on the given day to $10^{f.}$ and $10^{f.}$ $6^{in.}$ in the Table for 16° N. latitude, are 3^h 49^m and 3^h 54^m respectively, where a difference of 5 minutes

---

of this equation on the given day ascertained from the table in art. 28 is + 11 m. ; so that the mean time sought is either 9h. 46m. A. M. or 2h. 36m. P. M.

(1) The equation of time on the given day is —15 m. ; so that the corresponding mean time, or the time that would be shown by a well regulated clock, is either 10 h. 9 m. A. M., or 1 h. 21 m. P. M.

(2) Whenever this term is used absolutely, it is always intended to signify the shadow of a rod of 4 feet, answering to the centre of the sun, and obtained either by measuring to the centre of the penumbra, or by allowing for it as shown in art. 14.

is produced by a variation of 6 inches in the length of the shadow. Consequently we have the following proportion; as $6 : 4 :: 5 : \frac{5 \times 4}{6} = 3\frac{1}{3}$ minutes, which is the correction due to 4 inches. Hence $3^h\ 49^m + 3\frac{1}{3}^m = 3^h\ 52\frac{1}{3}^m$ is the time required,(1) and the watch having indicated only $3^h\ 51^m$, it was therefore $1\frac{1}{3}^m$ too slow.

17. It will be perceived that in laying down the preceding rules in articles (15) and (16), we have assumed that slight variations of declination and latitude cannot materially affect the results obtained from the Tables. This is not strictly true, but the deviations from accuracy are so small, that except for the single purpose of regulating watches, we may consider the rules as generally applicable. Even for this purpose, by measuring the shadow at times favorable for observation, the deviations of the corresponding results may be reduced within very narrow limits. Should it however, be required to allow for changes of declination and latitude, it may be done in the following manner.

Rule III.

18. Case 1st. To correct for changes of declination.

In the table adapted to the given place, find by the process mentioned in art. 9, the two days of the year which answer to consecutive declinations,(2) and have the given day situated between them. Then, proceed as in articles (15) and (16), to determine the interval corresponding to the measured shadow, and each of the days just found. Take the propor-

(1) The equation of time on the given day being —7m, the time required is properly 3h. $45\frac{1}{3}$m. so that the watch was, in fact, $5\frac{2}{3}$m. too fast.

(2) These days may be ascertained by inspection only from Table II. or IV. of the general Tables attached to this work.

tional part of the *difference* between these two intervals, due to the situation of the given day, and apply it to one of them by addition or subtraction, as the case may require, when the interval sought will be obtained.

EXAMPLE.

At Bellary, on the 7th. of October, I measured the shadow, which I found to be $5^{f.}$ $3^{in.}$. Required the time.

In the Table for 15° North latitude, we find by art. 9 that Oct. 9 and Oct. 6 are the two days, which answer to consecutive declinations viz. 6° and 5°, and have the given day situated between them. Now by art. 16, the intervals corresponding to $5^{f.}$ $3^{in.}$ and the above days are 3^h 15^m and 3^h 17^m respectively, where a difference of 2^m, is produced in 3 days. Hence the difference due to one day is $\frac{2}{3}^m$; consequently, the interval sought is $3^h\ 17^m - \frac{2}{3}^m = 3^h\ 16\frac{1}{3}^m$; and the time required $8^h\ 43\frac{2}{3}^m$ A. M. or $3^h\ 16\frac{1}{3}^m$ P. M.(1).

Case 2d. To correct for changes of latitude.

Having, as in the preceding case, determined the two intervals which correspond to the measured shadow, the given day, and the degrees of latitude next less, and next greater, than the latitude of the place of observation, take the difference between these intervals, and find the proportional part of it, due to the situation of the given latitude. Apply this correction to either of the intervals, as the case may require, and the interval sought will be obtained.

EXAMPLE 1.

At Cuddapah, on the 16th. of November, I found the shadow

(1) The equation of time on the given day is — 10m. Therefore, the corresponding mean time is either 8h. $30\frac{2}{3}$m. A. M., or 3h. $9\frac{2}{3}$m. P. M.

to be $3^{f.}$ $11^{in.}$, when my watch showed exactly 1^h 45^m P. M. Required the error of the watch.

The intervals corresponding to the 16th. of November, and $3^{f.}$ $11^{in.}$ of shadow, in the Tables for 14° and 15° North latitude, determined as in case 1st. of this rule, are 2^h 12^m and 1^h $57\frac{1}{2}^m$ respectively, the difference between which, is $4\frac{1}{2}^m$. Therefore, since Cuddapah is in 14° 28′ North latitude, we have $\frac{4\frac{1}{2} \times 28}{60} = 2^m$ nearly, for the proportional part of the above difference due to its situation. Hence 2^h $12^m - 2^m = 2^h$ 0^m., is the correct interval at the time of the observation. Consequently, the watch was 15^m too slow.(1)

EXAMPLE 2.

At Trichinopoly, in latitude 10° 50′ N. I measured the shadow on the 3d. of January, and found it to be $3^{f.}$ $9^{in.}$. Required the time of the day, and the error of my watch, which indicated 10^h $13\frac{1}{2}^m$ A. M. at the time of observation.

From Table II. of the general Tables attached to this work, we find that Jan. 2nd. and Jan. 6th. are the days which answer to consecutive declinations viz. 23° and $22\frac{1}{2}$° and have the given day situated between them. Now by art. 15, the intervals corresponding to $3^{f.}$ $9^{in.}$ and Jan. 2nd. and Jan. 6th. in the Table for 10° latitude, are 1^h 54^m and 1^h 56^m respectively; whence the interval corresponding to Jan. 3rd. is 1^h 54^m + ($\frac{1}{4}$ of 2^m) = 1^h $54\frac{1}{2}^m$. In like manner, the interval corresponding to the given day and shadow in the Table for 11° latitude, is 1^h 49^m. Consequently, in the latitude of 10° 50′, we have 1^h 50^m nearly, for the interval answering to the given day and shadow. Whence, the time required

(1) The equation of time in the given day being — 15m, the watch was really not in error.

is 10^h 10^m A. M.(1), and the error of the watch $+ 3\frac{1}{2}^m$, or $3\frac{1}{2}$ minutes too fast.

EXAMPLE 3.

At Bangalore, in latitude 12° 58′ N., the sky being partially clouded, I found the dark shadow on the 13th. of May to be $2^{f.}$ $7^{in.}$. Required the corresponding time.

Ans. 10^h $43\frac{1}{2}^m$ A. M., or 2^h $16\frac{1}{2}^m$ P. M.

EXAMPLE 4.

At Vizagapatam, in latitude 17° 42′ N., I measured the dark shadow on the 8th. of November with a three-feet rod, and found it to be $5^{f.}$ $4\frac{1}{2}^{in.}$. Required the corresponding *mean* time. Ans. 9^h 18^m A. M., or 3^h 10^m P. M. nearly.

19. Those who are conversant with astronomical calculations, will be aware of the fact, that in all observations dependant upon the motions of the heavenly bodies, there are certain times, at which the results of the observations are obtained with greater accuracy, than at others. Thus, in the problem which forms the subject of the present work, altitudes taken too near to the horizon, will be affected with the uncertainties of refraction, while those observed too near to the zenith will be liable to error, in consequence of the slowness of the motion in altitude. The former inaccuracy, however, does not take place within the limits to which the accompanying Tables extend ; but the latter does, and to such a degree, as to render observations taken too near to the meridian liable to much uncertainty. A cursory inspection of the Tables will be sufficient to convince us of this fact ; for while a difference of one inch in the shadow, does not create more

(1) Corrected for the equation of time from the Table in art 28, this time becomes 10h. 15m. A.M, so that the watch was $1\frac{1}{2}$m. too *slow*.

than a few seconds' difference in the corresponding time, when the sun is near the horizon, or when the shadow measures about 20 feet, it will be perceived that the same variation causes a difference of as much as 20 minutes, when the sun is close to the meridian in extreme south declinations. Hence it becomes necessary, before we determine upon the accuracy of any practical result, to ascertain what error a small difference of shadow is likely to create in it, assuming for this purpose, a deviation of one quarter of an inch in the measured shadow. When the Sun is more than two hours distant from the meridian, an error of this magnitude will not affect the corresponding result in a sensible manner, so that a single observation will, in general, suffice to determine the time accurately to the nearest minute; but when the sun is not so distant, it is necessary to repeat the observations at short intervals, and to consider the mean of the corresponding results as the true one.

Example.

At Bellary, on the 1st. of October, I took the following observations of the shadow, viz.

$1^{f.}\ 9^{in.}$	when my watch indicated	$10^h\ 41^m$ A. M.
$1^{f.}\ 8\frac{1}{2}^{in.}$	do.	$10^h\ 45\frac{1}{2}^m$,,
$1^{f.}\ 7\frac{1}{4}^{in.}$	do.	$10^h\ 53\frac{1}{4}^m$,,

Required the error of the watch.

The time determined from the first observation, as directed in the foregoing rules, is $10^h\ 58\frac{5}{6}^m$. Hence, the error of the watch is $-17\frac{5}{6}^m$, or $17\frac{5}{6}^m$ too slow. By the second observation, the time is $11^h\ 2\frac{1}{2}^m$, and the error of the watch -17^m. In like manner, by the third observation, the time is $11^h\ 11\frac{1}{4}^m$, and the error of the watch -18^m. Consequently, taking the mean of all the three errors, we have — $17\frac{2}{3}^{m}$ for the true error of the watch.(1).

20. The results obtained from the Tables according to the above rules, are, as we have already mentioned, in *true* or *apparent* time. This is the time indicated by a correct sun-dial; and being dependant upon the motion of the Sun, is never of the same value between two successive revolutions of that orb round any particular meridian. But the motion of a well regulated clock being equable, can never correspond with that of the Sun. Thus, the clock, if it goes true all the year round, will be before the sun from the 24th. of December till the 15th of April; from that day, till the 15th. of June, the Sun will be before the clock; from the 15th. of June, till the 31st. of August, the clock will be again before the Sun; and from thence to the 24th. of December, the Sun will be faster than the clock. Hence, the times shown by a well regulated clock and a good sun-dial, are never exactly the same, except on the 15th. of April, the 15th. of June, the 31st. of August, and the 24th. of December. The difference between these two times, is technically denominated the *Equation of Time*, and depends relatively to its causes, upon two circumstances, viz. the obliquity of the ecliptic to the equator, and the unequal motion of the Sun in its orbit.

21. In order to explain the first cause, let us suppose two Suns to set out, at the same instant, from the vernal equinox, or the first point of Aries, and to travel equably; the real sun in the ecliptic, and the imaginary sun in the

(1) The equation of time on the given day being — 10m., the watch was only $7\frac{2}{3}$m. too slow. It is to be observed, that when the equation of time is to be applied to the error of a watch in apparent time, it must be done with a sign contrary to that interposed in art. 28.

equator; the motion of the latter orb being, consequently, the measure of mean time, or the time shown by a well regulated clock. After a lapse of time, both Suns will have advanced the same number of degrees in their respective orbits. Let S denote the place of the real sun in the ecliptic, S' the corresponding position of the imaginary sun in the equator, A the first point of Aries, and β the obliquity of the ecliptic to the equator. Then, supposing a meridian to pass through S, it will intersect the equator at some point P, the relation between which and the point S, will be expressed by the following formula, deduced from Napier's analogies; viz.

$$\tan. AS \times \cos. \beta = \tan. AP.$$

Now since β is about 23 28′, its cosine is less than the radius, which is here considered to be unity; hence, tan. AP is less than tan. AS; consequently, in the first quadrant of the ecliptic, AP is less than AS, or its equal AS'. Whence, the right ascension of the real Sun, is less than the right ascension of the imaginary Sun; and the former orb, therefore, comes to the meridian sooner than the latter, or solar noon precedes noon by the clock. The real Sun thus continues to precede the imaginary, till both are 90° distant from A, when their right ascensions being the same, both Suns will come to the meridian at the same instant.

22. When the Suns have passed the solstitial colure, and have entered the second quadrant of the ecliptic, the arcs AS and AS' are each of them greater than 90°; hence, their tangents are negative: and, because in arcs greater than 90°, a greater arc has numerically a less tangent, and vice versâ, we have, from the analytical relation above adduced, the arc

AP greater than the arc AS, or its equal AS'. Consequently, in the second quadrant, the right ascension of the imaginary Sun is less than the right ascension of the real Sun. Mean noon, therefore, precedes the apparent, and it continues so in advance, till both Suns come to the autumnal equinox, when they again pass the meridian at the same instant.

23. In the remainder of the ecliptic, the same phenomena are exhibited as in the first two quadrants, with this exception only that the real Sun now moves in the southern hemisphere. Hence, in the third quadrant, apparent noon precedes mean noon; and in the fourth quadrant, is itself preceded by the latter.

24. To explain the second cause, let us suppose the earth to be situated in the focus of an ellipse representing the orbit of the Sun, and two Suns starting simultaneously from the apogee, and travelling the same way round it, the imaginary Sun with a velocity equal to the mean motion of the real Sun. Then, since the velocity of the real sun is slowest at the apogee, in consequence of his being there at the greatest distance from the earth, it is clear that the imaginary Sun will at once take the lead of the former; hence, any terrestrial meridian comes sooner to the real Sun, than to the imaginary, or solar noon precedes noon by the clock. The imaginary Sun continues to precede the real, till the accelerated velocity of the latter reaches its mean value, when the two Suns will be at their greatest separation. The real Sun now begins to gain upon the other, and finally overtakes him at the perigee; when both Suns being in conjunction, solar and mean noons happen at the same instant.

25. On passing the perigee, the accelerated motion of the real Sun having there attained its maximum, carries him before the imaginary Sun ; hence, the same meridian comes sooner to the imaginary, than to the real Sun, or mean noon precedes apparent noon. The real Sun continues in advance with a decreasing velocity, till his motion reaches its mean value, when the two Suns will be again at their greatest separation. From this moment, the imaginary Sun gains upon the real, and finally overtakes him at the apogee, where, as before, both suns being in conjunction, solar and mean noons happen at the same instant.

26. Thus we see, that in relation to the first cause, the equation of time vanishes at the equinoxes and solstices ; and in relation to the second cause, it vanishes at the perihelion and aphelion points, which do not coincide with any of the former. Hence, under the operation of both causes, it will vanish at none of the six points above mentioned, but at four intermediate ones ; which, when determined by calculation, are found to be the points in which the Sun is situated on the dates mentioned in article (20).

27. The equation of time computed for every day in the year, is inserted in the principal almanacs published at Madras, for the purpose of deducing mean solar from apparent time. In order to regulate its application, the signs + and —, are interposed in the column which contains its several values ; and it is to be observed, that when the interposed sign is + , the equation of time must be added to, and when the sign is — , it must be subtracted from, apparent time, to obtain the corresponding mean time.

28. The subjoined table exhibits the equation of time

for every day of the year at Madras; and as the quantities inserted in it vary but imperceptibly for longitude, it may be used in any part of India.

TABLE OF THE EQUATION OF TIME.

Day of the Month.	January	February	March	April	May	June	July	August	September	October	November	December
	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
1	+ 4	+14	+13	+ 4	− 3	− 3	+ 3	+ 6	+ 0	−10	−16	−11
2	4	14	13	4	3	2	4	6	− 0	10	16	11
3	5	14	12	3	3	2	4	6	1	11	16	10
4	5	14	12	3	3	2	4	6	1	11	16	10
5	6	14	12	3	3	2	4	6	1	11	16	9
6	6	14	12	3	4	2	4	6	2	12	16	9
7	6	14	11	2	4	2	4	6	2	12	16	8
8	7	14	11	2	4	1	5	5	2	12	16	8
9	7	15	11	2	4	1	5	5	3	13	16	8
10	8	15	11	1	4	1	5	5	3	13	16	7
11	8	15	10	1	4	1	5	5	3	13	16	7
12	9	15	10	1	4	1	5	5	4	13	16	6
13	9	15	10	1	4	0	5	5	4	14	16	6
14	9	15	10	0	4	0	5	5	4	14	15	5
15	10	14	9	+ 0	4	− 0	5	4	5	14	15	5
16	10	14	9	− 0	4	+ 0	6	4	5	14	15	4
17	10	14	9	0	4	0	6	4	5	14	15	4
18	11	14	8	1	4	1	6	4	6	15	15	3
19	11	14	8	1	4	1	6	4	6	15	14	3
20	11	14	8	1	4	1	6	3	6	15	14	2
21	12	14	7	1	4	1	6	3	7	15	14	2
22	12	14	7	1	4	1	6	3	7	15	14	1
23	12	14	7	2	4	2	6	3	7	15	13	1
24	12	14	7	2	4	2	6	2	8	16	13	− 0
25	13	13	6	2	3	2	6	2	8	16	13	+ 0
26	13	13	6	2	3	2	6	2	8	16	13	1
27	13	13	6	2	3	3	6	1	9	16	12	1
28	13	+13	5	3	3	3	6	1	9	16	12	2
29	13		5	3	3	3	6	1	9	16	12	2
30	14		5	− 3	3	+ 3	6	1	−10	16	−11	3
31	+14		+ 4		− 3		+ 6	+ 0		−16		+ 3

29. We shall conclude this part of the subject, by annexing a table of the latitudes of the principal places in the Madras Presidency and the southern parts of Bombay; from which, the latitude of any intermediate place, may be found approximately by the usual method of interpolation.

Example 1.

Required the latitude of Putticonda, which is 18 miles from Gooty on the main road to Adoni, supposing the distance between these two places to be 38 miles.

The difference of latitude between Gooty and Adoni, being 37 minutes, we have, $38 : 20 :: 37 : 19\frac{1}{2}$ minutes, for the difference of latitude between Gooty and Putticonda. Consequently, $15° \ 12' + 19\frac{1}{2}' = 15° \ 31'$ nearly, is the latitude required.

Example 2.

Required the latitude of Ramiapatam, which is situated on the high road from Nellore to Ongole, and is 33 miles from the latter place.

By reference to a Road-book, we find that the distance between Nellore and Ongole is 78 miles; and as the difference of latitude between them, is $1° \ 2'$ or $62'$,

$$\text{we have, } 78 : 33 :: 62' : 26\tfrac{1}{4} \text{ minutes.}$$

$$\therefore 15° \ 30' - 26' = 15° \ 4' \text{ is the latitude required.}$$

Example 3.

Required the latitude of Adamancottah, which is situated on the road from Bangalore to Salem, and is 36 miles from the latter place, and 34 miles from Royacottah.

Ans. $12° \ 13'$ North, nearly.

Table of Latitudes.

Name of Place.	North Latitude.	District or Province.	Name of place.	North Latitude.	District or Province
Adoni	15° 39′	Bellary	Hurryhur	14° 29′	Mysore
Alleppy	9 21	Travancore	Hyderabad	17 12	Hyderabad
Ahmednuggur	19 5	Ahmednuggur	Itchapoor	19 6	Ganjam
Anantapoor	14 41	Bellary	Jaulnah	19 52	Hyderabad
Arcot	12 54	N. Arcot	Jeypoor	18 47	Jeypoor
Arnee	12 41	Do.	Kulladghee	16 12	S. Mahratta
Aurungabad	19 56	Hyderabad	Kurnool	15 50	Kurnool
Avenashy	11 8	Coimbatore	Linga Soogoor	16 7	Hyderabad
Bangalore	12 58	Mysore	Madras	13 5	Chingleput
Baugapilly	13 47	Do.	Madura	9 55	Madura
Beejapoor	16 50	Sattarah	Mahe	11 41	N. Malabar
Belgaum	15 53	S. Mahratta	Malligaum	20 28	Candeish
Bellary	15 9	Bellary	Manantody	11 41	N. Malabar
Berhampore	19 18	Ganjam	Manargoody	10 23	Tanjore
Bombay	18 56	Concan	Mangalore	12 52	Canara
Calicut	11 15	S. Malabar	Masulipatam	16 9	Masulipatam
Cannanore	11 51	N. Malabar	Mercara	12 25	Coorg
Chicacole	18 15	Ganjam	Mominabad	18 42	Hyderabad
Chingleput	12 41	Chingleput	Muctul	16 30	Do.
Chinroypatam	12 55	Mysore	Mysore	12 18	Mysore
Chittledroog	13 56	Do.	Nagercoil	8 11	Travancore
Chittoor	13 12	N. Arcot	Negapatam	10 46	Tanjore
Cocanada	16 57	Rajahmundry	Nellore	14 28	Nellore
Cochin	9 58	Cochin	Nellumboor	11 13	S. Malabar
Coimbatore	11 0	Coimbatore	Nuggur	13 50	Mysore
Colapoor	16 47	Sattarah	Nundidroog	13 23	Do.
Combaconum	10 57	Tanjore	Ongole	15 30	Nellore
Coonoor	11 20	Coimbatore	Oossoor	12 44	Salem
Coringa	16 48	Rajahmundry	Ootacamund	11 23	Coimbatore
Cottayam	9 36	Travancore	Palamcottah	8 44	Tinnevelly
Cranganore	10 12	Cochin	Palaveram	12 57	Chingleput
Cuddalore	11 43	S. Arcot.	Palmanair	13 11	N. Arcot
Cuddapah	14 29	Cuddapah	Paulghautcherry	10 47	S. Malabar
Cumbum	15 34	Do.	Pondicherry	11 56	French Terry.
Cuttack	20 27	Cuttack	Poodoocottah	10 23	Madura
Dharwar	15 25	S. Mahratta	Poonah	18 30	Poonah
Dindigul	10 22	Madura	Poonamallee	13 4	Chingleput
Ellore	16 45	Masulipatam	Porto Novo	11 29	S. Arcot
French Rocks	12 18	Mysore	Pulicat	13 25	Chingleput
Ganjam	19 22	Ganjam	Quilon	8 53	Travancore
Goa	15 29	Portuguese	Rajahmundry	17 0	Rajahmundry
		Territory	Ramapatam	15 5	Nellore
Goomsoor	19 53	Ganjam	Ramnad	9 20	Madura
Gooty	15 12	Bellary	Royacottah	12 31	Salem
Gopalpoor	19 15	Ganjam	Russelcondah	19 56	Ganjam
Guntoor	16 18	Guntoor	Sadras	12 32	Chingleput
Hingolee	19 36	Hyderabad	Salem	11 39	Salem
Honawar	14 17	N. Canara	Samulcottah	17 3	Rajahmundry
Hoonsoor	12 19	Mysore	Sattarah	17 40	Sattarah
Hospet	15 16	Bellary	Sattimunglum	11 31	Coimbatore

Name of place.	North Latitude.	District or Province.	Name of place.	North Latitude.	District or Province.
Secunderabad	17° 27′	Hyderabad	Trevandrum	8° 31′	Travancore
Sedashegur	14 51	Canara	Trichinopoly	10 50	Trichinopoly
Serah	13 44	Mysore	Trichoor	10 31	Cochin
Seringapatam	12 32	Do.	Trippasore	13 8	Chingleput
Sheemooga	13 52	Do.	Tutacorin	8 47	Tinnevelly
Sholapoor	17 41	Sholapoor	Vellore	12 54	N. Arcot
Sircy	14 37	Soonda Bilgy	Vingorla	15 49	S. Concan
St. Thos.' Mount	13 0	Chingleput	Vizagapatam	17 42	Vizagapatam
Tanjore	10 47	Tanjore	Vizianagrum	18 8	Do.
Tellicherry	11 45	N. Malabar	Wallajahbad	12 46	Chingleput
Tinnevelly	8 44	Tinnevelly	Waltair	17 45	Vizagapatam
Toomcoor	13 18	Mysore	Yelwal	12 20	Mysore
Tranquebar	11 2	Tanjore			

General Tables.

30. Having thus given a short, but we trust sufficiently clear, explanation of the first set of Tables comprised in this volume, which are applicable only to the Madras Presidency, and the southern parts of Bombay, we now proceed to explain the succeeding set, or General Tables, which are adapted to the whole of British India.

31. It has already been stated in article (1), that when the shadow of a rod of 4 feet is given, the determination of the corresponding time is effected by the solution of a spherical triangle, the three sides of which are known; and in article (2) we gave the formula,

$$\cos. h = \sin. A. \sec. L. \sec. D \mp \tan L. \tan. D,$$

as the one best adapted to that solution; but it is obvious that the operations indicated by the above expression, cannot be readily performed without the aid of subsidiary Tables, showing the values of

$$\sin. A, \sec. L. \sec. D, \tan. L. \tan. D, \text{ and } \cos. h,$$

for given quantities. The general Tables which we propose to explain are, in fact, the subsidiary Tables here alluded to, and the manner of using them is, consequently, indicated by the relation which subsists between the terms of the above formula.

32. It is necessary to observe in this place, that as the term sin. *A*. sec. *L*. sec. *D* of the second member of the formula, contains three factors, it gives rise to a process of multiplication between the quantities represented by sin. *A* and sec. *L*. sec. *D*. This multiplication, it is plain, may be avoided, by making the subsidiary Tables exhibit the logarithmic, instead of the natural, values of sin. *A* and sec. *L*. sec. *D*, and by adding one more Table, from which the number answering to the sum of any two of those logarithms may be ascertained. With these modifications, therefore,

33. TABLE I. contains the logarithms of sin. *A*, for every inch of shadow from 0 to 20 feet, the altitudes denoted by *A*, being in the first instance, corrected for refraction. The *feet* are inserted in the first vertical, and the inches in the first horizontal column; and, the log. sin. *A* answering to any measured shadow, is found in the horizontal line marked with the feet, and the vertical column headed by the inches. Thus, the log. sin. *A* corresponding to $6^{f.}\ 7^{in.}$ is 9.7151, the index 9 being common to all the tabulated numbers. When fractional parts of an inch occur in the shadow, the log. sin. *A* answering thereto must be obtained by interpolation in a manner similar to that directed in article (16). Thus, the log. sin. *A* for $10^{f.}\ 4\frac{1}{3}^{in.}$ is 9.5557.

34. TABLE II. expresses the logarithmic values of sec. *L*. sec. *D* for every degree of latitude and declination; the former argument being ranged in the left hand column, and the latter in the third horizontal row of the Table. The logarithms are carried to four decimal places, and have 20 for their index; but the significant parts only are expressed

in the Table, so that both the index and the omitted cyphers, will have to be supplied when deemed necessary. To obviate a reference to other books, the days of the year on which the Sun arrives at each degree of declination, are inserted in corresponding columns; and by means of these, the value of sec. *L.* sec. *D* for any other given day may be readily ascertained. For instance, let it be required to find the value of sec. *L.* sec. *D* for the 24th. of May in latitude 15° N.; then, since the values of sec. *L.* sec. *D* for the 21st. and 26th. of May are 20·0421 and 20·0449 rspectively, we have a difference of ·0028 created in 5 days; whence the difference due to 3 days is ·0017 nearly, and the required number is, therefore, 20·0421 + ·0017 = 20·0438. When the latitude contains fractions of a degree, a similar interpolation must be performed.

35. TABLE III. is one of anti-logarithms, and differs from the tables in common use, by having the natural numbers inserted in the place of the logarithms, and vice versâ; so that a number is found from its logarithm by the same process as that which ordinarily finds the logarithm from the number. Thus, let it be required to find the natural number corresponding to 0·8567. The first two figures 85 being found in the first column, and the third figure 6 at the top of the page, we have, opposite the former and under the latter, the number 7·178 for the quantity answering to the first three figures of the given logarithm. The proportional part to be added, for the fourth figure 7, is 12, which is obtained from the column headed "Proportional parts" by looking in the same line with the number 7·178 already found, and under the given figure 7, so that the natural number required is 7.190. In

like manner, the natural number answering to 9.4567 is ·2863; and that answering to 9·8963 is ·7875.

36. TABLE IV. gives the significant parts of the *natural* values of tan. *L.* tan. *D* for every degree of latitude and declination, and is arranged in the same manner as Table II; but it is to be observed that the numbers inserted in it (being natural) have no index, and that they are *additive* when the declination is south, and *subtractive* when it is north(1).

37. TABLE V. contains the significant parts of the natural values of cos. *h* for every fifteen minutes of angular measure converted into minutes of time. When the observation of the shadow is made in the forenoon, the corresponding time is obtained from the Table by looking for the hours at the top, and for the minutes in the left hand column; and when in the afternoon, by looking for those quantities respectively in the columns opposite to the former.

38. The mode in which these Tables are applied is now obvious.—Having ascertained from Table I, the logarithm answering to the measured shadow, add to it the logarithm from Table II., corresponding to the given day and latitude; and reject 20 from the index. Find the natural number answering to this sum from Table III, and add to, or subtract from it, the number from Table IV. corresponding to the given day and latitude, according as the declination is south or north. Finally, look for this sum or difference in Table V.; when the corresponding time will be supplied by the upper and left hand columns, if the observation be made in the forenoon; and by the lower and right hand columns, if in the afternoon.

(1) As regards the Sun, the numbers are subtractive from March 21st. to Sept. 23d. during which his declination is north, and additive from Sept. 23d. to March 21st. during which it is south.

Example 1.

In the forenoon of the 19th. of April, I measured the shadow at Bellary, and found it to be 3f. 7in.. Required the corresponding mean time.

Number from Table I. answering to 3f. 7in....	9·8720
do. Table II. do. April 19th. and 15° 10′ latitude...	20·0234
Sum rejecting 20 from the index...........	9·8954
Natural number answering to it from Table III..................................	·7859
Number from Table IV. answering to April 19th. and 15° 10′ latitude........	·0527
Difference,—the declination on the given day being north..........................	·7332
Apparent time from Table V. answering to .7332................................	9h 9m nearly
Equation of time................................	—1
Mean time required............................	9h 8m A. M.

It is obvious that by rejecting all the figures and points not essentially necessary to the calculation, the computation might stand simply as follows :—

Number from Table I.................	8720
do. Table II................	234
	8954
Natural number from Table III........	7859
Number from Table IV.................	527
Difference....................................	7332
Corresponding apparent time...........	9h 9m
Equation of time........................	—1
Mean time required......................	9h 8m A. M.

Example 2.

At Trichinopoly, in the afternoon of the 26th. of January, I measured the shadow and found it to be $2^{f.}\ 7^{in.}$. Required the corresponding mean time.

9243
316
9559
9035
650
9685
$0^h\ 58^m$
+ 13 Equation of time.
$1^h\ 11^m$ P. M. Time required.

The computations by means of these Tables, are so readily made, that when the interpolations mentioned in Rule III, have to be performed, it would be decidedly preferable to resort to them.

39. By means of these Tables, the time of Sun-rise and Sun-set at any given place may be easily determined; for it is to this form, that the general problem is reduced when the Sun's real altitude is supposed to be 0, or the measured shadow to be infinitely great. In this case, as sin. A is 0, the formula given in article (31), becomes simply,

$$\cos. h = \mp \tan. L. \tan. D,$$

the double sign denoting that h is *greater* than 90° when the declination is north, and *less* when it is south; or that the semi-diurnal arcs are, in the one case, greater, and in the other, less than 6 hours. To find these arcs, therefore, we have merely to take from Table IV. the number corresponding to the given day and latitude, or the given declination and latitude, and to look for it in Table V; when, if the declination be North,(1) the semi-diurnal arc would be given by the upper and left hand columns, and if it be South, by the lower and right hand columns. Thus,

EXAMPLE 1.

Let it be required to find the time of Sun-rise and Sun-set on the 16th. of May, at Calcutta, in latitude 21° 2′ N.

Here the number from Table IV, answering to the given day and latitude is 1324; consequently, looking in Table V. for this number, we find (as the declination on the given day is North), that the semi-diurnal arc is $6^h\ 30\frac{1}{2}^m$ nearly.

Hence, the Sun rises at $12^h - 6^h\ 30\frac{1}{2}^m = 5^h\ 29\frac{1}{2}^m$ } apparent
and sets at .... $6^h\ 30\frac{1}{2}^m$ } time.

EXAMPLE 2.

Let it again be required to find the time of Sun-rise and Sun-set at Aurungabad, in latitude 19° 56′ North, on the 2d. of January.

Here the number from Table IV. is 1540; and as the declination on the given day is South, the semi-diurnal arc from Table V., corresponding to this number, is $5^h\ 24\frac{1}{2}^m$.

Hence, the Sun rises
at $6^h\ 35\frac{1}{2}^m$ of apparent, or $6^h\ 39\frac{1}{2}^m$ of mean time,
and sets at $5^h\ 24\frac{1}{2}^m$ of do. or $5^h\ 28\frac{1}{2}^m$ of do.

40. It is to be borne in mind, that the times of rising and setting thus obtained are the times when the Sun is *really* in the eastern and western horizon, and not the times of his appearance and disappearance; which phenomena, in consequence of refraction, take place when he is 32′ 56″

(1) Vide note to art. 36.

below the horizon. The time required to pass through this arc, which is about $2\frac{1}{4}$ minutes, must therefore be subtracted from the computed time of rising, and added to that of setting, to obtain the times of actual appearance and disappearance. The results of the preceding examples being thus modified, would stand as follows,

In the first example, $\begin{cases} 5^h\ 27^m & \text{apparent time of rising.} \\ 6^h\ 33^m & \text{do. of setting.} \end{cases}$

In the second example, $\begin{cases} 6^h\ 37^m & \text{mean time of rising.} \\ 5^h\ 31^m & \text{do of setting.} \end{cases}$

41. Hitherto we have confined ourselves to observations of the shadow made in sun-light, but it is evident from the nature of the problem, that there is nothing in it to restrict the application of the Tables to such cases only, and that the declination and altitude of the Moon, or a Star, with the corresponding measured or determined shadow, would furnish equally good data for calculating its meridional distance at the time of observation. There is however, one peculiarity with reference to the Sun, which deserves notice. His motion being the immediate measure of our day and night, the intervals afforded by the Tables express at once the required times in ordinary reckoning, while in the case of any other luminary, they would represent merely the horary distance of the object from the meridian at the time of observation, and therefore require not only a correction on account of its easterly motion in right ascension, but also a subsequent application by addition, or subtraction, to the time of transit. But these operations are readily and easily made; and as the advantage of possessing some means of determining time at night is great, particularly with travellers, we shall devote a few pages to a brief consideration of the subject.

42. Next in importance to the Sun, is the Moon, the light reflected from which exhibits a perceptible and measurable shadow when intercepted, but to render it available for the determination of time, it must undergo two corrections; one, for the phases of the Moon, and the other, for her parallax.

43. As the Moon is an opaque body and depends for its light upon the Sun, it is obvious that the illuminated portion of its surface is always turned towards that orb, so that if a plane were drawn through its centre perpendicular to a straight line joining it to the centre of the Sun, it would be divided into two hemispheres, one luminous, and the other dark. But to a spectator situated on the Earth's surface, only that portion of the disc is visible, which is cut off by a plane passing through the centre of the Moon perpendicular to a straight line drawn from it to the centre of the Earth. Hence, whatever portion of the illuminated surface is common to the two hemispheres will appear bright, while the rest of the disc will be invisible. When the Moon is new, i. e. when its longitude and that of the Sun are alike, the circle of illumination is directly opposite to that of vision, so that no portion of the Moon's surface can be visible to us; but as it recedes from that luminary, the above circles gradually slide upon each other, thereby exhibiting more and more of the bright surface to the earth, till in quadrature i. e. when the Moon's elongation, or distance from the Sun, is 90°, half of the disc appears bright, and the other half, dark. The luminous portion continues to increase till the circles of vision and illumination coincide, when the whole of the bright surface is presented to us. At this time, the Moon is said to be full, and has attained its greatest distance from the Sun,

viz. 180°. Similar phenomena are exhibited as the Moon returns to that luminary in the other half of her orbit, but in a reverse order, till at length it comes in conjunction and totally disappears, to begin a new monthly revolution, and undergo similar changes.

44. It is therefore clear that in the first quarter of her orbit, the Moon appears entirely to the west of the meridian after Sun-set, and has its lower limb perfect. In the second quarter the perfect edge is turned upwards while the Moon is to the east of the meridian, but downwards after it has passed that circle. In the third quarter, i. e. after Full-Moon, the perfect limb is turned downwards *before* coming to the meridian, but upwards after passing that circle ; and in the fourth quarter, the Moon is entirely to the east of the meridian before Sun-rise, and has its lower limb perfect. The magnitude of the illuminated portion may, in every case, be easily computed, by the well-known theorem that it varies in proportion to the versed-sine of the Moon's elongation.

45. When the perfect limb is turned upwards, the shadow corresponding to the centre of the Moon may be found by measuring to the dark shadow, which would be that of the upper limb, and correcting it by the quantities inserted in the Table of article (14), for the apparent diameters of the Sun and Moon are nearly alike, and may be assumed to be exactly so for our purposes.

46. When the limb is turned downwards, the dark shadow would be that of the imperfect edge, and would consequently be greater or less than the true shadow according as the Moon is at the time less, or more, than half-full. In a case of this nature, the requisite correction may be obtained from the subjoined table, by looking for the measured shadow in

the left hand column, and for the number of days *from* or *to* the nearest quarter at the top, and taking out the number answering thereto; which will be additive if the Moon is more, and subtractive if less, than half-full.

TABLE.

Measured Shadow	Number of days *from* or *to* the nearest Quarter.					
	1	2	3	4	5	6
Feet	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
2	0·1	0·1	0·2	0·3	0·3	0·3
4	0·1	0·2	0·3	0·4	0·4	0·5
6	0·2	0·3	0·5	0·6	0·7	0·7
8	0·2	0·4	0·7	0·8	1·0	1·1
10	0·3	0·6	0·9	1·2	1·4	1·5
12	0·4	0·8	1·3	1·7	1·9	2·1
14	0·5	1·1	1·7	2·2	2·5	2·8
16	0·7	1·4	2·1	2·7	3·1	3·5
18	0·9	1·8	2·7	3·5	4·0	4·5
20	1·2	2·3	3·4	4·4	5·0	5·5

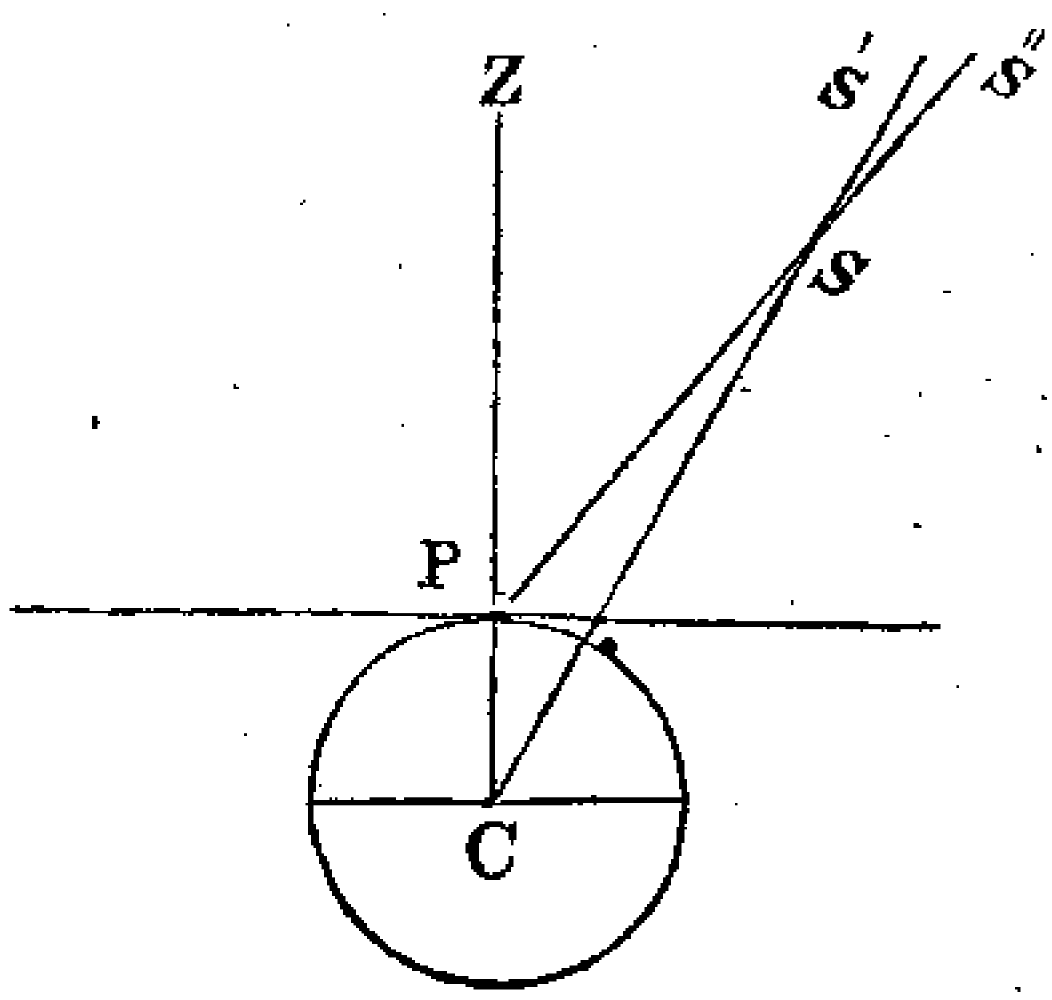
47. As the line joining the cusps of the Moon is not necessarily parallel to the horizon, but is more or less inclined to it according to the position of the Sun, (for the above line must always be perpendicular to that joining the centres of the two luminaries) it is obvious that the numbers inserted in the above table would not always apply; but their deviations from the accurate results would be so small in any real case, as to make this a matter of no consideration.

48. When the Moon is more than six days distant from her quadratures, she must be regarded as New or Full. Also, when her enlightened surface is not bright enough to cause a visible shadow, a different method of procedure must be adopted; for which, see article (85).

49. The second correction to be made in the measured shadow arises from the consideration of parallax.

50. In astronomical processes, all heavenly bodies are assumed to be observed from the centre of the Earth; because that being a fixed and invariable point, the phenomena which are supposed to be seen from it, would partake of the same characters. With regard to the Stars indeed, whose distance is so immense, that even the diameter of the Earth's orbit does not bear any sensible proportion to it, it is a matter of perfect indifference from what point they are observed: but it is not so with the Planets. Their nearness to the earth renders their apparent places liable to be much affected by the observer's situation, and therefore, before we can apply observations made under such circumstances, it is necessary to reduce the *apparent* to the *true* places.

Let C be the centre of the earth, P any place on its surface and S the position of the Moon, or any other planet; then,



as seen from P, the body would evidently be referred to the point S'' in the heavens, which is its *apparent* place, while from C it would be referred to S', which is the *true* place.

The difference between these two places, or the angle CSP is denominated parallax, and it is obvious that the nearer the planet is to the earth, the greater would be the amount of this parallactic angle.—

Since $PS : PC :: \sin. PCS : \sin. PSC$,

we have, $\sin. PSC = \frac{PC}{PS} \cdot \sin. PCS$;

But $\frac{PC}{PS}$ is very nearly constant for the same heavenly body; therefore, sin. PSC varies as sin. PCS, or as the sine of the Zenith distance; and because in small arcs, the sines vary as the arcs themselves, the angle PSC varies as sin. PCS, or which is the same thing, as the cosine of the altitude. Now, the cosine of an arc is the greatest when the arc is equal to 0, because then, the cosine is equal to the radius, or unity; hence the parallax is the greatest when the body is in the horizon, and at any other altitude it is equal to

the hor. par. × cos. alt.

51. Now to see what effect the Moon's parallax has upon the shadow of a rod intercepting its light, let us assume the measured shadow to be 10f. 6in.. Then by article (1), 10f. 6in. : 4f. : : 1 (radius) : ·380952 = tan. of 20° 51′ 16″, which is, therefore, the apparent altitude corresponding to the given shadow. Again, because the Moon's horizontal parallax is 57′·1*, we have 57′·1 × cos. 20° 51′ 16″ = 57′·1 × ·9345 = 53′ 22″ for the parallax in altitude at 20° 51′ 16″; hence, (since parallax always depresses an object) 20° 51′ 16″ + 53′ 22″ = 21° 44′ 38″ is the true altitude of the Moon, subject to a correction for refraction. The shadow corres-

* The Moon's horizontal parallax varies from 54′ to 1° 1′, but for our purposes it will be sufficient to take its *mean* value, which is 57′·1.

ponding to this altitude being $\frac{4 \text{ feet}}{\tan. 21^\circ\ 44'\ 38''} = \frac{4}{\cdot 398836}$ $= 10^{f.} \cdot 029 = 10^{f.}\ 0 \cdot 3^{in.}$, the correction to be applied to the measured shadow on account of parallax, is — 5·7 inches.

52. By proceeding in this manner for every six inches of shadow, we derive the following,

TABLE, showing the reduction to be made on the measured shadow on account of the Moon's Parallax.

Measured Shadow		Reduction		Measured Shadow		Reduction		Measured Shadow		Reduction		Measured Shadow		Reduction	
f.	*in.*	*f.*	*in.*	*f.*	*in.*	*f.*	*in.*	*f.*	*in.*	*f.*	*in.*	*f.*	*in.*	*f.*	*in.*
0	0	0	0·0	5	6	0	1·8	11	0	0	6·2	16	6	1	1·1
	6		0·1	6	0		2·1		6		6·7	17	0		1·8
1	0		0·2		6		2·4	12	0		7·2		6		2·6
	6		0·3	7	0		2·7		6		7·9	18	0		3·4
2	0		0·4		6		3·1	13	0		8·4		6		4·2
	6		0·6	8	0		3·5		6		9·1	19	0		5·1
3	0		0·7		6		3·9	14	0		9·6		6		5·9
	6		0·9	9	0		4·3		6		10·3	20	0		6·8
4	0		1·1		6		4·7	15	0		10·9		6		7·7
	6		1·3	10	0		5·2		6	0	11·6	21	0		8·6
5	0	0	1·6		6	0	5·7	16	0	1	0·3		6	1	9·5

53. When the measured shadow is not found exactly in the above Table, the reduction corresponding to it must be found by interpolation. Thus, the reduction for $16^{f.}\ 4^{in.}$ would be $1^{f.}\ 0^{in}\ \cdot 8$, and so on.

54. Having thus corrected the shadow measured in moonlight, the interval between the time of observation and the Moon's meridian passage corresponding thereto, may be found from the first or second set* of Tables, by the rules

* When the Moon's declination exceeds 24°, the numbers from Table II on IV, corresponding thereto, must be found by looking for the declination in the column of latitudes, and for the latitudes in the column of declinations, as explained in art (61.)

already given; but it is to be carefully noticed that the days inserted opposite to the declinations in either of these Tables apply to the Sun only, and that in determining time by the Moon, or Stars, their declinations must be invariably used. Thus,

EXAMPLE.

Let it be required to find the interval corresponding to $4^{f.}\ 10^{in.}$, the shadow measured in Moonlight at Madras on the 25th. of January 1840.

Correcting the *apparent* shadow for parallax, we have $4^{f.}\ 10^{in.} - 1\frac{1}{2}^{in.} = 4^{f.}\ 8\frac{1}{2}^{in.}$ for the *true* shadow at the time of observation. Therefore, turning to the table adapted to the given place, and looking opposite to $4^{f.}\ 8\frac{1}{2}^{in.}$, we find, in correspondence to 14° 23′, (the Moon's declination at the time of observation,) the quantity $2^{h}\ 47^{m}$, which consequently was the Moon's distance in time, from the meridian, when the shadow was measured.

55. But the interval thus obtained will not express correctly the time that the Moon would take to reach the meridian; for inconsequence of her proper motion round the earth in a direction contrary to her apparent course, the latter is retarded daily at an average rate of about 52 minutes, or hourly at the rate of about $2\frac{1}{4}$ minutes; so that a correction on account of this retrograde movement must be added to the computed interval to obtain the real time of her reaching the meridian. The difference between the times of two successive transits of the moon, ascertained from an almanac, will give accurately the amount of the daily retardation, the proportional part of which due to any distance from the meridian may then be ascertained from the accompanying Table.

Time from Moon's transit.		Daily retardation of the Moon's passing the Meridian.													
		40*m*.	42*m*.	44*m*.	46*m*.	48*m*.	50*m*.	52*m*.	54*m*.	56*m*.	58*m*.	60*m*.	62*m*.	64*m*.	66*m*.
h.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.	*m*.
0	0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
	20	0·5	0·6	0·6	0·6	0·6	0·7	0·7	0·7	0·7	0·8	0·8	0·8	0·9	0·9
	40	1·1	1·1	1·2	1·2	1·3	1·3	1·4	1·4	1·5	1·5	1·6	1·7	1·7	1·8
1	0	1·6	1·7	1·8	1·9	1·9	2·0	2·1	2·2	2·2	2·3	2·4	2·5	2·6	2·6
	20	2·2	2·3	2·4	2·5	2·6	2·7	2·8	2·9	3·0	3·1	3·2	3·3	3·4	3·5
	40	2·7	2·8	3·0	3·1	3·2	3·4	3·5	3·6	3·7	3·9	4·0	4·1	4·3	4·4
2	0	3·2	3·4	3·6	3·7	3·9	4·0	4·2	4·3	4·5	4·6	4·8	5·0	5·1	5·3
	20	3·8	4·0	4·1	4·3	4·5	4·7	4·9	5·1	5·2	5·4	5·6	5·8	6·0	6·1
	40	4·3	4·5	4·7	5·0	5·2	5·4	5·6	5·8	6·0	6·2	6·4	6·6	6·8	7·0
3	0	4·9	5·1	5·3	5·6	5·8	6·0	6·3	6·5	6·7	7·0	7·2	7·4	7·7	7·9
	20	5·4	5·7	5·9	6·2	6·4	6·7	7·0	7·2	7·5	7·7	8·0	8·3	8·5	8·8
	40	5·9	6·2	6·5	6·8	7·1	7·4	7·7	8·0	8·2	8·5	8·8	9·1	9·4	9·6
4	0	6·5	6·8	7·1	7·4	7·7	8·1	8·4	8·7	9·0	9·3	9·6	9·9	10·2	10·5
	20	7·0	7·4	7·7	8·0	8·4	8·8	9·1	9·4	9·7	10·0	10·4	10·7	11·1	11·4
	40	7·6	7·9	8·3	8·7	9·0	9·5	9·8	10·1	10·5	10·8	11·2	11·6	11·9	12·3
5	0	8·1	8·5	8·9	9·3	9·7	10·1	10·5	10·8	11·2	11·6	12·0	12·4	12·8	13·1
	20	8·6	9·1	9·5	9·9	10·3	10·8	11·2	11·6	12·0	12·4	12·8	13·2	13·6	14·0
	40	9·2	9·6	10·1	10·5	11·0	11·5	11·9	12·3	12·7	13·2	13·6	14·0	14·5	14·9
6	0	9·7	10·2	10·7	11·1	11·6	12·1	12·5	13·0	13·5	13·9	14·4	14·9	15·3	15·8
	20	10·3	10·8	11·3	11·7	12·3	12·8	13·2	13·7	14·2	14·7	15·2	15·7	16·2	16·7
	40	10·8	11·3	11·9	12·4	12·9	13·5	13·9	14·5	15·0	15·4	16·0	16·5	17·0	17·5

56. We shall now proceed to exemplify the preceding remarks and observations.

EXAMPLE 1.

At Bellary, on the 5th. May 1841 about 9 o'clock in the evening, I measured the shadow of a rod of four feet in Moonlight, and found it to be $7^{f.}$ $8^{in.}$. Required the time of the night.

By referring to the Nautical Almanac for 1841, we obtain the following data.—

Moon's meridian passage at Bellary on the 4th. of May 1841	11^h 11^m
do. do. 5th. do....	12 0
Consequently, the daily retardation............	0 49
Moon's declination at the approximate time of observation..................................	21° 22′ S.

And the time of Full-moon......................the given day.

Therefore, the computation stands as follows,

Given shadow...	$7^{f.}$	$8^{in.}$
Correction to the Moon's centre...	+	1
Do. for parallax......	—	3·2
	7	5·8

Interval from the Table for 15° N. latitude corresponding to $7^{f.}$ $5^{in.}$·8 and 21° 22′ S. declination...........	3^{h}	25^{m}
Proportional part of the daily retardation corresponding to the above interval	+	6·5
True interval required...	3	31·5
Moon's meridian passage...	12	0
Mean time required...	8	28·5 P. M.

The results thus obtained do not require any correction on account of the equation of time, that correction being already made in the meridian passages inserted in the Almanac.

EXAMPLE 2.

At Madras, the shadow measured being $5^{f.}$ $9^{in.}$,—required the time of the night, supposing the Moon's culmination to be at 15^{h} 6^{m}·7; the daily retardation, 48 minutes; the declination at the time of observation, 15° 20′ N.; and the number of days elapsed since Full-moon, three.

Hence, the number of days to the fourth quarter is four; and the computation stands as follows,

Given shadow...	$5^{f.}$	$9^{in.}$
Correction to the Moon's centre...	+	0·6
Do. for parallax...	—	1
	5	8·6

Quantity from the Table for 13° N. latitude answering to $5^{f.}\ 8^{in}\cdot 6$ and 15° 20′ N. decln.	$3^h\ 47^m\cdot 3$
Proportional part of the daily retardation corresponding to $3^h\ 47^m$	+ 7·3
True interval required...	3 54·6
Moon's meridian passage...	15 6·7
Mean time required...	11 12·1

When the time of observation is not very far from that of the Moon's culmination, and it is necessary to repeat the observations at short intervals as recommended in article (19), it will be sufficient, in finding the several intervals from the meridian, to use that declination only which corresponds to the middle of the observed times.

57. The elements of declination and meridian passage made use of in the foregoing examples, and which are essential to the solutions, were obtained from the Nautical Almanac. The meridian passage, however, is inserted in the Almanacs published at this Presidency, but it is to be regretted that so important an element as the declination of the Moon should be omitted from those publications, especially when one of the quantities necessary for the determination of its place is virtually given. It appears to the author that the declination calculated to the time of transit may be conveniently inserted in one of the columns at present occupied by the times of the rising and setting of the Moon; for as only one of these phenomena is of practical utility in consequence of the other's happening during the presence of the Sun, it is evident that the latter may be omitted, and that therefore, both phenomena may be incorporated and exhibited in the same column.

58. Were the above suggestion adopted, and carried into effect in the future issues of the Madras Almanac, it would no doubt prove a great convenience; but in the absence of this being done, it becomes necessary to provide within this Work, the means of determining the Moon's declination, to such a degree of accuracy at least, as may be sufficient for the purposes of the accompanying Tables.

59. The Moon's declination, unlike that of the Sun, is dependant upon quantities that are very variable. The inclination of its orbit to the ecliptic fluctuates between 5° and 5° 18′, while the nodes themselves retrograde (or travel in a direction contrary to the order of the twelve signs) at the rate of 19° 19′·7 annually. Inconsequence of the disturbing forces of the Sun, Earth, and the other Planets, but especially of the first two, even the latter quantity is not constant, and in fact, every element of the Moon's orbit is subject to a perpetual variation.

60. In the three Tables which follow, and from which it is intended to find the Moon's declination, the obliquity of the Lunar orbit, has been supposed to be constant, and equal to 5° 9′; and the regression of the nodes equable. It will be seen, therefore, that a great many equations depending upon solar perturbation, have been omitted, and that the declinations given by the Tables cannot inconsequence be precise. The greatest error, however, does not exceed 10 or 11 minutes, and this happens only when the Moon is in syzygies or quadratures.

61. Assuming the equable regression of the nodes, Table 1. exhibits in time for the first day of every month of the years from 1845 to 1860, the distance between the first

point of Aries, and the intersection of the Moon's orbit with the equator; the arc being determined by the solution of a spherical triangle in which two angles and the included side are given, or, by taking the difference of the two arcs, whose tangents are

$\frac{\cos. \frac{1}{2}(w-v)}{\cos. \frac{1}{2}(w+v)} . \tan. \frac{1}{2} l$ and $\frac{\sin. \frac{1}{2}(w-v)}{\sin. \frac{1}{2}(w+v)} . \tan. \frac{1}{2} l$ respectively;

where l denotes the longitude of the Moon's ascending node, $v = 5° 9'$, and $w = 23° 28'$, the obliquity of the ecliptic to the equator.

62. Table 2, exhibits the angle of this intersection, varying from 18° 19′ to 28° 37′, and may be calculated, with the aid of the results embodied in Table 1, by the expression

$$\sin. \ I = \frac{\sin l. \sin. v}{\sin. r},$$

where I represents the inclination sought, and r the results of Table 1: or, independently of those results, by the formula,

$$\cos. I = \cos. l. \sin. v. \sin. w - \cos. v. \cos. w.$$

which is well adapted for the computation of Tables, by the expressions sin. v. sin. w, and cos. v. cos. w being invariable.

63. Table 3, shows generally the declinations corresponding to any given right ascension and obliquity, and has been calculated by the formula

$$\tan. \text{decn.} = \tan. \text{obly.} \times \sin. \text{rt. ascn.};$$

but, as in the case of the Moon, the intersection of its orbit with the equator does not coincide with the first point of Aries, it is evident that the Right ascensions registered in the Table are equal to the real Right ascensions of the Moon, increased or diminished by the quantities in Table 1.

64. Hence, before we can find the Moon's declination at any given time by these Tables, it is necessary first to determine its right ascension. This may be done by taking the Sun's right ascension on the given day, applying to it the equation of time(1) with a contrary sign, and adding to the result the Moon's meridian passage converted into sidereal time by the addition of one minute for every six hours.(2) The sum (deducting 24 hours if necessary,) will be the Moon's right ascension at the time of transit, and will therefore require to be corrected by the addition or subtraction of a proportional part of the daily retardation(3) according as the given time is subsequent or antecedent to that phenomenon.

65. The Moon's right ascension being thus obtained, the declination corresponding to it may be ascertained as follows. To the former quantity apply the number from Table 1, answering to the given day and year. The result will be the Moon's modified right ascension, or that reckoned from the ascending node. Also, from Table 2. determine the obliquity of the Lunar orbit to the equator. Then look for the modified right ascension (diminished by 12 hours if necessary) in the *first* or *last* vertical column of Table 3, and for the obliquity at the top, and take out the declination sought; which will be north, if the modified right ascension be less, but south if it be greater, than 12 hours.

---

(1) Properly speaking, the equation should be reduced to sidereal time before being applied. The sum or difference will be the *sidereal time* at mean noon; and may also be found by the tables given in article (73).

(2) A sidereal day being equal in length to 23h. 56m. 4s·09 of mean time 24 hours of the latter are equal to 24h. 3m. 56s·55 of the former; consequently 6 hours of mean time are equal to 6h. 0m. 59s·14 of sidereal time. Hence the reason of the rule.

(3) Strictly, the daily increase of right ascension.

TABLE 1. Showing the correction to be applied to the Moon's Right ascension to obtain the first argument of Table 3.

Year.	January	February	March	April	May	June	July	August	September	October	November	December
	m.	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*
1845	+ 50·2	+ 49·7	+ 49·2	+ 48·7	+ 48·1	+ 47·5	+ 46·8	+ 46·0	+ 45·2	+ 44·4	+ 43·5	+ 42·6
1846	41·6	40·6	39·5	38·4	37·2	36·0	34·7	33·4	32·0	30·6	29·1	27·6
1847	26·1	24·6	23·0	21·4	+ 19·8	+ 18·1	+ 16·4	+ 14·7	+ 12·9	+ 11·1	+ 9·3	+ 7·5
1848	+ 5·6	+ 3·8	+ 1·9	+ 0·0	− 1·9	− 3·7	− 5·5	− 7·3	− 9·1	− 10·9	− 12·7	− 14·5
1849	− 16·2	− 17·9	− 19·6	− 21·2	22·8	24·4	26·0	27·5	29·0	30·4	31·8	33 2
1850	34·6	35·9	37·1	38·3	39·4	40·5	41·5	42·5	43·4	44·3	45·1	45·9
1851	46·7	47·4	48·0	48·6	49·1	49·6	50·1	50·5	50·9	51·3	51·5	51·7
1852	51·9	52·0	52·1	52·1	52·1	52·0	51·9	51·8	51·7	51·5	51·2	50·9
1853	50·6	50·3	49·9	49·5	49·1	48·6	48·1	47·6	47·0	46·1	45·8	45·1
1854	44·4	43·7	43·0	42·3	41·5	40·7	39·9	39·1	38·2	37·3	36·4	35·5
1855	34·5	83·5	32·6	31·6	30·6	29·6	28·5	27·4	26·4	25·3	24·2	23·1
1856	22·0	20·9	19·8	18·6	17·4	16·3	15·1	− 13 9	− 12·8	− 11·6	− 10·4	− 9·2
1857	− 8·0	− 6·8	− 5·7	− 4·5	− 3·3	− 2·1	− 0·9	+ 0 4	+ 1·6	+ 2·8	+ 4·0	+ 5·2
1858	+ 6·4	+ 7·6	+ 8·8	+ 10·0	+ 11 2	+ 12·3	+ 13·5	14·7	15·8	17·0	18 2	19·3
1859	20·4	21·5	22·6	23·7	24·8	25·9	27·0	28·1	29·1	30·1	31 1	32·1
1860	+ 33·1	+ 34·1	+ 35·1	+ 36·0	+ 36·9	+ 37·8	+ 38·7	+ 39·5	+ 40·3	+ 41·1	+ 41·8	+ 42·5

TABLE 2.

Showing the obliquity of the Moon's orbit to the Equator, which forms the second argument of Table 3.

Year.	January	February	March	April	May	June	July	August	September	October	November	December
1845	21° 35′	21° 26′	21° 18′	21° 10′	21° 2′	20° 54′	20° 47′	20° 39′	20° 31′	20° 24′	20° 16′	20° 9′
1846	20 2	19 55	19 48	19 42	19 36	19 30	19 24	19 18	19 13	19 8	19 3	18 58
1847	18 53	18 49	18 45	18 41	18 38	18 35	18 32	18 29	18 26	18 24	18 22	18 21
1848	18 20	18 20	18 19	18 19	18 19	18 19	18 20	18 21	18 22	18 24	18 26	18 28
1849	18 31	18 34	18 37	18 41	18 45	18 49	18 53	18 57	19 2	19 7	19 12	19 17
1850	19 23	19 29	19 35	19 41	19 47	19 54	20 1	20 8	20 15	20 23	20 30	20 38
1851	20 46	20 54	21 1	21 9	21 17	21 25	21 34	21 43	21 51	22 0	22 9	22 17
1852	22 26	22 34	22 42	22 51	23 0	23 8	23 17	23 26	23 35	23 44	23 53	24 1
1853	24 9	24 18	24 26	24 34	24 43	24 51	24 59	25 7	25 15	25 22	25 30	25 38
1854	25 45	25 53	26 0	26 7	26 14	26 21	26 27	26 34	26 41	26 47	26 53	26 59
1855	27 5	27 11	27 16	27 21	27 26	27 31	27 36	27 41	27 46	27 50	27 54	27 58
1856	28 2	28 6	28 9	28 12	28 15	28 18	28 21	28 24	28 26	28 28	28 30	28 32
1857	28 33	28 34	28 35	28 36	28 36	28 37	28 37	28 37	28 37	28 36	28 36	28 35
1858	28 34	28 33	28 32	28 30	28 28	28 26	28 24	28 22	28 19	28 16	28 13	28 10
1859	28 7	28 4	28 0	27 56	27 5[illegible]	27 48	27 43	27 38	27 34	27 29	27 24	27 19
1860	27 13	27 7	27 1	26 55	26 49	26 43	26 37	26 31	26 25	26 18	26 11	26 [illegible]

Table 3.

Showing the Declination of the Moon corresponding to any given Right ascension, and obliquity of its orbit.

Moon's Rt. ascen. corrected by number from Table 1		Obliquity of the Moon's orbit to the Equator.																								Moon's Rt. ascen. corrected by number from Table 1.	
		18°		19°		20°		21°		22°		23°		24°		25°		26°		27°		28°		29°			
h.	m.	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	h.	m.
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
	10	0	49	0	51	0	54	0	57	1	1	1	4	1	7	1	10	1	13	1	16	1	20	1	23	11	50
	20	1	37	1	43	1	49	1	55	2	1	2	7	2	13	2	20	2	26	2	32	2	39	2	46		40
	30	2	26	2	31	2	43	2	52	3	1	3	10	3	20	3	29	3	39	3	48	3	58	4	8		30
	40	3	14	3	26	3	37	3	49	4	1	4	13	4	25	4	38	4	50	5	3	5	17	5	50		20
0	50	4	1	4	16	4	30	4	45	5	0	5	15	5	30	5	46	6	2	6	18	6	34	6	50		10
1	0	4	48	5	6	5	23	5	40	5	58	6	16	6	34	6	53	7	12	7	31	7	50	8	10	11	0
	10	5	35	5	55	6	15	6	35	6	55	7	16	7	37	7	59	8	20	8	43	9	5	9	28	10	50
	20	6	20	6	43	7	6	7	29	7	52	8	16	8	40	9	4	9	28	9	53	10	18	10	44		40
	30	7	5	7	30	7	56	8	21	8	47	9	14	9	40	10	7	10	34	11	2	11	30	11	59		30
	40	7	49	8	16	8	45	9	13	9	41	10	10	10	39	11	9	11	39	12	9	12	40	13	11		20
1	50	8	32	9	2	9	32	10	3	10	34	11	5	11	37	12	9	12	42	13	14	13	48	14	21		10
2	0	9	14	9	46	10	19	10	52	11	25	11	59	12	33	13	8	13	42	14	18	14	53	15	30	10	0
	10	9	54	10	29	11	4	11	39	12	15	12	51	13	27	14	4	14	41	15	19	15	57	16	35	9	50
	20	10	33	11	10	11	48	12	25	13	3	13	41	14	20	14	59	15	38	16	18	16	58	17	38		40
	30	11	11	11	50	12	30	13	9	13	49	14	29	15	10	15	51	16	32	17	14	17	56	18	39		30
	40	11	48	12	29	13	10	13	52	14	34	15	16	15	58	16	41	17	24	18	8	18	52	19	37		20
2	50	12	23	13	6	13	49	14	32	15	16	16	0	16	45	17	29	18	14	19	0	19	45	20	32		10
3	0	12	56	13	41	14	26	15	11	15	57	16	43	17	29	18	15	19	2	19	49	20	36	21	24	9	0
	10	13	28	14	15	15	1	15	48	16	35	17	23	18	10	18	58	19	47	20	35	21	24	22	14	8	50
	20	13	59	14	47	15	35	16	23	17	12	18	1	18	50	19	40	20	29	21	20	22	10	23	1		40
	30	14	27	15	17	16	7	16	56	17	46	18	37	19	27	20	18	21	9	22	1	22	52	23	45		30
	40	14	54	15	45	16	36	17	26	18	19	19	11	20	2	20	55	21	47	22	40	23	32	24	26		20
3	50	15	19	16	12	17	4	17	56	18	49	19	42	20	35	21	28	22	22	23	15	24	9	25	3		10
4	0	15	43	16	36	17	30	18	23	19	17	20	11	21	5	21	59	22	54	23	49	24	43	25	39	8	0
	10	16	5	16	59	17	54	18	48	19	43	20	38	21	32	22	28	23	24	24	19	25	15	26	11	7	50
	20	16	25	17	20	18	16	19	11	20	7	21	3	21	59	22	55	23	51	24	47	25	44	26	41		40
	30	16	43	17	39	18	35	19	32	20	28	21	25	22	22	23	18	24	15	25	13	26	10	27	7		30
	40	16	59	17	56	18	53	19	50	20	47	21	45	22	42	23	40	24	37	25	35	26	34	27	31		20
4	50	17	13	18	11	19	9	20	6	21	4	22	2	23	0	23	59	24	57	25	55	26	53	27	52		10
5	0	17	25	18	24	19	22	20	20	21	19	22	18	23	16	24	15	25	13	26	12	27	11	28	10	7	0
	10	17	36	18	35	19	34	20	33	21	32	22	31	23	30	24	29	25	28	26	27	27	26	28	25	6	50
	20	17	45	18	44	19	43	20	42	21	42	22	41	23	40	24	40	25	39	26	39	27	38	28	38		40
	30	17	52	18	51	19	31	20	50	21	50	22	50	23	49	24	49	25	48	26	48	27	48	28	48		30
	40	17	56	18	56	19	56	20	56	21	55	22	55	23	55	24	55	25	55	26	55	27	55	28	54		20
5	50	17	59	18	59	19	59	20	59	21	59	22	59	23	59	24	59	25	59	26	59	27	59	28	59		10
6	0	18	0	19	0	20	0	21	0	22	0	23	0	24	0	25	0	26	0	27	0	28	0	29	0	6	0

EXAMPLE 1.

Required the declination of the Moon at 2 o'clock A. M. on the 28th of May 1845, at Madras.

The given time being, in astronomical reckoning, the 14th. hour of the 27th. of May, we have the following computation.

Sun's right ascension on the 27th. of May from the almanac........................	4^h	16^m
Equation of time on do. with a contrary sign.	+	3
Sidereal time at mean noon....................	4	19
Moon's meridian passage on the 27th., viz. $17^h\ 52^m$ converted to sidereal time.....	17	55
∴ Moon's right ascen. when on the meridian.	22	14
The retardation on the 27th. being 51^m, the proportional part of it due to $3^h\ 52^m$, the interval between the given hour and the moon's transit, is................		7·8
∴ Moon's right ascension at the given hour.	22	6·2
Number from Table 1....	+	47·6
Modified Right ascension...	22	53·8

The quantity from Table 3, answering to this right ascension (diminished by 12 hours) and 20° 55′ the obliquity on the given day, is 6° 12′, which is, consequently, the required declination; and it is south, since the modified right ascension is greater than 12 hours.

EXAMPLE 2.

Required the Moon's declination at Sedashegur in longitude 74° 13′ E. on the 16th. of March 1845, at 9 o'clock P. M.

Since the Moon passes the Meridian of Madras on the given day at $6^h\ 27^m$, and the difference of longitude between

Sedashegur and Madras is $80^\circ\ 15' - 74^\circ\ 13' = 6^\circ\ 2'$, or $\frac{2}{5}$ of an hour in time nearly, we have $\frac{48^m \text{ (the daily retardn.)}}{24} \times \frac{2}{5} = \frac{4}{5}$ of a minute, for the difference between the times of transit at Madras and Sedashegur: hence, the moon culminates at the latter place at $6^h\ 27^m + \frac{4}{5}^m = 6^h\ 27^m\frac{4}{5}$. Therefore, we have the following computation.

Sidereal time at mean noon on the 16th. of March, from the Tables in article (73)....	23^h	35^m
Moon's meridian passage at Sedashegur converted to sidereal time....................	6	29
∴ Moon's right ascension at transit.........	6	4
Proportional part of the daily retardation due to $2^h\ 32^m$	+	5
Moon's right ascension at the given hour...	6	9
Number from Table 1...	+	49
Modified right ascension...	6	58

The obliquity on the given day being 21° 14′, the declination required is found from Table 3, to be 20° 37′ N.

66. An allowance for difference of longitude has been made in the preceding example in reducing the transit of the Moon as registered in the almanac, from the meridian of Madras to that of Sedashegur. This correction was obviously necessary as its omission would have produced an error of nearly one minute of time in the result; but it is at the same time to be borne in mind that the example we have selected is an extreme case, and that for places situated in other parts of the Presidency, the reduction would hardly have been called for. When any instance of this kind presents itself, it will rest with the observer to determine whether al-

lowances for difference of longitude need be entertained in his calculations with reference to the degree of accuracy he may expect from the final results.

67. Bearing in mind the observations made with reference to the Sun in article (39), we may, by a process analogous to that described in it, find the times of the rising and setting of the Moon on any given day.

Example.

Required the time when the Moon rose and set at Madras on the 1st. June 1845, on which day her transit was at $21^h\ 46^m$, and daily retardation $47^m \frac{1}{2}$.

By proceeding as in Example 1 or 2 of article (65), we find that the Moon's right ascension when on the meridian was $2^h\ 28^m$. Consequently, her declination ascertained from Table 3, is 16° 2′ N. The number from Table IV. of the General Tables answering to this declination, and 13° 5′ latitude, is 667, the semi-diurnal arc corresponding to which from Table V. is $6^h\ 15^m$. Since the Moon's retardation was $47^m \frac{1}{2}$, the change of right ascension due to $6^h\ 15^m$ is by article (55) $12^m \cdot 0$ Hence the Moon's right ascension when rising, was $2^h\ 28^m - 12^m = 2^h\ 16^m$; and when setting, $2^h\ 28^m + 12^m = 2^h\ 40^m$. The declinations answering to these right ascensions being 15° 19′ N. and 16° 43′ N, the semi-diurnal arcs at the times of rising and setting are $6^h\ 14^m \frac{3}{5}$ and $6^h\ 16^m$ respectively. Consequently, $21^h\ 46^m - (6^h\ 14^m \frac{3}{5} + 12^m) = 15^h\ 19^m \frac{2}{5}$ was the time of the Moon's rising, and $21^h\ 46^m + (6^h\ 16^m + 12^m) = 4^h\ 14^m$ of the 2nd. of June was the time of setting required.

68. But, as observed with regard to the sun in art. (40), the times of rising and setting thus obtained, are the times

when the Moon is really in the eastern and western horizon, and not the times of her appearance and disappearance; which phenomena, inconsequence of her parallax exceeding the amount of refraction by about 24′, take place when she is so much *above* the horizon. The two semi-diurnal arcs, therefore, must be reduced by the time required to pass through this arc (which is about one minute and a half), before being applied to the meridian passage; or, which is the same thing, the times of rising and setting computed as in the foregoing example, should be increased and diminished respectively by that quantity, to obtain the times of the Moon's actual appearance and disappearance.

69. Thus, with the exception of the meridian passage, we have provided every thing necessary for the determination of time by means of observations of the shadow made in Moon-light. In the case of the fixed stars, upon the consideration of which we now propose to enter, their transits may be easily predicted, and the only operation involving any difficulty is that of finding their altitudes.

70. As the time denoting the transit of a Star is reckoned from mean noon, and represents the period elapsed since the occurrence of that phenomenon, it is obvious, that if it be converted into sidereal time, it would be equal to the difference between the right ascension of the Star (increased by 24^h, if necessary,) and the right ascension of the meridian at mean noon. Hence, since the first term is very nearly a constant quantity, the determination of the sought transit rests exclusively on a knowledge of the right ascension of the meridian, or as it is generally called, sidereal time at mean noon.

71. The motion of the earth round its axis being perfect-

ly uniform, and equal at all times of the year, any terrestrial meridian revolves from a Star to the Star again in the same quantity of time, viz. $23^h\ 56^m\ 4^s \cdot 09$; while its mean revolution from the Sun to the Sun again is performed in 24 hours. Hence, a sidereal day falls short of a mean solar day by $3^m\ 55^s \cdot 91$ of the latter reckoning, or $3^m\ 56^s \cdot 55$* of the former. Consequently, if the sidereal time at mean noon of Jan. 1, of any year be known, the sidereal time at mean noon of any other day may be found by multiplying $3^m\ 56^s \cdot 55$ by the number of days elapsed since Jan. 1, and adding the product to the given time.

72. The first of the following Tables, accordingly, represents to the nearest tenth of a minute in the longitude of Madras, the sidereal time at mean noon of Jan. 1. of the years from 1845 to 1860, calculated by the formula,

$$S = 18^h\ 42^m\ 41^s \cdot 44 + t.\ 1^s \cdot 84038 + t^2.\ 0^s \cdot 000008 - f.\ 59^s \cdot 139 + \text{Equation of the equinoxes};$$

where S denotes the sidereal time required, t the given year reckoned from 1800, and f for the 19th. Century, the number of years from the *preceding* leap year. Vide, Preface to the Nautical Almanac.

73. The second Table exhibits with like precision the multiples of $3^m\ 56^s \cdot 55$ corresponding to any given day and month; so that the sidereal time at mean noon for that day is found by simply adding the quantity inserted in it, to the quantity from the first Table answering to the given year, and rejecting 24^h from the sum when it exceeds one sidereal day.

* This quantity is styled in astronomical language, the daily acceleration of sidereal on mean time.

Tables for determining the Sidereal time at mean noon of any given day.

I.

Year	Sidereal time at mean noon of January 1. h.	m.
1845	18	43·1
1846	18	42·1
1847	18	41·2
1848	18	40·2
1849	18	43·2
1850	18	42·3
1851	18	41·3
1852	18	40·3
1853	18	43·3
1854	18	42·4
1855	18	41·4
1856	18	40·5
1857	18	43·5
1858	18	42·5
1859	18	41·5
1860	18	40·6

N. B. In leap years, if the given day be subsequent to the 28th. of February, the quantity from the above Table answering to the day *following*, should be selected.

II.

Day	Jan. h. m.	Feb. h. m.	Mar. h. m.	April h. m.	May h. m.	June h. m.	July h. m.	Aug. h. m.	Sept. h. m.	Oct. h. m.	Nov. h. m.	Dec. h. m.
1	0 0·0	2 2·2	3 52·6	5 54·8	7 53·1	9 55·3	11 53·6	13 55·8	15 58·0	17 56·3	19 58·5	21 56·8
2	3·9	6·2	3 56·6	5 58·8	7 57·1	9 59·3	11 57·5	13 59·8	16 2·0	18 0·3	20 2·5	22 0·8
3	7·9	10·1	4 0·5	6 2·7	8 1·0	10 3·2	12 1·5	14 3·7	5.9	4·2	6·4	4·7
4	11·8	14·0	4·4	6·7	4·9	7·2	5·4	7·7	9·9	8·2	10·4	8·7
5	15·8	18·0	8·4	10·6	8·9	11·1	9·4	11·6	13·8	12·1	14·3	12·6
6	19·7	21·9	12·3	14·5	12·8	15·0	13·3	15·5	17·8	16·0	18·3	16·5
7	23·7	25·9	16·3	18·5	16·8	19·0	17·3	19·5	21·7	20·0	22·2	20·5
8	27·6	29·8	20·2	22·4	20·7	22·9	21·2	23·4	25·6	23·9	26·1	24·4
9	31·5	33·8	24·2	26·4	24·6	26·9	25·1	27·4	29·6	27·9	30·1	28·4
10	35·5	37·7	28·1	30·3	28·6	30·8	29·1	31·3	33·5	31·8	34·0	32·3
11	39·4	41·6	32·0	34·3	32·5	34·8	33·0	35·3	37·5	35·7	38·0	36·2
12	43·4	45·6	36·0	38·2	36·5	38·7	37·0	39·2	41·4	39·7	41·9	40·2
13	47·3	49·5	39·9	42·1	40·4	42·6	40·9	43·1	45·4	43·6	45·9	44·1
14	51·3	53·5	43·9	46·1	44·4	46·6	44·9	47·1	49·3	47·6	49·8	49·1
15	55·2	2 57·4	47·8	50·0	48·3	50·5	48·8	51·0	53·2	51·5	53·7	52·0
16	0 59·1	3 1·4	51·8	54·0	52·2	54·5	52·7	55·0	16 57·2	55·5	20 57·7	56·0
17	1 3·1	5·3	55·7	6 57·9	8 56·2	10 58·4	12 56·7	14 58·9	17 1·1	18 59·4	21 1·6	22 59·9
18	7·0	9·2	4 59·6	7 1·9	9 0·1	11 2·4	13 0·6	15 2·8	5·1	19 3·3	5·6	23 3·8
19	11·0	13·2	5 3·6	5·8	4·1	6·3	4·6	6·8	9·0	7·3	9·5	7·8
20	14·9	17·1	7·5	9·7	8·0	10·2	8·5	10·7	13·0	11·2	13·5	11·7
21	18·9	21·1	11·5	13·7	12·0	14·2	12·5	14·7	16·9	15·2	17·4	15·7
22	22·8	25·0	15·4	17·6	15·9	18·1	16·4	18·6	20·8	19·1	21·3	19·6
23	26·7	29·0	19·3	21·6	19·8	22·1	20·3	22·6	24·8	23·1	25·3	23·6
24	30·7	32·9	23·3	25·5	23·8	26·0	24·3	26·5	28·7	27·0	29·2	27·5
25	34·6	36·8	27·2	29·5	27·7	30·0	28·2	30·4	32·7	30·9	33·2	31·4
26	38·6	40·8	31·2	33·4	31·7	33·9	32·2	34·4	36·6	34·9	37·1	35·4
27	42·5	44·7	35·1	37·3	35·6	37·8	36·1	38·3	40·6	38·8	41·1	39·3
28	46·4	3 48·7	39·1	41·3	39·6	41·8	40·1	42·3	44·5	42·8	45·0	43·3
29	50·4	—	43·0	45·2	43·5	45·7	44·0	46·2	48·4	46·7	48·9	47·2
30	54·3	—	46·9	7 49·2	47·4	11 49·7	47·9	50·2	17 52·4	50·7	21 52·9	51·2
31	1 58·3	—	5 50·9	—	9 51·4	—	13 51·9	15 54·1	—	19 54·6	—	23 55·1

EXAMPLE 1.

Required the sidereal time at mean noon of May 27th. 1845.

	h.	m.
Quantity from the 1st. table ans. to 1845	18	43·1
do. from the second table answering to the 27th. of May	9	35·6
Sidereal time required...	4	18·7

EXAMPLE 2.

Required the sidereal time at mean noon of March 16th. 1845.

	h.	m.
Quantity from the first Table...........	18	43·1
do. from the second do.	4	51·8
Sidereal time required...	23	34·9

EXAMPLE 3.

What will be the sidereal time at mean noon of May 26th. 1848.

Since the given year is a leap year, and the given day is subsequent to February 28th., we have,

	h.	m.
Quantity from the first table..............	18	40·2
do. from the second do. answering to the 27th. of May......	9	35·6
Sidereal time required...	4	15·8

EXAMPLE 4.

Required the transit of Regulus, or α Leonis on the 27th. of May 1845, its right ascension being $10^h\ 0^m{\cdot}1$.

	h.	m.
Sidereal time at mean noon of the given day as determined in example 1..............	4	18·7
Right ascension of the given star..............	10	0·1
Sidereal interval between Mean noon and the Star....................................	5	41·4

which, being converted into mean time,* gives $5^h\ 40^m{\cdot}5$ P. M. for the time of transit required.

74. It is to be carefully observed that the sidereal time at mean noon is the quantity to be always subtracted from the Star's right ascension, the latter being increased by 24^h, when it is less than the former. Thus, in the preceding example, had the sidereal time been $10^h\ 0^m{\cdot}1$ and the Star's right ascension $4^h\ 18^m{\cdot}7$, the sidereal interval would have been $18^h\ 18^m{\cdot}6$ instead of $5^h\ 41^m{\cdot}4$.

75. The right ascension of α Leonis adduced in the preceding example has been obtained from the Nautical Almanac, but as this Ephemeris may not be accessible to all persons, we shall for the convenience of our readers, subjoin a list of such of the principal fixed Stars, as, with reference to their declinations, fall within the limits of the accompanying Tables.

Mean places of 57 principal fixed Stars for Jan. 1. 1848.

Star's name.	Mag.	Right ascension.		Annual Variation	Declination.		Annual Variation
		h.	m.	m.	°	′	′
α Andromedæ (*Alpherat*)	1	0	0·5	+ 0·05	N. 28	15·1	+ 0·33
γ Pegasi (*Algenib*)......	2·3	0	5·4	·05	N. 14	20·8	·33
β Ceti	2·3	0	36·0	·05	S. 18	53·9	·33
θ^1 Ceti	3	1	16·4	·05	S. 9	2·5	·32
α Arietis	3	1	58·6	·06	N. 22	44·5	·29
γ Ceti	3	2	35·4	·05	N. 2	35·5	·26
α Ceti (*Menkar*)........	2·3	2	54·3	·05	N. 3	29·4	·24
η Tauri (*Pleides*)........	3	3	38·4	·06	N. 23	37·9	·19
γ^1 Eridani..	2·3	3	50·9	·05	S. 13	59·1	·18
α Tauri (*Aldebaran*) . ..	1	4	27·2	·06	N. 16	11·9	·13
β Orionis (*Rigel*)	1	5	7·2	·05	S. 8	23·9	·08
β Tauri	2	5	16·7	·06	N. 28	28·4	·06
γ Orionis (*Bellatrix*)	2	5	17·1	·05	N. 6	12·7	·07
δ Orionis	2	5	24·2	+ ·05	S. 0	25·7	+ ·05

* Since a sidereal day is equal to 23h. 56m. 4s·09 of a mean solar day 6h. of the former are equal to 5h. 59m. 1s·02 of the latter. Hence, sidereal time may be converted into mean time by deducting at the rate of 59s. or nearly one minute, for every six hours.

Mean places of 57 principal fixed Stars for Jan. 1, 1848.

Star's name.	Mag.	Right ascension.		Annual Variation	Declination			Annual Variation
		h.	m.	m.		°	′	′
α Orionis (*Betelgeux*)	1	5	46·9	+ 0·05	N.	7	22·4	+ 0·0[illegible]
μ Geminorum	3	6	13·7	·06	N.	22	35·2	− ·02
α Can. Maj. (*Sirius*)	1	6	38·4	·04	S.	16	29·7	·07
α² Geminorum (*Castor*).	3	7	24·9	·06	N.	32	1[illegible]·0	·12
α Can. Min. (*Procyon*)	1·2	7	31·3	·05	N.	5	36·6	·14
β Geminorum (*Pollux*)	2	7	37·0	·06	N.	28	23·3	·13
15 Argus	3·4	8	1·1	·04	S.	23	49·8	·17
ε Hydræ	4	8	38·7	·05	N	6	58·4	·21
α Hydræ (*Cor. Hydræ*)	2	9	20·1	·05	S.	7	56·6	·26
ε Leonis	3	9	37·2	·06	N.	24	28·3	·27
α Leonis (*Regulus*)	1	10	0·3	·05	N.	12	42·5	·29
γ Leonis	2	10	11·6	·06	N.	20	36·9	·29
δ Leonis	3	11	6·0	·05	N.	21	21·4	·32
β Leonis (*Deneb*)	2·3	11	41·3	·05	N.	15	25·3	·33
β Corvi	2·3	12	26·4	·05	S.	22	28·6	·33
ε Virginis (*Vindemiatrix*).	3	12	54·6	·05	N.	12	46·7	·32
α Virginis (*Spica*)	1	13	17·2	·05	S.	10	17·5	·31
η Bootis	3	13	47·4	·05	N.	19	9·8	·[illegible]0
α Bootis (*Arcturus*)	1	14	8·7	·05	N.	19	58·6	·31
ε Bootis (*Mirac*)	3	14	38·[illegible]	·04	N.	27	43·1	·26
β Libræ	2·3	15	8·8	·05	S.	8	45·9	·25
α Cor. Bor. (*Alpheta*)	2	15	28·3	·04	N.	27	13·8	·21
α Serpentis	2·3	15	36·8	·05	N.	6	54·5	·20
β¹ Scorpii	2	15	56·6	·06	S.	19	20·6	·17
δ Ophiuchi	3	16	6·4	·05	S.	3	15·6	·16
α Scorpii (*Antares*)	1	16	20·1	·06	S.	26	3·4	·14
α Herculis (*Ras Algethi*).	3·4	17	7·7	·05	N.	14	34·1	·08
α Ophiuchi (*Ras Alhague*).	2	17	27·9	·05	N.	12	40·6	− ·05
μ¹ Sagittarii	3·4	18	4·7	·06	S.	21	5·6	+ ·01
β Lyræ	3	18	44·5	·04	N.	33	11·4	·06
ζ Aquilæ	3	18	58·4	·05	N.	13	38·6	·08
δ Aquilæ	3·4	19	17·8	·05	N.	2	49·0	·11
γ Aquilæ	3	19	39·0	·05	N.	10	14·8	·14
α Aquilæ (*Altair*)	1·2	19	43·3	·05	N.	8	29·2	·15
α² Capricorni	3	20	9·6	·06	S.	13	3·1	·18
ε Cygni	3	20	40·9	·04	N.	33	23·9	·21
ζ Cygni	3	21	6·5	·04	N.	29	36·4	·24
β Aquarii	3	21	23·5	·05	S.	6	17·8	·26
ε Pegasi	2·3	21	36·7	·05	N.	9	10·9	·27
α Aquarii	3	21	58·0	·05	S.	1	7·4	·29
ζ Pegasi	3	22	33·8	·05	N.	10	2·4	·31
α Pis Australis (*Fomalhaut*)	1	22	49·2	·06	S.	30	30·0	·32
α Pegasi (*Markab*)	2	22	57·2	+ ·05	N.	14	23·3	+ ·32

76. Although the declinations of some of the Stars inserted in the above list, exceed 24°, (the limit to which the

General Tables Nos. II. and IV. are carried), yet it is to be remarked that they are not on this account without the limits of those Tables; for the formula in art. (31) being symmetrical with regard to the quantities L and D, it is obvious that either of them may be substituted for the other without altering the nature of the expression; so that when we have a declination greater than 24° to deal with, we have merely to look for it in the column of latitudes; and for the latitude, in the column of declinations; and then to find out the number sought in the usual manner.

77. The altitude of the Stars which is the only element now remaining to be determined, may be easily ascertained by means of a quadrant, sextant, or any other instrument for measuring vertical angles; and then by calculating the shadow corresponding to that altitude, the time required may be evolved by a process similar to that employed in the case of the Sun and Moon. But as the use of such expensive instruments would not accord with our purpose, we must have recourse to some other expedient for ascertaining the shadow.

78. If a plane reflecting medium were interposed horizontally between the eye and a Star, and the eye be moved backwards and forwards until the image of the Star appear in it, the height of the eye above the plane of the reflecting surface, would evidently be the co-tangent of the angle of reflection to a radius equal to the distance of the eye from the point of incidence: but the angle of reflection is, by a well-known optical law, equal to the angle of incidence, which, in the case of a Star, represents the zenith distance of that luminary. Hence, the co-tangent of the zenith distance, or the tangent of the altitude, is equal to the height

of the eye divided by the aforesaid distance, and consequently when the height of the eye is four feet, its distance from the cathetus, or perpendicular at the point of incidence would, by art. (1) represent the length of the shadow of a rod of the same height intercepting the rays emitted from the Star.

79. To find the shadow corresponding to the altitude of any Star, therefore, place a mirror or looking glass on the ground, in a horizontal position(1) between yourself and the star; and with the eye resting on the top of a rod of four feet, or viewing through a sight placed there, retire backwards, until the image of the Star becomes visible in the mirror; at which instant, observe the position of the radiant point, and measure the distance between it and the foot of the rod, for the shadow required.(2)

80. The above rule, if strictly attended to, will furnish the required shadow with great accuracy, but in the practical application of it there are circumstances which detract from its usefulness. The levelling of the mirror is an operation involving delay and difficulty; the contraction of the field of view as the eye retires from the reflecting surface, renders it extremely difficult to identify any particular star; and the distance from it at the time of observation makes it almost impossible to note correctly the position of the radiant point. For these reasons, the following rule seems to possess greater advantages.

81. Fix the rod perpendicularly on a level piece of

---

(1) The horizontality of the glass may be tested by holding a plumb-line over its surface and seeing whether the reflected image of it appears in the same straight line with the direct one.

(2) If the mirror be elevated above the ground on a frame, the lower end of the rod must be raised to the same level.

ground, by attaching it to some support, as the frame of a chair &c.; then, retiring backwards in a straight line with the rod and the star, place the mirror on the ground in such a position that the reflected images of the Star and the top of the rod may seem to coincide. Note the point of the surface in which the coincidence appears to take place,* and measure the distance between it and the foot of the rod for the shadow required.

82. In the above method, as the point of incidence only of the rays issuing from the Star and touching the top of the rod, is observed, and the course of the emergent rays is totally disregarded, it is obvious, that whatever be the inclination of the mirror to the horizon, it can have no effect upon the distance of the point of coincidence from the rod, provided both of these be on the same level; a circumstance which is essential to the operation, by the very hypothesis of article (78).

83. Having thus obtained the shadow corresponding to the altitude of any Star, the interval between the time of observation and that of transit, may be ascertained from the Tables in the usual manner, (see article 54,) but the interval must be diminished on account of the acceleration of sidereal time, before being applied to the computed mean time of transit.

84. The following examples, which are a faithful transcript of the observations made by the author, will elucidate

---

* Care is requisite in determining this point accurately, for the slightest motion in the eye of the observer will cause a corresponding change in its position on the surface of the glass.

the preceding rules.

EXAMPLE 1.

At Bellary, on the 13th of June 1845, the following observations were made,

			h.	m.	
Moon-Shadow	$2^{f.}$ $4^{in.}$	Time by watch	7	$48\frac{1}{2}$	P. M.
α Scorpii....	$6^{f.}$ $5\frac{3}{4}^{in.}$	do.	7	56	,,
β Leonis......	$2^{f.}$ $1^{in.}$	do.	8	3	,,

Required the error of the watch by each of the above observations.

BY THE MOON.

From the Almanac it appears that the Moon's meridian passage on the given day was 6^h 15^m, her retardation being 46^m. Also, as she was in the meridian about the time of sunset, she must have been in her first quarter.

	h.	m.
From Table 1. art. (73) we get for 1845......	18	43·1
do. 2, for 13th. June...	10	42·6
∴ Sidereal time at mean noon...	5	25·7
Moon's meridian passage in sidereal time.....	6	16·0
Moon's right ascension at transit...	11	41·7
Proportional part of retardation....	+	2·8
Moon's right ascension at the given hour...	11	44·5
Number from table 1 art. (65)....	+	47·2
Modified right ascension....	12	31·7

The obliquity on the given day ascertained from Table 2. of art. (65), being 20° 51′, we obtain from Table 3. of the same article, 3° S. for the Moon's declination at the time of observation.

	f.	*in.*
Again, measured shadow...	2	4
Correction for parallax...	—	0·5
True shadow...	2	3·5
Interval from the Table for 15° N. latitude answering to 2f. 3in·5, and 3° S. Dec....	*h.* 1	*m.* 36
Proportional part of retardation....	+	2·8
True interval...	1	38·8
Moon's meridian passage...	6	15·0
Mean time of observation...	7	53·8
Time by watch...	7	48·5
Watch slow...	0	5·3

By the Stars.

	α Scorpii		β Leonis	
	h.	*m.*	*h.*	*m.*
Sidereal time at mean noon...	5	25·7.......	5	25·7
Right ascension...	16	20·0.......	11	41·2
Sidereal interval to transit....	10	54·3.......	6	15·5
Mean time of transit...........	10	52·5.......	6	14·5
Intervals corresponding to declination and shadow reduced by amount of acceleration...	2	50·3......	1	53·7
Mean time of observation ...	8	2·2.......	8	8·2
Time by watch....	7	56·0.......	8	3·0
Watch slow...	0	6·2......	0	5·2

The results afforded by the Moon and β Leonis agree very nearly, and are more trust-worthy than that given by α Scorpii, which being a very southern star, his motion in altitude is slow, and consequently a trifling error in the measurement of the shadow would have a sensible effect upon the corresponding issue of the calculation. When practicable, it is always more advantageous to select a star whose motion is as near as possible vertical at the time of observation, than another whose course is more inclined.

EXAMPLE 2.

At Bellary, on the 27th. June 1845, the following stars were observed.

		f.	in.		h.	m.
α Leonis......	Shadow...	8	3	Time by watch...	8	8
β Leonis......	do. ...	3	4½	do.	8	12
δ Ophiuchi...	do. ...	2	2	do.	8	20½
α Ophiuchi...	do. ...	3	5	do.	8	26

Required the error of the watch by each of the above observations.

	h. m.
From table 1, art. (73) for 1845, we have.	18 43·1
do. 2, for 27th. June........	11 37·8
∴ Sidereal time at mean noon...	6 20·9

Hence, we have by

	α Leonis Dec. N. 12° 43′	β Leonis Dec. N. 15° 26′	δ Ophiuchi Dec. S. 3° 16′	α Ophiuchi Dec. N. 12° 41′
	h. m.	h. m.	h. m.	h. m.
Sid. time at M. noon....	6 20·9	6 20·9	6 20·9	6 20·9
Star's R. A....	10 0·2	11 41·2	16 6·2	17 27·8
Sidereal intervals.	3 39·3	5 20·3	9 45·3	11 6·9
M. time of transit.	3 38·7	5 19·4	9 43·7	11 5·1
Intervals to declination, shadow, and latitude corrected for acceleration...	4 24·5	2 44·5	1 27·5	2 43·0
M. time of observation.	8 3·2	8 3·9	8 16·2	8 22·1
Time by watch.....	8 8·0	8 12·0	8 20·5	8 26·0
Watch fast...	0 4·8	0 8·1	0 4·3	0 3·9

The results clearly show that some error must have been committed in determining the shadow corresponding to β Leonis. Therefore, rejecting the observation of this star, and taking the mean of the three others, we get 4^m nearly, as the quantity by which the watch was too fast.

EXAMPLE 3.

At Madras, on Nov. 9, 1847, the following observations were made.

	f.	in.		h.	m.
Aldebaran—shadow...	2	6·4	Time by watch	11	1 A. M.
Rigel......... do. ...	4	1·3	do.	11	11·5

Required the error of the watch.

	Aldebaran		Rigel	
	h.	m.	h.	m.
Sid. time at mean noon on the given day.........	15	11·3	15	11·3
Star's right ascension...	4	27·1	5	7·2
Sidereal intervals...	13	15·8	13	55·9
Mean time of transit....	13	13·6	13	53·6
Intervals to shadow, latitude, and declination reduced by acceleration... ...	2	12·9	2	42·4
Mean time of observation...	11	0·7	11	11 2
Time by watch...	11	1·0	11	11·5
Watch fast....	0	0·3	0	0·3

The results given by the two stars agree exactly. This circumstance must be attributed to the care with which the shadow was determined, for in order to note correctly the position of the point where the Star and the top of the rod appeared together, a line was drawn across the silvered surface of the glass, and during the observation, the mirror was moved about till the above point appeared on the line. Then, the required distance was accurately measured by means of a three-feet rule graduated to tenths of an inch.

85. The above method of finding the shadow corresponding to the altitude of the stars may, it is obvious, be employed with advantage in determining that of the Moon, when from the obscuration of the sky, or from the circumstance of her being near her conjunction, her light is not bright enough to cause a perceptible shadow. In such a case it will be best to observe her perfect limb, and correct for the centre by the addition or subtraction of the quantities in art. (14), according as that limb forms the upper or lower one.

86. It only remains for us to show how the times of the rising and setting of a star may be determined from the accompanying tables. The method of procedure is as follows. Take out from Table IV. of the General Tables, the number corresponding to the latitude of the place, and the declination of the star, and from Table V. the semi-diurnal arc answering thereto, which being corrected for acceleration, must be subtracted from the mean time of transit to obtain the time of the star's rising, and added to it, to obtain that of setting. The results being then corrected for refraction as in the case of the Sun (art. 40) will give the times of the Star's actual appearance and disappearance.

EXAMPLE 1.

Find the times of the rising and setting of Aldebaran at Madras on the 11th. of November 1847.

	h.	m.
Table 1, art. (73) for 1847...	18	41·2
do. 2, for 11th. Nov....	20	38·0
Sidereal time at mean noon...	15	19·2
Star's right ascension...	4	27·1
Sidereal interval...	13	7·9

Mean time of transit...	13	5·7
Number from Table IV. corresponding to 13° 5′ lat. and 16° 12′ dec. being 675, the semi-diurnal arc is 6^h 15^m·5, which being corrected for acceleration and refraction gives for the true semi-diurnal arc... ...	6	16·7
Hence the time of rising is...	6	49·0 P.M.
And that of setting...	19	22·4 or

7^h 22^m·4 A. M. of Nov. 12th.

Example 2.

Required the times of the rising and setting of Sirius at Rajahmundry on 12th. Nov. 1847.

	h.	m.
Table 1, art. 73, for 1847...	18	41·2
do. 2, for 12th. November...	20	41·9
Sidereal time at mean noon...	15	23·1
Star's right ascension...	6	38·4
Sidereal interval...	15	15·3
Mean time of transit...	15	12·8
Number from table IV, corresponding to 17° Lat. and 16° 30′ Dec. being 906, the semi-diurnal arc is (since the dec. is S.) 5^h 39^m·2 which being corrected for acceleration and refraction is...	5	40·5
Hence, the star rises at...	9	32·3 P. M.
And sets at...	20	53·3 or

8^h 53^m·3 A. M. of 13th. Nov.

87. In conclusion we shall add a few examples in further illustration of the rules.

EXERCISES.

(1). Suppose at Madras, on the 21st. of January 1848, the shadow measured in Moon-light be $5^{f.}\ 4\frac{1}{2}^{in.}$, what would be the time of night?

(2). At what time does the Moon rise and set at Bellary on the day mentioned in the previous example. Also the stars Sirius and Regulus?

(3). Being anxious to know the time at Seringapatam on the 12th. December 1847, and not having a rod of 4 feet, I stood directly between the corner of a building and the star α Orionis in the East, and then measuring the height of my eye and the point of the building which the star appeared to touch, found that the latter was $6^{f.}\ 4^{in.}$ above the former, while the distance between the two points was $20^{f.}\ 8^{in.}$. Required the time of night?

(4). What would be the length of shadow corresponding to the altitude of Sirius at Madras on the 21st. of January 1848, at 10 o'Clock P. M.?

END OF THE EXPLANATION.

TABLES.

Rule.—Having carefully measured the length of the shadow of a rod of four feet, held perpendicularly on the ground in sun-light, look for it in the first column of the Table which is headed by the latitude of the place, or which has the place of observation mentioned in the list at the bottom. Also, find the period which contains the day of observation. Then, in a line with the former and under the latter, will be found the interval in hours and minutes between noon and the time of observation.

When the shadow is not found exactly in the first column proceed as in Rule II. page 10. Also, when it is necessary to allow for changes of declination and latitude proceed as in Rule III. page 11, or adopt the quicker process explained in art. (38) page 26.

Length of the shadow		Dec 22 to Dec 29	Dec 30 to Jan. 4	Jan. 5 to Jan. 8	Jan. 9 to Jan. 11	Jan. 12 to Jan. 14	Jan. 15 to Jan. 17	Jan. 18 to Jan. 20	Jan. 21 to Jan. 23	Jan. 24 to Jan. 26	Jan. 27 to Jan. 29	Jan. 30 to Jan. 31	Feb. 1 to Feb. 3	Feb. 4 to Feb. 6	Feb. 7 to Feb. 9	Feb. 10 to Feb. 12	Feb 13 to Feb 15	Feb 16 to Feb 18	Feb 19 to Feb 21	Feb. 22 to Feb. 24
f.	in.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 19	0 32	0 40
	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 20	33	41	48
	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	34	43	49	0 55
	9	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	35	44	51	0 56	1 1
	10	.	.	.	.	.	.	.	.	.	.	.	.	0 22	35	45	52	0 58	1 3	7
	11	.	.	.	.	.	.	.	.	.	.	.	0 23	36	45	0 53	0 59	1 4	9	13
2	0	.	.	.	.	.	.	.	.	.	0 14	0 28	37	46	0 54	1 0	1 6	10	15	19
	1	.	.	.	.	.	.	.	.	0 21	32	40	47	0 54	1 1	7	12	16	20	24
	2	.	.	.	.	.	.	0 10	0 26	36	43	50	0 55	1 2	8	13	17	21	25	28
	3	.	.	.	.	.	0 19	31	39	46	0 52	0 58	1 2	8	14	19	23	26	30	33
	4	.	.	.	0 16	0 27	35	43	50	0 55	1 0	1 5	9	14	19	24	28	31	35	38
	5	.	0 11	0 26	34	41	46	0 53	0 58	1 3	7	12	15	20	25	29	33	36	39	42
	6	0 24	33	40	46	51	0 56	1 1	1 5	10	14	18	21	26	30	34	37	41	44	46
	7	38	45	50	0 55	0 59	1 3	8	12	16	20	24	26	31	35	39	42	45	48	50
	8	49	0 54	0 59	1 3	1 6	10	14	18	22	25	29	31	36	40	43	46	49	52	54
	9	0 58	1 2	1 6	10	13	16	20	24	27	30	34	36	41	44	47	50	53	1 56	1 58
	10	1 6	9	13	16	19	22	26	29	32	35	38	41	45	48	51	54	1 57	2 0	2 2
	11	13	16	19	22	25	28	31	34	37	40	43	46	49	52	55	1 58	2 1	4	6
3	0	19	22	25	28	30	33	36	39	42	45	47	50	1 53	1 56	1 59	2 2	5	7	9
	2	30	32	35	38	40	42	45	48	51	1 53	1 55	1 58	2 1	2 4	2 7	9	12	14	16
	4	40	42	45	47	49	51	1 54	1 56	1 59	2 1	2 3	2 5	8	11	14	16	19	21	23
	6	49	51	1 53	1 55	1 57	1 59	2 2	2 4	2 6	8	10	12	15	18	21	23	25	27	29
	8	1 57	1 59	2 1	2 3	2 5	2 7	9	11	13	15	17	19	22	24	27	29	31	33	35
	10	2 5	2 6	8	10	12	14	16	18	20	22	24	25	28	30	33	35	37	39	40
4	0	12	13	15	17	19	20	22	24	26	28	30	31	34	36	38	40	42	44	46
	2	19	20	22	23	25	26	28	30	32	34	36	37	40	42	44	46	47	49	51
	4	25	26	28	29	31	32	34	36	38	39	41	43	45	47	49	51	52	54	2 56
	6	31	32	34	35	37	38	40	41	43	45	46	48	50	52	54	2 56	2 57	2 59	3 1
	8	36	37	39	40	42	43	45	46	48	50	51	52	55	2 57	2 58	3 0	3 2	3 3	5
	10	41	42	44	45	47	48	50	51	53	55	2 56	2 57	2 59	3 1	3 3	5	6	8	9
5	0	2 46	2 47	2 49	2 50	2 51	2 53	2 55	2 56	2 57	2 59	3 0	3 2	3 4	3 5	3 7	3 9	3 10	3 12	3 13

Length of the shadow	Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct 30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5 2	2 51	2 52	2 54	2 55	2 56	2 57	2 59	3 0	3 2	3 3	3 5	3 6	3 8	3 9	3 11	3 13	3 14	3 16	3 17
4	2 55	2 57	2 58	2 59	3 0	3 1	3 3	4	6	7	9	10	12	13	15	17	18	20	21
6	3 0	3 1	3 2	3 3	4	5	7	8	10	11	13	14	16	17	19	20	22	24	25
8	4	5	6	7	8	9	11	12	14	15	16	17	19	21	22	24	25	27	28
10	8	9	10	11	12	13	15	16	18	19	20	21	23	25	26	27	29	30	31
6 0	11	12	14	15	16	17	18	19	21	22	23	24	26	28	29	31	32	33	34
4	18	19	21	22	23	24	25	26	27	28	29	31	32	34	35	37	38	39	40
8	25	26	27	28	29	30	31	32	33	34	35	37	38	40	41	42	44	45	46
7 0	31	32	33	34	35	36	37	38	39	40	41	42	44	45	46	47	49	50	51
4	36	37	38	39	40	41	42	43	44	45	46	47	49	50	51	52	54	55	3 56
8	41	42	43	44	45	46	47	48	49	50	51	52	53	55	3 56	3 57	3 58	3 59	4 0
8 0	46	47	48	48	49	50	51	52	53	54	55	3 56	3 57	3 59	4 0	4 1	4 2	4 3	4
4	50	51	52	53	53	54	55	3 56	3 57	3 58	3 59	4 0	4 1	4 3	4	5	6	7	8
8	54	55	3 56	3 57	3 57	3 58	3 59	4 0	4 1	4 2	4 3	4	5	7	8	9	10	11	12
9 0	3 58	3 59	4 0	4 1	4 1	4 2	4 3	4	5	6	7	8	9	10	11	13	14	15	16
4	4 2	4 2	3	4	5	5	6	7	8	9	10	11	12	13	14	16	17	18	19
8	5	6	7	[illegible]	8	9	10	11	11	12	13	14	15	16	17	19	20	21	22
10 0	8	9	10	10	11	12	13	14	14	15	16	17	18	19	20	22	23	23	24
6	12	13	14	15	15	16	17	18	19	19	20	21	22	23	24	25	26	27	28
11 0	16	17	18	19	19	20	21	22	23	23	24	25	26	27	28	29	30	31	32
6	20	21	22	23	23	24	25	26	26	27	28	29	30	31	32	33	34	35	36
12 0	24	24	25	26	26	27	28	29	29	30	31	32	33	34	35	36	37	38	39
13 0	30	30	31	32	32	33	34	35	35	36	37	37	38	39	40	41	42	43	44
14 0	35	36	36	37	37	38	39	40	40	41	42	42	43	44	45	46	47	48	49
15 0	40	40	41	41	42	43	43	44	45	45	46	47	48	48	49	50	51	52	53
16 0	44	44	45	45	46	47	47	48	49	49	50	51	52	52	53	54	55	56	4 57
17 0	47	48	49	49	50	50	51	52	52	53	54	54	55	56	4 57	4 58	4 58	4 59	5 0
18 0	50	51	52	52	53	53	54	55	55	56	4 57	4 57	4 58	4 59	5 0	5 1	5 1	5 2	3
19 0	53	54	55	55	56	55	57	4 58	4 58	4 59	5 0	5 0	5 1	5 2	3	3	4	5	6
20 0	4 56	4 57	4 57	4 58	4 58	4 59	4 59	5 0	5 1	5 1	5 2	5 2	5 3	5 4	5 5	5 6	5 7	5 7	5 8
Declination.	23½ —	23° —	22½ —	22° —	21½ —	21° —	20⅓ —	19⅔ —	19° —	18⅓ —	17⅔ —	17° —	16° —	15° —	14° —	13° —	12° —	11° —	10° —

Applicable to Cape Comorin, Nagercoil, &c. &c.

° North Latitude. Page 11.

Length of the shadow f. in.	Feb 25 to Feb 26 h. m.	Feb 27 to Mar. 1 h. m.	Mar. 2 to Mar. 4 h. m.	Mar. 5 to Mar. 6 h. m.	Mar. 7 to Mar. 9 h. m.	Mar10 to Mar11 h. m.	Mar12 to Mar14 h. m.	Mar15 to Mar16 h. m.	Mar17 to Mar19 h. m.	Mar20 to Mar23 h. m.	Mar24 to Mar28 h. m.	Mar29 to Apr. 5 h. m.	Apr. 6 to Apr 16 h. m.	Apr 17 to Apr 27 h. m.	Apr 28 to May 9 h. m.	May10 to May20 h. m.	May21 to May30 h. m.	May31 to Jun.10 h. m.	Jun.11 to Jun.22 h. m.
1 6	0 46	0 52	0 56	1 0	1 4	1 7	1 10	1 12	1 14	1 16	1 19	1 21	1 23	1 22	1 18	1 12	1 6	1 1	0 57
7	0 53	0 58	1 2	6	9	12	15	17	19	21	23	25	27	26	22	17	11	7	1 3
8	1 0	1 4	8	11	14	17	19	21	23	25	28	30	31	31	27	22	17	12	9
9	6	10	13	16	19	22	24	26	28	30	32	34	35	35	31	27	22	18	15
10	11	15	18	21	24	26	28	30	32	34	37	38	39	39	35	32	27	23	20
11	17	20	23	26	29	31	33	35	36	38	41	42	43	43	40	36	31	28	25
2 0	22	25	28	31	33	35	37	39	40	42	44	46	47	47	44	40	36	33	30
1	27	30	33	35	37	39	41	43	44	46	48	50	51	51	48	44	40	37	35
2	32	34	37	39	41	43	45	47	48	50	52	53	55	54	52	48	45	42	40
3	36	39	41	44	46	47	49	51	52	53	55	1 57	1 59	1 58	1 56	52	49	46	44
4	41	43	45	48	50	51	53	55	1 56	1 57	1 59	2 1	2 2	2 2	2 0	1 56	53	51	49
5	45	47	50	52	54	55	1 57	1 58	2 0	2 1	2 3	4	6	6	3	2 0	1 57	55	53
6	49	51	54	56	1 57	1 59	2 1	2 2	3	5	6	8	9	9	7	4	2 1	1 59	1 57
7	53	55	1 57	1 59	2 1	2 3	4	6	7	8	10	11	13	13	11	8	5	2 3	2 1
8	1 57	1 59	2 1	2 [illegible]	5	6	8	9	10	11	13	15	16	16	14	11	9	7	5
9	2 1	2 3	5	7	9	10	11	12	14	15	17	18	19	19	18	15	13	10	9
10	4	6	8	10	12	13	15	16	17	18	20	21	23	23	21	18	16	14	13
11	8	10	12	14	15	17	18	19	20	21	23	24	26	26	24	22	20	18	16
3 0	11	13	15	17	18	20	21	22	23	25	26	28	29	29	27	25	23	21	20
2	18	20	22	23	25	26	28	29	30	31	32	33	35	35	34	32	30	28	27
4	25	26	28	29	31	32	34	35	36	37	38	39	41	41	40	38	36	35	33
6	31	32	34	35	37	38	39	40	41	42	44	45	46	47	46	44	42	41	39
8	36	38	40	41	42	44	45	46	47	48	49	50	52	52	51	50	48	47	45
10	42	44	45	46	48	49	50	51	52	53	54	2 55	2 57	2 57	2 56	2 55	53	52	51
4 0	47	49	50	52	53	54	2 55	2 56	2 57	2 58	2 59	3 0	3 2	3 2	3 2	3 0	2 59	2 58	2 57
2	52	54	2 55	2 57	2 58	2 59	3 0	3 1	3 2	3 3	3 4	5	7	7	6	5	3 4	3 3	3 2
4	2 57	2 59	3 0	3 1	3 2	3 4	4	5	6	7	9	10	11	12	11	10	9	8	7
6	3 2	3 3	4	6	7	8	9	10	11	12	13	14	15	16	16	14	13	12	12
8	6	8	9	10	11	12	13	14	15	16	17	18	20	20	20	19	18	17	16
10	10	12	13	14	15	16	17	18	19	20	21	22	24	24	24	23	22	21	21
5 0	3 15	3 16	3 17	3 18	3 19	3 20	3 21	3 22	3 23	3 24	3 25	3 26	3 28	3 28	3 28	3 27	3 26	3 26	3 25

5	2	3 19	3 20	3 21	3 22	3 23	3 24	3 25	3 26	3 27	3 27	3 29	3 30	3 31	3 32	3 32	3 31	3 30	3 29	3 29
	4	22	23	25	26	27	28	29	29	30	31	32	33	35	36	35	35	34	33	33
	6	26	27	28	29	30	31	32	33	34	34	36	37	38	39	39	38	38	37	36
	8	29	30	31	33	33	34	35	36	37	38	39	40	42	42	42	42	41	41	40
	10	33	34	35	36	37	38	39	39	40	41	42	43	45	46	46	45	44	44	43
6	0	36	37	38	39	40	41	42	42	43	44	45	46	48	49	49	48	48	47	47
	4	42	43	44	45	46	46	47	48	49	50	51	52	53	3 54	3 55	3 54	54	53	53
	8	47	48	49	50	51	52	53	54	54	3 55	3 56	3 57	3 59	4 0	4 0	4 0	3 59	3 59	3 59
7	0	52	53	54	3 55	3 56	3 57	3 58	3 58	3 59	4 0	4 1	4 2	4 4	5	5	5	4 5	4 4	4 4
	4	3 57	3 58	3 59	4 0	4 1	4 2	4 2	4 3	4 4	4	6	7	8	9	10	10	10	9	9
	8	4 1	4 2	4 3	4	5	6	7	7	8	9	10	11	13	14	14	14	14	14	14
8	0	6	6	7	8	9	10	11	11	12	13	14	15	17	18	18	18	18	18	18
	4	9	10	11	12	13	14	14	15	16	16	18	19	20	22	22	22	22	22	22
	8	13	14	15	16	16	17	18	19	19	20	21	22	24	25	26	26	26	26	26
9	0	16	17	18	19	20	20	21	22	23	23	24	26	27	28	29	29	29	29	29
	4	20	20	21	22	23	24	24	25	26	26	28	29	30	32	32	33	33	33	33
	8	23	23	24	25	26	27	27	28	29	29	30	31	33	35	35	36	36	36	36
10	0	25	26	27	28	29	29	30	31	31	32	33	34	36	37	38	39	39	39	39
	6	29	30	31	32	33	33	34	35	35	36	37	38	40	41	42	43	43	43	43
11	0	33	34	35	35	36	37	38	38	39	39	41	42	43	45	46	46	47	47	47
	6	36	37	38	39	39	40	41	42	42	43	44	45	47	48	49	50	50	50	50
12	0	39	40	41	42	42	43	44	45	45	46	47	48	50	51	52	53	53	53	54
13	0	45	45	46	47	48	48	49	50	50	51	52	53	4 55	4 56	4 58	4 59	4 59	4 59	4 59
14	0	50	50	51	52	53	53	54	55	55	4 56	4 57	4 58	5 0	5 1	5 3	5 4	5 4	5 4	5 4
15	0	54	54	55	4 56	4 57	4 57	4 58	4 59	4 59	5 0	5 1	5 2	4	5	7	8	8	9	9
16	0	4 58	4 58	4 59	5 0	5 0	5 1	5 2	5 2	5 3	4	5	6	8	9	11	12	12	13	13
17	0	5 1	5 2	5 2	3	4	4	5	5	6	7	8	9	11	13	14	15	16	16	16
18	0	4	5	5	6	7	7	8	8	9	10	11	12	14	16	17	18	19	19	19
19	0	7	8	8	9	9	10	10	11	12	12	13	14	16	18	20	21	21	22	22
20	0	5 9	5 10	5 10	5 11	5 12	5 12	5 13	5 13	5 14	5 15	5 16	5 17	5 19	5 21	5 22	5 23	5 24	5 24	5 25
Length of the shadow		Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep 25	Sep.24 to Sep.21	Sep 20 to Sep.16	Sep.15 to Sep. 8	Sep. 7 to Aug28	Aug27 to Aug16	Aug15 to Aug. 4	Aug. 3 to Jul. 24	Jul. 23 to Jul. 15	Jul. 14 to Jul. 4	Jul. 3 to Jun 22
Declination.		9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	2° +	4° +	8° +	12° +	16° +	19° +	21° +	22½ +	23½ +

Length of the shadow f.	in.	Dec.22 to Dec.29 h. m.	Dec.30 to Jan. 4 h. m.	Jan. 5 to Jan. 8 h. m.	Jan. 9 to Jan.11 h. m.	Jan.12 to Jan.14 h. m.	Jan.15 to Jan.17 h. m.	Jan.18 to Jan.20 h. m.	Jan.21 to Jan.23 h. m.	Jan.24 to Jan.26 h. m.	Jan.27 to Jan.29 h. m.	Jan.30 to Jan.31 h. m.	Feb. 1 to Feb. 3 h. m.	Feb. 4 to Feb. 6 h. m.	Feb. 7 to Feb. 9 h. m.	Feb.10 to Feb.12 h. m.	Feb.13 to Feb.15 h. m.	Feb.16 to Feb.18 h. m.	Feb.19 to Feb.21 h. m.	Feb.22 to Feb.24 h. m.
1	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 19	0 32
	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 20	33	41
	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 21	34	43	50
	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	35	44	51	0 57
	10	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	35	44	52	0 58	1 3
	11	.	.	.	.	.	.	.	.	.	.	.	.	0 23	36	45	0 53	0 59	1 4	9
2	0	.	.	.	.	.	.	.	.	.	.	.	0 22	37	46	0 54	1 0	1 5	10	15
	1	.	.	.	.	.	.	.	.	.	0 12	0 27	36	46	0 54	1 1	7	11	16	20
	2	.	.	.	.	.	.	.	.	0 21	32	40	47	0 55	1 2	8	13	17	21	25
	3	.	.	.	.	.	.	0 6	0 26	36	43	50	0 55	1 2	8	14	19	23	26	30
	4	.	.	.	.	.	0 16	30	39	47	0 52	0 58	1 3	9	14	19	24	28	31	35
	5	.	.	.	0 12	0 26	34	43	49	0 55	1 0	1 5	10	15	20	25	29	33	36	40
	6	.	0 6	0 24	33	40	46	0 52	0 58	1 3	8	12	16	21	26	30	34	37	41	44
	7	0 20	32	38	44	49	0 54	1 0	1 5	10	14	18	22	26	31	35	39	42	45	48
	8	37	43	49	0 54	0 58	1 2	7	12	16	20	23	27	31	35	39	43	46	49	52
	9	48	0 53	0 57	1 2	1 6	9	14	18	22	26	29	32	36	40	44	47	50	53	1 56
	10	0 57	1 1	1 5	9	13	16	20	24	27	31	34	37	41	45	48	51	54	1 57	2 0
	11	1 5	8	12	16	19	22	26	29	32	36	39	42	46	49	52	55	1 58	2 1	4
3	0	12	15	18	22	25	27	31	34	37	40	43	46	50	1 53	1 56	1 59	2 2	5	7
	2	24	27	30	32	35	37	41	43	46	49	1 52	1 54	1 58	2 1	2 4	2 7	9	12	14
	4	34	37	40	42	44	47	50	1 52	1 55	1 57	2 0	2 2	2 5	8	11	14	16	19	21
	6	43	46	49	51	1 53	1 55	1 58	2 0	2 3	2 5	7	9	12	15	18	21	23	25	27
	8	1 52	1 55	1 57	1 59	2 1	2 3	2 5	8	10	12	14	16	19	22	24	27	29	31	33
	10	2 0	2 2	2 4	2 6	8	10	12	15	17	19	21	23	25	28	30	33	35	37	39
4	0	7	9	11	13	15	17	19	21	23	25	27	29	31	34	36	38	40	42	44
	2	14	16	18	20	21	23	25	27	29	31	33	35	37	39	42	44	46	47	49
	4	21	22	24	26	27	29	31	33	35	37	38	40	42	45	47	49	51	52	54
	6	27	28	30	32	33	35	37	39	40	42	44	45	47	50	52	54	2 55	2 57	2 59
	8	32	34	36	37	38	40	42	44	45	47	49	50	52	54	2 56	2 58	3 0	3 2	3 3
	10	38	40	41	42	43	45	47	49	50	52	54	55	2 57	2 59	3 1	3 3	4	6	8
5	0	2 43	2 44	2 46	2 47	2 48	2 50	2 52	2 53	2 55	2 56	2 58	2 59	3 1	3 3	3 5	3 7	3 9	3 10	3 12

Length of the shadow	Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5 2	2 48	2 49	2 51	2 52	2 53	2 55	2 56	2 58	2 59	3 1	3 2	3 4	3 6	3 7	3 9	3 11	3 13	3 14	3 16
4	52	54	55	2 56	2 57	2 59	3 0	3 2	3 3	5	6	8	10	11	13	15	17	18	20
6	2 57	2 58	2 59	3 0	3 2	3 3	4	6	7	9	10	12	14	15	17	19	21	22	23
8	3 1	3 2	3 3	4	6	7	8	10	11	12	14	15	17	19	21	22	24	25	27
10	5	6	7	8	10	11	12	14	15	16	18	19	21	23	24	26	27	29	30
6 0	8	10	11	12	13	14	16	17	18	20	21	22	24	26	27	29	30	32	33
4	15	17	18	19	20	21	23	24	25	26	27	29	30	32	33	35	36	38	39
8	22	23	24	25	26	27	29	30	31	32	33	35	36	38	39	41	42	44	45
7 0	28	29	30	31	32	33	34	36	37	38	39	40	42	43	45	46	47	49	50
4	33	34	35	36	37	38	40	41	42	43	44	45	47	48	50	51	52	54	55
8	38	39	40	41	42	43	44	46	47	48	49	50	52	53	54	3 56	3 57	3 58	3 59
8 0	43	44	45	46	47	48	49	51	51	52	53	54	3 56	3 57	3 58	4 0	4 1	4 2	4 3
4	48	49	50	50	51	52	53	55	55	3 56	3 57	3 58	4 0	4 1	4 2	4	5	6	7
8	52	53	54	54	55	3 56	3 57	3 58	3 59	4 0	4 1	4 2	4	5	6	7	9	10	11
9 0	56	3 57	3 58	3 58	3 59	4 0	4 1	4 2	4 3	4	5	6	8	9	10	11	12	13	15
4	3 59	4 0	4 1	4 2	4 3	3	4	5	6	7	8	9	11	12	13	14	15	16	18
8	4 3	4	4	5	6	7	8	9	10	11	11	12	14	15	16	17	18	19	21
10 0	6	7	7	8	9	10	11	12	13	14	14	15	17	18	19	20	21	22	23
6	10	11	12	13	13	14	15	16	17	18	18	19	21	22	23	24	25	26	27
11 0	14	15	16	17	17	18	19	20	21	22	22	23	25	26	27	28	29	30	31
6	18	19	20	21	21	22	23	24	25	25	26	27	28	29	30	31	32	34	35
12 0	21	22	23	24	24	25	26	27	28	28	29	30	31	32	33	34	35	37	38
13 0	27	28	29	30	30	31	32	33	34	34	35	36	37	38	39	40	41	42	43
14 0	33	34	34	35	38	36	37	38	39	39	40	41	42	43	44	45	46	47	48
15 0	38	38	39	40	40	41	41	42	43	44	44	45	46	47	48	49	50	51	52
16 0	42	42	43	44	44	45	45	46	47	48	48	49	50	51	52	53	54	55	4 56
17 0	46	46	47	47	48	48	49	50	51	51	52	53	54	55	56	4 57	4 58	4 58	5 59
18 0	49	49	50	50	51	51	52	53	54	54	55	56	4 57	4 58	4 59	5 0	5 0	5 1	2
19 0	52	52	53	53	54	54	55	56	56	4 57	4 58	4 59	5 0	5 1	5 2	2	3	4	5
20 0	4 54	4 55	4 55	4 56	4 56	4 57	4 58	4 58	4 59	5 0	5 0	5 1	5 2	5 3	5 4	5 5	5 6	5 6	5 7
Declination	23½	23°	22½	22°	21½	21°	20⅓	19⅔	19°	18⅓	17⅔	17°	16°	15°	14°	13°	12°	11°	10°

Length of the shadow	Feb.25 to Feb.26	Feb.27 to Mar. 1	Mar. 2 to Mar. 4	Mar. 5 to Mar. 6	Mar. 7 to Mar. 9	Mar10 to Mar11	Mar12 to Mar14	Mar15 to Mar16	Mar17 to Mar19	Mar20 to Mar22	Mar23 to Mar25	Mar26 to Mar30	Mar31 to Apr. 7	Apr. 8 to Apr.18	Apr 19 to May 1	May 2 to May13	May14 to May25	May26 to Jun. 7	Jun. 8 to Jun.22
f. in.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1 6	0 40	0 46	0 52	0 57	1 1	1 4	1 7	1 10	1 12	1 14	1 16	1 19	1 21	1 23	1 22	1 18	1 12	1 7	1 1
7	48	0 53	0 58	1 3	6	9	12	15	17	19	20	24	26	28	27	23	17	12	7
8	0 55	1 0	1 4	8	11	14	17	19	22	24	25	28	30	32	31	27	22	17	13
9	1 1	6	10	13	16	19	22	24	26	28	30	32	34	36	35	31	27	22	18
10	7	11	15	18	21	24	26	28	30	32	34	36	38	40	39	36	31	27	24
11	13	17	20	23	26	29	31	33	35	36	38	40	42	44	43	40	36	32	28
2 0	18	22	25	28	31	33	35	37	39	41	42	44	46	48	47	44	40	37	33
1	23	27	30	33	35	38	40	41	43	45	46	48	50	52	51	48	44	41	38
2	28	32	34	37	39	42	44	45	47	49	50	52	54	55	55	52	49	45	42
3	33	36	39	41	44	46	48	49	51	53	54	56	1 57	1 59	1 59	1 56	53	50	47
4	38	41	43	45	48	50	52	53	55	1 56	1 57	1 59	2 1	2 3	2 2	2 0	1 57	54	51
5	42	45	47	49	52	54	56	1 57	1 59	2 0	2 1	2 3	5	6	6	4	2 1	1 58	1 56
6	46	49	51	53	1 55	1 57	1 59	2 1	2 2	4	5	7	8	10	10	7	5	2 2	2 0
7	50	53	55	1 57	2 59	2 1	2 3	5	6	7	8	10	12	13	13	11	8	6	4
8	54	1 57	1 59	2 1	3	5	6	8	9	10	12	13	15	17	16	15	12	10	7
9	1 58	2 1	2 3	5	7	9	10	12	13	14	15	17	18	20	20	18	16	14	11
10	2 2	4	6	8	10	12	13	15	16	17	18	20	22	23	23	22	19	17	15
11	6	8	10	12	14	15	17	18	20	21	22	23	25	26	26	25	23	21	19
3 0	9	11	13	15	17	18	20	21	23	24	25	27	28	29	30	28	26	24	22
2	16	18	20	22	24	25	26	28	29	30	31	33	34	35	36	34	32	30	29
4	23	25	26	28	30	31	32	34	35	36	37	39	40	41	42	40	39	37	35
6	29	31	32	34	36	37	38	39	41	42	43	44	46	47	47	46	45	43	41
8	35	36	38	40	41	42	44	45	46	47	48	49	51	52	53	52	50	49	47
10	41	42	44	45	47	48	49	50	51	52	53	2 55	2 56	2 57	2 58	2 57	2 56	2 54	53
4 0	46	47	49	50	52	53	54	2 55	2 56	2 57	2 58	3 0	3 1	3 2	3 3	3 2	3 1	3 0	2 59
2	51	52	54	2 55	2 57	2 58	2 59	3 0	3 1	3 2	3 3	5	6	7	8	7	6	5	3 4
4	2 56	2 57	2 59	3 0	3 1	3 2	3 4	5	6	7	8	9	10	12	12	12	11	10	9
6	3 1	3 2	3 4	5	6	7	8	9	10	11	12	13	14	16	17	17	16	14	13
8	5	6	8	9	10	11	12	13	14	15	16	17	19	20	21	21	20	19	18
10	9	10	12	13	14	15	16	17	18	19	20	21	23	24	25	25	24	23	22
5 0	3 13	3 15	3 16	3 17	3 18	3 19	3 20	3 21	3 22	3 23	3 24	3 25	3 27	3 28	3 29	3 29	3 28	3 27	3 27

Length of the shadow		Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep 25	Sep.24 to Sep.22	Sep 21 to Sep.19	Sep.18 to Sep.13	Sep.12 to Sep. 4	Sept. 3 to Aug25	Aug24 to Aug13	Aug12 to Jul. 31	Jul. 30 to Jul. 19	Jul. 18 to Jul. 6	Jul. 5 to Jun 22
Declination.		9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	9° +	13° +	17° +	20° +	22° +	23½ +
5	2	3 17	3 19	3 20	3 21	3 22	3 23	3 24	3 25	3 26	3 27	3 28	3 29	3 30	3 32	3 33	3 33	3 32	3 31	3 31
	4	21	22	23	25	26	27	28	29	30	30	31	33	34	35	36	36	36	35	34
	6	24	26	27	28	29	30	31	32	33	34	35	36	37	39	40	40	39	39	38
	8	28	29	30	32	33	34	35	36	36	37	38	39	41	42	43	43	43	42	42
	10	31	33	34	35	36	37	38	39	40	40	41	42	44	45	46	47	46	46	45
6	0	34	36	37	38	39	40	41	42	43	43	44	46	47	48	49	50	49	49	48
	4	40	42	43	44	45	46	47	48	48	49	50	51	52	3 54	3 55	3 56	3 55	3 55	3 54
	8	46	47	48	49	50	51	52	53	54	55	3 55	3 57	3 58	4 0	4 1	4 1	4 1	4 1	4 0
7	0	51	52	53	54	3 55	3 56	3 57	3 58	3 59	3 59	4 0	4 1	4 3	4	6	6	6	6	6
	4	3 56	3 57	3 58	3 59	4 0	4 1	4 2	4 3	4 3	4 4	5	6	7	9	10	11	11	11	11
	8	4 0	4 1	4 2	4 3	4	5	6	7	8	8	9	10	12	13	15	15	15	15	15
8	0	5	6	7	8	8	9	10	11	12	12	13	14	16	17	19	19	20	20	20
	4	8	9	10	11	12	13	14	15	15	16	17	18	19	21	22	23	24	24	24
	8	12	13	14	15	16	17	17	18	19	20	20	22	23	25	26	27	27	27	27
9	0	15	16	17	18	19	20	21	22	22	23	24	25	26	28	29	30	31	31	31
	4	19	20	20	21	22	23	24	25	25	26	27	28	29	31	33	34	34	34	34
	8	22	23	23	24	25	26	27	28	28	29	30	31	32	34	36	37	37	37	37
10	0	24	25	26	27	28	29	30	30	31	32	33	34	35	37	39	40	40	40	40
	6	28	29	30	31	32	33	33	34	35	36	36	38	39	41	42	43	44	44	44
11	0	32	33	34	35	36	36	37	38	39	39	40	41	42	44	46	47	48	48	48
	6	35	36	37	38	39	40	40	41	42	42	43	44	45	47	49	50	51	52	52
12	0	38	39	40	41	42	43	43	44	45	46	46	47	49	51	52	54	4 54	4 55	4 55
13	0	44	45	45	46	47	48	49	49	50	51	51	52	54	4 56	4 58	4 59	5 0	5 0	5 1
14	0	49	50	50	51	52	53	54	54	55	4 56	4 56	4 57	4 59	5 1	5 3	5 4	5	6	6
15	0	53	54	54	55	4 56	4 57	4 57	4 58	4 59	5 0	5 0	5 1	5 3	5	7	8	9	10	10
16	0	4 57	4 58	4 58	4 59	5 0	5 1	5 1	5 2	5 3	3	4	5	6	9	11	12	13	14	14
17	0	5 0	5 1	5 2	5 2	3	4	4	5	6	7	7	8	10	12	14	15	17	17	18
18	0	3	4	5	5	6	7	7	8	9	10	10	11	13	15	17	19	20	20	21
19	0	6	7	8	8	9	9	10	11	11	12	13	14	15	17	19	21	22	23	24
20	0	5 8	5 9	5 10	5 10	5 11	5 12	5 12	5 13	5 14	5 15	5 15	5 16	5 18	5 20	5 22	5 24	5 25	5 26	5 26

Applicable to Alleppy, Palamcottah, Quilon, Ramnad, Trevandrum, Tutacorin, &c. &c.

10° North Latitude. Page 1.

Length of the shadow f.	in.	Dec.22 to Dec.29 h. m.	Dec.30 to Jan. 4 h. m.	Jan. 5 to Jan. 8 h. m.	Jan. 9 to Jan.11 h. m.	Jan.12 to Jan.14 h. m.	Jan.15 to Jan.17 h. m.	Jan.18 to Jan.20 h. m.	Jan.21 to Jan.23 h. m.	Jan.24 to Jan.26 h. m.	Jan.27 to Jan.29 h. m.	Jan.30 to Jan.31 h. m.	Feb. 1 to Feb. 3 h. m.	Feb. 4 to Feb. 6 h. m.	Feb. 7 to Feb. 9 h. m.	Feb.10 to Feb.12 h. m.	Feb.13 to Feb.15 h. m.	Feb.16 to Feb.18 h. m.	Feb.19 to Feb.21 h. m.	Feb.22 to Feb.24 h. m.
1	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 19
	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 20	32
	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 21	34	43
	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	35	44	51
	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36	45	52	0 58
	11	.	.	.	.	.	.	.	.	.	.	.	.	.	0 23	36	45	0 53	0 59	1 4
2	0	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36	46	0 54	1 0	1 6	10
	1	.	.	.	.	.	.	.	.	.	.	.	0 22	36	46	0 54	1 1	7	12	16
	2	.	.	.	.	.	.	.	.	.	0 10	0 27	36	47	0 55	1 2	8	13	17	21
	3	.	.	.	.	.	.	.	.	0 18	31	40	47	0 55	1 2	8	14	19	23	26
	4	.	.	.	.	.	.	.	0 24	35	43	50	0 56	1 3	9	14	19	24	28	31
	5	.	.	.	.	.	0 12	0 29	38	46	0 52	0 58	1 3	10	15	20	25	29	33	36
	6	.	.	.	0 6	0 24	33	42	49	0 55	1 1	1 5	10	16	21	26	30	34	37	41
	7	.	.	0 20	30	38	44	0 51	0 57	1 3	8	12	16	22	26	31	35	39	42	45
	8	0 16	0 28	37	43	49	0 54	1 0	1 5	10	14	18	22	27	31	35	39	43	46	49
	9	34	41	49	0 53	0 57	1 2	7	12	16	20	24	27	32	36	40	44	47	50	53
	10	46	0 52	0 57	1 1	1 5	9	14	18	22	26	29	32	37	41	45	48	51	54	1 57
	11	0 55	1 0	1 4	8	12	16	20	24	27	31	34	37	42	45	49	52	55	1 58	2 1
3	0	1 3	7	11	15	18	21	25	29	32	36	39	42	46	49	1 53	1 56	1 59	2 2	5
	2	16	20	23	26	29	32	35	39	42	45	48	50	1 54	1 57	2 1	2 4	2 7	9	12
	4	28	31	34	37	39	42	45	48	51	1 53	1 56	1 58	2 2	2 5	8	11	14	16	18
	6	38	41	43	46	48	51	1 53	1 56	1 59	2 1	2 4	2 6	9	12	15	18	20	23	25
	8	47	50	1 52	1 54	1 56	1 59	2 1	2 4	2 6	9	11	13	16	19	22	24	26	29	31
	10	1 55	1 58	2 0	2 2	2 4	2 6	8	11	13	16	18	20	22	25	28	30	32	35	37
4	0	2 3	2 5	7	9	11	13	15	18	20	22	24	26	28	31	34	36	38	40	42
	2	10	12	14	16	18	20	22	24	26	28	30	32	34	37	39	42	44	46	47
	4	17	19	20	22	24	26	28	30	32	34	35	37	40	42	44	47	49	51	52
	6	23	25	26	28	30	32	34	36	37	39	41	43	45	47	49	52	54	2 56	2 57
	8	29	30	32	34	35	37	39	41	42	44	46	48	50	52	54	2 56	2 58	3 0	3 2
	10	34	36	37	39	40	42	44	46	47	49	51	53	55	2 57	2 59	3 1	3 3	4	6
5	0	2 39	2 41	2 42	2 44	2 45	47	2 49	2 50	2 52	2 54	2 55	2 57	2 59	3 1	3 3	3 5	3 7	3 9	3 10

Length of the shadow	Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5 2	2 44	2 46	2 47	2 49	2 50	52	2 54	2 55	2 57	2 58	3 0	3 1	3 3	3 5	3 7	3 9	3 11	3 13	3 14
4	49	50	52	53	55	2 56	2 58	2 59	3 1	3 2	4	5	7	9	11	13	15	16	18
6	53	55	2 56	2 58	2 59	0	3 2	3 3	5	6	8	9	11	13	15	17	19	20	22
8	2 57	2 59	3 0	3 2	3 3	4	6	7	9	10	12	13	15	17	19	20	22	24	25
10	3 1	3 3	4	6	7	8	10	11	13	14	16	17	19	21	23	24	26	27	29
6 0	5	7	8	9	10	11	13	15	16	17	19	20	22	24	26	27	29	30	32
4	12	14	15	16	17	18	20	22	23	24	25	27	28	30	32	33	35	36	38
8	19	20	21	23	24	25	26	28	29	30	31	33	34	36	38	39	41	42	43
7 0	26	26	27	29	30	31	32	33	35	36	37	38	40	41	43	44	46	47	48
4	31	32	33	34	35	36	37	38	40	41	42	43	45	46	48	49	51	52	53
8	36	37	38	39	40	41	42	43	45	46	47	48	50	51	53	54	3 56	3 57	3 58
8 0	41	42	43	44	45	46	47	48	49	50	52	53	54	3 56	3 57	3 58	4 0	4 1	4 2
4	45	46	47	48	49	50	51	52	53	54	56	3 57	3 58	4 0	4 1	4 2	4	5	6
8	49	50	51	52	53	54	55	3 56	3 57	3 58	3 59	4 0	4 2	3	5	6	7	9	10
9 0	53	54	55	56	3 57	3 58	3 59	4 0	4 1	4 2	4 3	4	6	7	9	10	11	12	13
4	3 57	3 58	3 59	3 59	4 0	4 1	4 2	3	4	5	6	7	9	10	12	13	14	15	16
8	4 0	4 1	4 2	4 3	4	5	6	7	8	9	10	11	12	13	15	16	17	18	19
10 0	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	21	22
6	8	9	10	10	11	12	13	14	15	16	17	18	19	20	22	23	24	25	26
11 0	12	13	14	14	15	16	17	18	19	20	21	22	23	24	25	27	28	29	30
6	16	17	18	18	19	20	21	22	23	24	25	25	27	28	29	30	31	33	34
12 0	19	20	21	22	22	23	24	25	26	27	28	28	30	31	32	33	34	36	37
13 0	25	26	27	28	28	29	30	31	32	33	34	34	36	37	38	39	40	41	42
14 0	31	31	32	33	34	34	35	36	37	38	39	39	41	42	43	44	45	46	47
15 0	36	36	37	38	38	39	40	40	41	42	44	44	45	46	47	48	49	50	51
16 0	40	40	41	42	42	43	44	45	45	46	48	48	49	50	51	52	53	54	55
17 0	43	44	45	45	46	47	47	48	49	50	51	51	52	53	54	55	56	4 57	4 58
18 0	46	47	48	48	49	50	50	51	52	53	54	54	55	56	4 57	4 58	4 59	5 0	5 1
19 0	49	50	51	51	52	53	53	54	55	56	4 57	4 57	4 58	4 59	5 0	5 1	5 2	3	4
20 0	4 52	4 53	4 53	4 54	4 54	4 55	4 56	4 57	4 57	4 58	5 59	5 0	5 1	5 2	5 3	5 4	5 4	5 5	5 6
Declination	$23\frac{1}{2}$ —	23° —	$22\frac{1}{2}$ —	22° —	$21\frac{1}{2}$ —	21° —	$20\frac{1}{3}$ —	$19\frac{2}{3}$ —	19° —	$18\frac{1}{3}$ —	$17\frac{2}{3}$ —	17° —	16° —	15° —	14° —	13° —	12° —	11° —	10° —

Applicable to Cochin, Cottayam, Cranganore, Dindigul, Madura, &c. &c.

Length of the shadow	Feb.25 to Feb.26	Feb.27 to Mar. 1	Mar. 2 to Mar. 4	Mar. 5 to Mar. 6	Mar. 7 to Mar. 9	Mar10 to Mar11	Mar12 to Mar14	Mar15 to Mar16	Mar17 to Mar19	Mar20 to Mar22	Mar23 to Mar25	Mar26 to Mar28	Mar29 to Apr. 2	Apr. 3 to Apr 10	Apr 11 to Apr 21	Apr 22 to May 4	May 5 to May18	May19 to Jun. 2	Jun. 3 to Jun.22
f. in.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1 6	0 32	0 40	0 46	0 52	0 57	1 1	1 4	1 7	1 10	1 12	1 14	1 16	1 19	1 21	1 24	1 23	1 18	1 12	1 5
7	41	48	0 53	0 58	1 2	6	9	12	15	17	19	21	24	26	28	27	23	17	11
8	50	0 55	1 0	1 4	8	11	14	17	19	22	24	25	28	30	32	31	27	22	16
9	0 57	1 1	6	10	13	16	19	22	24	26	28	30	32	34	36	35	32	27	21
10	1 3	7	12	15	18	21	24	26	28	30	32	34	36	38	40	39	36	32	26
11	9	13	17	20	23	26	29	31	33	35	36	38	40	42	44	44	41	36	31
2 0	15	19	22	25	28	31	33	35	37	39	41	42	44	46	48	48	45	41	36
1	20	24	27	30	33	35	38	40	41	43	45	46	48	50	52	52	49	45	41
2	25	28	32	34	37	39	42	44	45	47	49	50	52	54	56	55	53	49	45
3	30	33	36	39	41	44	46	48	49	51	52	54	1 56	1 57	1 59	1 59	1 57	53	49
4	35	38	41	43	46	48	50	52	53	55	1 56	1 58	2 0	2 1	2 3	2 3	2 1	1 57	54
5	40	42	45	47	50	52	54	55	1 57	1 59	2 0	2 1	3	5	7	6	4	2 1	1 58
6	44	46	49	51	54	56	1 57	1 59	2 1	2 2	4	5	7	8	10	10	8	5	2 2
7	48	50	53	55	1 57	1 59	2 1	2 3	4	6	7	8	10	11	14	14	12	9	6
8	52	54	1 57	1 59	2 1	2 3	5	7	8	9	11	12	14	15	17	17	15	13	10
9	1 56	1 58	2 1	2 3	5	7	9	10	12	13	14	15	17	18	20	20	19	16	13
10	2 0	2 2	4	6	8	10	12	14	15	16	17	19	20	22	24	24	22	20	17
11	4	6	8	10	12	14	16	17	18	20	21	22	24	25	27	27	26	23	21
3 0	7	9	11	13	15	17	19	20	21	23	24	25	27	28	30	30	29	27	24
2	14	16	18	20	22	24	25	27	28	29	30	31	33	34	36	36	35	33	31
4	21	23	25	26	28	30	31	33	34	35	36	37	39	40	42	42	41	39	37
6	27	29	31	32	34	36	37	38	40	41	42	43	44	46	47	48	47	45	43
8	33	35	37	38	40	41	43	44	45	46	47	48	50	51	53	53	53	51	49
10	39	40	42	44	45	47	48	49	50	51	52	53	2 55	2 56	2 58	2 59	2 58	2 57	2 55
4 0	44	46	47	49	50	52	53	54	2 55	2 56	2 57	2 58	3 0	3 1	3 3	3 4	3 3	3 2	3 0
2	49	51	52	54	2 55	2 57	2 58	2 59	3 0	3 1	3 2	3 3	5	6	8	8	8	7	5
4	54	2 56	2 57	2 59	3 0	3 1	3 2	3 4	5	6	7	8	9	11	12	13	13	12	10
6	2 59	3 1	3 2	3 3	5	6	7	8	9	10	11	12	14	15	17	18	17	16	15
8	3 3	5	6	8	9	10	11	13	14	15	16	16	18	19	21	22	22	21	20
10	8	9	11	12	13	14	16	17	18	19	20	20	22	23	25	26	26	25	24
5 0	3 12	3 13	3 15	3 16	3 17	18	3 20	3 21	3 22	3 23	3 24	3 24	3 26	3 27	3 29	3 30	3 30	3 29	3 28

Length of the shadow	Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep.25	Sep.24 to Sep.22	Sep 21 to Sep.20	Sep.19 to Sep.16	Sep.15 to Sep.11	Sep.10 to Sep. 3	Sept. 2 to Aug22	Aug21 to Aug. 9	Aug. 8 to Jul. 27	Jul. 26 to Jul. 11	Jul. 10 to Jun 22
5 2	3 16	3 17	3 19	3 20	3 21	3 22	3 23	3 24	3 25	3 26	3 27	3 28	3 29	3 31	3 33	3 34	3 34	3 33	3 32
4	20	21	22	24	25	26	27	28	29	30	31	32	33	34	36	37	37	37	36
6	23	25	26	27	28	30	31	32	33	33	34	35	36	37	40	41	41	41	40
8	27	28	29	30	32	33	34	35	36	37	38	38	40	41	43	44	44	44	43
10	30	31	33	34	35	36	37	38	39	40	41	42	43	44	46	47	48	47	47
6 0	33	34	36	37	38	39	40	41	42	43	44	45	46	47	49	50	51	51	50
4	39	40	41	43	44	45	46	47	48	49	49	50	52	53	3 55	3 56	3 57	3 56	3 56
8	45	46	47	48	49	50	51	52	53	54	3 55	3 56	3 57	3 58	4 0	4 2	4 2	4 2	4 2
7 0	50	51	52	53	54	3 55	3 56	3 57	3 58	3 59	4 0	4 1	4 2	4 3	5	6	7	7	7
4	55	3 56	3 57	3 58	3 59	4 0	4 1	4 2	4 3	4 4	5	5	7	8	10	11	12	12	12
8	3 59	4 0	4 1	4 2	4 3	5	5	6	7	8	9	10	11	12	14	16	17	17	17
8 0	4 3	4	6	7	8	9	10	10	11	12	13	14	15	16	18	20	21	21	21
4	7	8	9	10	11	12	13	14	15	16	17	17	19	20	22	24	25	25	25
8	11	12	13	14	15	16	17	18	19	19	20	21	22	23	26	27	28	29	29
9 0	15	16	16	17	18	19	20	21	22	23	23	24	25	27	29	31	32	32	33
4	18	19	20	21	22	22	23	24	25	26	27	27	29	30	32	34	35	36	36
8	21	22	23	24	25	25	26	27	28	29	30	30	32	33	35	37	38	39	39
10 0	23	24	25	26	27	28	29	30	31	32	32	33	34	36	38	40	41	42	42
6	27	28	29	30	31	32	33	34	35	35	36	37	38	39	41	43	45	46	46
11 0	31	32	33	34	35	36	37	37	38	39	40	40	42	43	45	47	49	49	50
6	35	36	36	37	38	39	40	41	41	42	43	44	45	46	48	50	52	53	53
12 0	38	39	39	40	41	42	43	44	44	45	46	47	48	49	52	54	4 55	4 56	4 57
13 0	43	44	45	46	46	47	48	49	50	50	51	52	53	54	4 57	4 59	5 1	5 2	5 3
14 0	48	49	50	51	51	52	53	54	55	55	4 56	4 57	4 58	4 59	5 2	5 4	6	7	8
15 0	52	53	54	54	55	4 56	4 57	4 58	4 58	4 59	5 0	5 1	5 2	5 3	6	8	10	11	12
16 0	56	4 57	4 58	4 58	4 59	5 0	5 1	5 2	5 2	5 3	4	5	6	7	10	12	14	15	16
17 0	4 59	5 0	5 1	5 2	5 3	3	4	5	6	6	7	8	9	10	13	15	17	19	20
18 0	5 2	3	4	5	6	6	7	8	9	9	10	11	12	13	16	18	20	22	23
19 0	5	6	6	7	8	9	10	11	11	12	13	13	15	16	18	21	23	24	25
20 0	5 7	5 8	5 9	5 10	5 11	5 11	5 12	5 13	5 14	5 14	5 15	5 16	5 17	5 18	5 21	5 23	5 25	5 27	5 28
Declination.	9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	2° +	4° +	6° +	10° +	14° +	18° +	21° +	23½ +

TABLES FOR DETERMINING TIME.

Length of the shadow f. in.	Dec.22 to Dec.29 h. m.	Dec.30 to Jan. 4 h. m.	Jan. 5 to Jan. 8 h. m.	Jan. 9 to Jan.11 h. m.	Jan.12 to Jan.14 h. m.	Jan.15 to Jan.17 h. m.	Jan.18 to Jan.20 h. m.	Jan.21 to Jan.23 h. m.	Jan.24 to Jan.28 h. m.	Jan.27 to Jan.29 h. m.	Jan.30 to Jan.31 h. m.	Feb. 1 to Feb. 3 h. m.	Feb. 4 to Feb. 6 h. m.	Feb. 7 to Feb. 9 h. m.	Feb.10 to Feb.12 h. m.	Feb.13 to Feb.15 h. m.	Feb.16 to Feb.18 h. m.	Feb.19 to Feb.21 h. m.	Feb.22 to Feb.24 h. m.
1 6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 20
8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 21	34
9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	35	44
10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36	45	52
11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 23	36	45	0 53	0 59
2 0	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36	46	0 54	1 0	1 6
1	.	.	.	.	.	.	.	.	.	.	.	.	0 21	36	46	0 54	1 1	7	12
2	.	.	.	.	.	.	.	.	.	.	.	0 20	36	47	0 55	1 2	8	13	17
3	.	.	.	.	.	.	.	.	.	0 5	0 26	36	46	0 55	1 2	8	14	19	23
4	.	.	.	.	.	.	.	.	0 16	30	39	46	0 55	1 3	9	14	19	24	28
5	.	.	.	.	.	.	.	0 22	34	42	49	0 55	1 3	10	15	20	25	29	33
6	.	.	.	.	.	0 6	0 27	37	45	0 52	0 58	1 3	10	16	21	25	30	34	37
7	.	.	.	.	0 20	30	40	48	0 54	1 0	1 5	10	16	22	26	30	35	39	42
8	.	.	0 15	0 28	36	43	51	0 57	1 2	7	12	16	22	27	31	35	39	43	46
9	0 6	0 25	34	41	47	0 52	0 59	1 4	9	14	18	22	27	32	36	40	44	47	50
10	32	39	46	51	0 56	1 1	1 6	11	16	20	24	27	32	37	41	45	48	51	54
11	44	49	0 55	0 59	1 4	8	13	17	22	26	29	32	37	42	45	49	52	55	1 58
3 0	0 54	0 58	1 3	1 7	11	15	19	23	27	31	34	37	42	46	49	1 53	1 56	1 59	2 2
2	1 9	1 13	16	20	23	26	30	33	37	40	43	46	50	1 54	1 57	2 1	2 4	2 7	9
4	21	25	28	31	34	36	40	43	46	49	1 52	1 54	1 38	2 2	2 5	8	11	14	16
6	32	35	38	40	43	45	49	1 52	1 54	1 57	2 0	2 2	2 6	9	12	15	18	21	23
8	42	44	47	49	1 52	1 54	1 57	2 0	2 2	2 5	7	9	13	16	19	21	24	27	29
10	50	1 53	1 55	1 57	2 0	2 2	2 4	7	9	12	14	16	20	22	25	27	30	33	35
4 0	1 58	2 1	2 3	2 5	7	9	11	14	16	18	21	23	26	28	31	33	36	38	40
2	2 5	8	10	12	14	16	18	20	22	24	27	29	32	34	37	39	41	44	46
4	12	14	16	18	20	22	24	26	28	30	32	34	37	40	42	44	46	49	51
6	19	21	22	24	26	28	30	32	34	36	38	40	42	45	47	49	51	54	2 56
8	25	27	28	30	32	33	35	37	39	41	43	45	47	50	52	54	2 56	2 58	3 0
10	31	32	34	35	37	39	40	42	44	46	48	50	52	55	2 57	2 59	3 1	3 3	4
5 0	2 36	2 37	2 39	2 40	2 42	[illegible] 44	2 45	2 47	2 49	2 51	2 53	2 54	2 57	2 59	3 1	3 3	3 5	3 7	3 9

Length of the shadow		Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5	2	2 41	2 42	2 44	2 45	2 47	49	2 50	2 52	2 54	2 56	2 57	2 59	3 1	3 3	3 5	3 7	3 9	3 11	3 13
	4	45	47	48	50	51	53	55	2 56	2 58	3 0	3 1	3 3	5	7	9	11	13	15	16
	6	50	52	53	54	2 56	57	2 59	3 0	3 2	4	5	7	9	11	13	15	17	19	20
	8	54	2 56	2 57	2 58	3 0	1	3 3	4	6	8	9	11	13	15	17	19	20	22	24
	10	2 58	3 0	3 1	3 2	4	5	7	8	10	12	13	15	17	19	21	22	24	26	27
6	0	3 2	4	5	6	8	9	10	12	14	15	16	18	20	22	24	25	27	29	30
	4	9	11	12	13	15	16	17	19	21	22	23	25	26	28	30	32	33	35	36
	8	16	17	19	20	21	22	24	25	27	28	29	31	32	34	36	38	39	41	42
7	0	22	23	25	26	27	28	30	31	33	34	35	36	38	40	41	43	44	46	47
	4	28	29	30	31	32	34	35	36	38	39	40	41	43	45	46	48	49	51	52
	8	33	34	35	36	37	39	40	41	43	44	45	46	48	50	51	53	54	3 56	3 57
8	0	38	39	40	41	42	43	44	46	47	48	49	51	32	54	55	3 57	3 58	4 0	4 1
	4	43	44	45	46	47	48	49	50	51	52	54	55	3 56	3 58	3 59	4 1	4 2	4	5
	8	47	48	49	50	51	52	53	54	55	3 56	3 58	3 59	4 0	4 2	4 3	5	6	7	9
9	0	51	52	53	54	55	56	3 57	3 58	3 59	4 0	4 2	4 3	4	6	7	8	10	11	12
	4	54	55	3 56	3 57	3 58	3 59	4 0	4 1	4 2	4	5	6	7	9	10	11	13	14	15
	8	3 58	3 59	4 0	4 1	4 2	4 2	4	5	6	7	8	9	10	12	13	14	16	17	18
10	0	4 1	4 2	3	4	5	5	7	8	9	10	11	12	13	15	16	17	19	20	21
	6	6	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	23	24	25
11	0	10	10	11	12	13	14	15	16	17	18	19	20	21	23	24	25	27	28	29
	6	14	14	15	16	17	18	19	20	21	22	23	24	25	26	28	29	30	31	33
12	0	17	18	19	19	20	21	22	23	24	25	26	27	28	29	31	32	33	34	36
13	0	23	24	25	25	26	27	28	29	30	31	32	33	34	35	36	38	39	40	41
14	0	29	29	30	31	32	32	33	34	35	36	37	38	39	40	41	43	44	45	46
15	0	33	34	35	36	36	37	38	39	40	40	41	42	43	45	46	47	48	49	50
16	0	37	38	39	40	40	41	42	43	44	44	45	46	47	49	50	51	52	53	54
17	0	41	42	43	43	44	45	46	46	47	48	49	50	51	52	53	54	55	56	4 57
18	0	44	45	46	46	47	48	49	49	50	51	52	53	54	55	56	4 57	4 58	4 59	5 0
19	0	47	48	49	49	50	51	52	52	53	54	55	56	57	4 58	4 59	5 0	5 1	5 2	3
20	0	4 50	4 51	4 51	4 52	4 53	4 53	4 54	4 55	4 56	4 57	4 57	4 58	4 59	5 0	5 1	5 2	5 3	5 4	5 5
Declination.		23½	23°	22½	22°	21½	21°	20⅓	19⅔	19°	18⅓	17⅔	17°	16°	15°	14°	13°	12°	11°	10°

Applicpble to Calicut, Coimbatore, Cuddalore, Negapatam, Ootacamund, Tanjore, Tranquebar, Trichinopoly, &c. &c.

Length of the shadow f. in.	Feb.25 to Feb.26 h. m.	Feb 27 to Mar. 1 h. m.	Mar. 2 to Mar. 4 h. m.	Mar. 5 to Mar. 6 h. m.	Mar. 7 to Mar. 9 h. m.	Mar10 to Mar11 h. m.	Mar12 to Mar14 h. m.	Mar15 to Mar16 h. m.	Mar17 to Mar19 h. m.	Mar20 to Mar22 h. m.	Mar23 to Mar24 h. m.	Mar25 to Mar28 h. m.	Mar29 to Apr. 3 h. m.	Apr. 4 to Apr13 h. m.	Apr 14 to Apr 24 h. m.	Apr 25 to May 8 h. m.	May 9 to May22 h. m.	May23 to Jun. 7 h. m.	Jun. 8 to Jun.22 h. m.
1 6	0 19	0 32	0 40	0 47	0 52	0 57	1 1	1 4	1 7	1 10	1 12	1 15	1 18	1 22	1 24	1 23	1 19	1 13	1 9
7	33	41	48	0 54	0 58	1 2	6	10	12	15	17	19	23	26	28	27	23	18	14
8	43	49	0 55	1 0	1 4	8	12	15	17	20	22	24	27	30	32	32	28	23	19
9	51	0 56	1 2	6	10	14	17	20	22	25	27	28	31	34	36	36	32	27	24
10	0 58	1 3	8	12	15	19	22	24	27	29	31	32	35	38	40	40	37	32	29
11	1 4	9	14	17	20	24	26	29	31	33	35	37	40	42	44	44	41	37	34
2 0	10	15	19	22	25	28	31	33	35	37	39	41	44	46	48	48	45	41	39
1	16	20	24	27	30	33	35	38	40	42	43	45	48	50	52	52	49	46	43
2	21	25	29	32	35	37	40	42	44	46	47	49	51	54	1 56	1 56	53	50	47
3	26	30	34	37	39	42	44	46	48	50	51	53	55	1 58	2 0	2 0	1 57	54	52
4	31	35	38	41	43	46	48	50	52	53	55	1 57	1 59	2 2	3	3	2 1	1 58	1 56
5	36	39	42	45	47	50	52	54	56	1 58	1 59	2 0	2 3	5	7	7	5	2 2	2 0
6	41	44	46	49	51	54	1 56	1 58	1 59	2 2	2 3	4	6	9	11	11	9	6	4
7	45	48	51	53	55	1 58	2 0	2 1	2 3	5	6	7	10	12	14	14	12	10	8
8	49	52	55	1 57	1 59	2 1	3	5	7	8	10	11	13	16	17	18	16	13	12
9	53	1 56	1 59	2 1	2 3	5	7	9	10	12	13	14	17	19	21	21	20	17	15
10	1 57	2 0	2 2	4	6	8	10	12	14	15	17	18	20	22	24	24	23	20	19
11	2 1	4	6	8	10	12	14	16	17	19	20	21	23	25	27	28	26	24	23
3 0	5	7	9	12	14	15	17	19	20	22	23	24	26	29	30	31	29	27	26
2	12	14	16	19	21	22	24	25	27	28	29	30	32	35	36	37	36	34	33
4	19	21	23	25	27	28	30	31	33	34	35	36	38	41	42	43	42	40	39
6	25	27	29	31	33	34	36	37	39	40	41	42	44	46	48	49	48	46	45
8	31	33	35	37	38	40	41	43	44	45	47	48	49	52	53	54	53	52	51
10	37	39	41	42	44	46	47	48	50	51	52	53	2 54	2 57	2 59	2 59	2 59	2 58	2 57
4 0	42	44	46	47	49	51	52	53	55	2 56	2 57	2 58	3 0	3 2	3 4	3 4	3 4	3 3	3 2
2	47	49	51	52	54	2 56	2 57	2 58	2 59	3 1	3 2	3 3	4	6	8	9	9	8	7
4	52	54	2 56	2 57	2 59	3 0	3 2	3 3	3 4	5	6	7	9	11	13	14	14	13	12
6	2 57	2 59	3 1	3 2	3 4	5	6	7	8	10	11	12	13	15	17	18	18	17	17
8	3 2	3 3	5	6	8	9	11	12	13	14	15	16	18	20	22	23	23	22	21
10	6	8	9	11	12	13	15	16	17	18	19	20	22	24	26	27	27	26	26
5 0	3 10	3 12	3 13	3 15	3 16	17	3 19	3 20	3 21	3 22	3 23	3 24	3 26	3 28	3 30	3 31	3 31	3 30	3 30

Length of the shadow	Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep.25	Sep.24 to Sep.22	Sep 21 to Sep.20	Sep.19 to Sep.16	Sep.15 to Sep. 9	Sep. 8 to Aug31	Aug30 to Aug19	Aug18 to Aug. 6	Aug. 5 to Jul. 22	Jul. 21 to Jul. 6	Jul. 5 to Jun 22
Declination.	9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	2° +	4° +	7° +	11° +	15° +	19° +	22° +	23½ +
5 2	3 14	3 16	3 17	3 19	3 20	3 21	3 22	3 24	3 25	3 26	3 27	3 28	3 29	3 31	3 33	3 34	3 35	3 34	3 34
4	18	20	21	22	24	25	26	27	28	29	30	31	33	35	37	38	38	38	38
6	22	24	25	26	28	29	30	31	32	33	34	35	36	38	40	42	42	42	41
8	25	27	28	29	31	32	33	34	35	36	37	38	40	42	44	45	45	45	45
10	29	30	31	33	34	35	36	37	38	39	40	41	43	45	47	48	49	49	48
6 0	32	33	35	36	37	38	39	41	42	43	43	44	46	48	50	51	52	52	52
4	38	39	40	42	43	44	45	46	47	48	49	50	52	54	3 56	3 57	3 58	3 58	3 58
8	44	45	46	47	49	50	51	52	53	54	55	3 55	3 57	3 59	4 1	4 3	4 3	4 4	4 4
7 0	49	50	51	52	53	55	3 56	3 57	3 58	3 59	3 59	4 0	4 2	4 4	6	8	8	9	9
4	54	55	3 56	3 57	3 58	3 59	4 1	4 2	4 2	4 3	4 4	5	7	9	11	12	13	14	14
8	3 58	3 59	4 1	4 2	4 3	4 4	5	6	7	8	8	9	11	13	15	17	18	18	18
8 0	4 2	4 3	5	6	7	8	9	10	11	12	13	13	15	17	19	21	22	23	23
4	6	7	9	10	11	12	13	14	15	15	16	17	19	21	23	25	26	26	27
8	10	11	12	13	14	15	16	17	18	19	20	21	22	24	27	28	30	30	31
9 0	13	15	16	17	18	19	20	21	21	22	23	24	26	28	30	31	33	34	34
4	16	18	19	20	21	22	23	24	25	25	26	27	29	31	33	35	36	37	38
8	19	21	22	23	24	25	26	27	28	28	29	30	32	34	36	38	39	40	41
10 0	22	23	25	26	27	28	29	30	30	31	32	33	34	36	39	41	42	43	44
6	26	27	28	29	30	31	32	33	34	35	36	37	38	40	43	45	46	47	48
11 0	30	31	32	33	34	35	36	37	38	39	40	40	42	44	46	48	50	51	52
6	34	35	36	37	37	38	39	40	41	42	43	44	45	47	50	52	53	54	55
12 0	37	38	39	40	41	42	42	43	44	45	46	47	48	50	53	4 55	4 57	4 58	4 58
13 0	42	43	44	45	46	47	48	49	49	50	51	52	53	4 55	4 58	5 0	5 2	5 3	5 4
14 0	47	48	49	50	51	52	53	54	54	55	4 56	4 57	4 58	5 0	5 3	5	7	9	9
15 0	51	52	53	54	55	4 56	4 57	4 57	4 58	4 59	5 0	5 1	5 2	4	7	9	11	13	14
16 0	55	56	4 57	4 58	4 59	5 0	5 1	5 1	5 2	5 3	4	5	6	8	11	13	15	17	18
17 0	4 58	4 59	5 0	5 1	5 2	3	4	5	5	6	7	8	9	11	14	17	19	20	21
18 0	5 1	5 2	3	4	5	6	7	8	8	9	10	11	12	14	17	20	22	24	24
19 0	4	5	6	7	8	8	9	10	11	12	13	13	15	17	20	22	24	26	27
20 0	5 6	5 7	5 8	5 9	5 10	5 11	5 12	5 13	5 13	5 14	5 15	5 16	5 17	5 19	5 22	5 25	5 27	5 29	5 30

Applicable to Calicut, Coimbatore, Combaconum, Negapatam, Ootacamund, Porto Novo, Tanjore, Tranquebar, Trichinopoly, &c. &c.

12° North Latitude. Page 1.

Length of the shadow f. in.	Dec.22 to Dec.29 h. m.	Dec.30 to Jan. 4 h. m.	Jan. 5 to Jan. 8 h. m.	Jan. 9 to Jan.11 h. m.	Jan.12 to Jan.14 h. m.	Jan.15 to Jan.17 h. m.	Jan.18 to Jan.20 h. m.	Jan.21 to Jan.23 h. m.	Jan.24 to Jan.26 h. m.	Jan.27 to Jan.29 h. m.	Jan.30 to Jan.31 h. m.	Feb. 1 to Feb. 3 h. m.	Feb. 4 to Feb. 6 h. m.	Feb. 7 to Feb. 9 h. m.	Feb.10 to Feb.12 h. m.	Feb.13 to Feb.15 h. m.	Feb.16 to Feb.18 h. m.	Feb.19 to Feb.21 h. m.	Feb.22 to Feb.24 h. m.
1 6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 21
9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	35
10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 23	36	45
11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36	45	0 53
2 0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36	46	0 54	1 0
1	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36	46	0 54	1 1	7
2	.	.	.	.	.	.	.	.	.	.	.	.	0 21	37	47	0 55	1 2	8	13
3	.	.	.	.	.	.	.	.	.	.	.	0 19	36	47	0 55	1 2	8	14	19
4	.	.	.	.	.	.	.	.	.	.	0 24	35	47	0 55	1 2	9	14	19	24
5	.	.	.	.	.	.	.	.	0 13	0 29	38	46	0 55	1 3	9	15	20	25	29
6	.	.	.	.	.	.	.	0 19	33	42	49	0 55	1 3	10	15	21	25	30	34
7	.	.	.	.	.	.	0 24	36	44	51	0 57	1 2	10	16	21	26	30	35	39
8	.	.	.	.	0 15	0 28	39	47	0 54	0 59	1 5	9	16	22	27	31	35	39	43
9	.	.	0 5	0 25	34	41	49	0 56	1 2	1 6	12	16	22	27	32	36	40	44	47
10	.	0 20	31	39	46	51	0 58	1 4	9	13	18	22	27	32	37	41	44	48	51
11	0 27	36	43	50	0 55	0 59	1 5	11	15	19	24	27	32	37	41	45	49	52	55
3 0	0 41	0 47	0 53	0 58	1 3	1 7	12	17	21	25	29	32	37	42	46	49	1 53	1 56	1 59
2	1 0	1 4	1 8	1 13	16	19	24	28	32	35	39	41	46	50	1 54	1 57	2 1	2 4	2 7
4	14	18	21	25	28	31	35	38	41	45	48	50	1 54	1 58	2 2	2 5	8	11	14
6	25	29	32	35	38	40	44	47	50	1 53	1 56	1 58	2 2	2 6	9	12	15	18	20
8	36	39	41	44	47	49	1 52	1 55	1 58	2 1	2 3	2 6	9	13	16	19	21	24	26
10	45	48	50	1 52	1 55	1 57	2 0	2 3	2 5	8	10	13	16	19	22	25	27	30	32
4 0	1 53	1 56	1 58	2 0	2 3	2 5	7	10	12	15	17	19	22	25	28	31	33	36	38
2	2 1	2 3	2 5	7	10	12	14	17	19	21	23	25	28	31	34	37	39	41	44
4	8	10	12	14	16	18	20	23	25	27	29	31	34	37	39	42	44	46	49
6	15	16	18	20	22	24	26	29	31	33	35	37	40	42	45	47	49	51	54
8	21	22	24	26	28	30	32	34	35	38	40	42	45	47	50	52	54	2 56	2 58
10	27	28	30	32	34	35	37	39	41	43	45	47	50	52	54	2 57	2 59	3 1	3 3
5 0	2 32	2 34	2 35	2 37	2 39	2 40	2 42	2 44	2 46	2 48	2 50	2 52	2 54	2 57	2 59	3 1	3 3	3 5	3 7

Length of the shadow	Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5 2	2 37	2 38	2 40	2 42	2 44	2 45	2 47	2 49	2 51	2 53	2 55	2 56	2 59	3 1	3 3	3 5	3 7	3 9	3 11
4	42	43	45	47	48	50	52	53	55	2 57	2 59	3 0	3 3	5	7	9	11	13	15
6	47	48	50	51	53	54	2 56	2 58	2 59	3 1	3 3	4	7	9	11	13	15	17	19
8	51	52	54	55	2 57	2 58	3 0	3 2	3 3	5	7	8	11	13	15	17	19	20	22
10	55	2 56	2 58	2 59	3 1	3 2	4	6	7	9	11	12	15	17	19	21	22	24	26
6 0	2 59	3 0	3 2	3 3	5	6	8	9	11	12	14	16	18	20	22	24	25	27	29
4	3 6	7	9	10	12	13	15	16	18	19	21	22	24	26	28	30	32	33	35
8	13	14	16	17	18	20	21	23	24	26	27	28	30	32	34	36	38	39	41
7 0	19	20	22	23	24	26	27	29	30	32	33	34	36	38	40	41	43	44	46
4	25	26	28	29	30	31	32	34	35	37	38	39	41	43	45	46	48	49	51
8	30	31	33	34	35	36	37	39	40	42	43	44	46	48	50	51	53	54	3 56
8 0	35	36	38	39	40	41	42	44	45	46	47	49	50	52	54	55	3 57	3 58	4 0
4	40	41	42	43	44	45	47	48	49	50	52	53	54	3 56	3 58	3 59	4 1	4 2	4
8	44	45	46	47	48	49	51	52	53	54	3 56	3 57	3 58	4 0	4 2	4 3	5	6	7
9 0	48	49	50	51	52	53	55	56	3 57	3 58	4 0	4 1	4 2	4	6	7	8	10	11
4	52	53	54	55	56	3 57	3 58	3 59	4 0	4 2	3	4	5	7	9	10	11	13	14
8	55	56	3 57	3 58	3 59	4 0	4 1	4 3	4	5	6	7	9	10	12	13	14	16	17
10 0	3 58	3 59	4 0	4 1	4 2	3	4	6	7	8	9	10	12	13	15	16	17	19	20
6	4 3	4 4	5	6	7	8	9	10	11	12	13	14	16	17	19	20	21	23	24
11 0	7	8	9	10	11	12	13	14	15	16	17	18	20	21	23	24	25	27	28
6	11	12	13	14	15	16	17	18	19	20	21	22	24	25	26	28	29	30	31
12 0	15	15	16	17	18	19	20	21	22	23	24	25	27	28	29	31	32	33	34
13 0	21	21	22	23	24	25	26	27	28	29	30	31	33	34	35	36	37	39	40
14 0	26	27	28	29	30	30	31	32	33	34	35	36	38	39	40	41	43	44	45
15 0	31	32	33	34	34	35	36	37	38	39	40	41	42	43	44	46	47	48	49
16 0	35	36	37	38	38	39	40	41	42	43	44	45	46	47	48	50	51	52	53
17 0	39	40	41	41	42	43	44	45	46	46	47	48	50	51	52	53	54	55	56
18 0	42	43	44	44	45	46	47	48	49	49	50	51	53	54	55	56	4 57	4 58	4 59
19 0	45	46	47	47	48	49	50	51	52	52	53	54	55	57	4 58	4 59	5 0	5 1	5 2
20 0	4 48	4 49	4 49	4 50	4 51	4 51	4 52	4 53	4 54	4 55	4 56	4 57	4 58	4 59	5 0	5 1	5 2	5 3	5 4
Declination.	$23\frac{1}{2}$	23°	$22\frac{1}{2}$	22°	$21\frac{1}{2}$	21°	$20\frac{1}{3}$	$19\frac{2}{5}$	19°	$18\frac{1}{3}$	$17\frac{2}{3}$	17°	16°	15°	14°	13°	12°	11°	10°

pplicable to Cannanore, Cuddalore, French Rocks, Mahe, Mercara, Mysore, Pondicherry, Salem, Tellicherry, Yelwal, &c. &c.

12° North Latitude. Page II.

Length of the shadow	Feb.25 to Feb.26	Feb 27 to Mar. 1	Mar. 2 to Mar. 4	Mar. 5 to Mar. 6	Mar. 7 to Mar. 9	Mar10 to Mar11	Mar12 to Mar14	Mar15 to Mar16	Mar17 to Mar19	Mar20 to Mar22	Mar23 to Mar25	Mar26 to Mar31	Mar31 to Apr. 6	Apr 7 to Apr 15	Apr 16 to Apr 27	Apr 28 to May11	May12 to May25	May26 to Jun. 8	Jun. 9 to Jun.22
f. in.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1 6	.	0 19	0 32	0 40	0 47	0 52	0 57	1 1	1 4	1 7	1 10	1 15	1 18	1 22	1 24	1 23	1 19	1 15	1 12
7	0 20	33	41	48	0 54	0 58	1 2	6	10	12	15	19	22	26	29	28	24	20	17
8	34	43	50	0 55	1 0	1 4	8	12	15	17	20	24	27	31	33	32	28	25	22
9	44	51	0 57	1 2	6	10	14	17	20	22	24	28	32	35	37	36	33	30	27
10	52	0 58	1 3	8	12	15	19	22	24	27	29	33	36	39	41	40	37	34	32
11	0 59	1 4	9	14	17	20	23	26	29	31	33	37	40	43	45	44	42	39	36
2 0	1 5	10	15	19	22	25	28	31	33	36	38	41	44	47	49	48	46	43	41
1	11	16	20	24	27	30	33	35	38	40	42	45	48	51	53	52	50	48	45
2	17	21	25	29	32	35	37	40	42	44	46	49	52	54	1 56	1 56	54	52	50
3	23	26	30	34	37	39	42	44	46	48	50	53	56	1 58	2 0	2 0	1 58	1 56	54
4	28	31	35	38	41	43	46	48	50	52	54	1 57	1 59	2 2	4	4	2 2	2 0	1 58
5	33	36	40	42	45	48	50	52	54	1 56	1 57	2 0	2 3	6	7	8	6	4	2 2
6	37	41	44	47	49	52	54	1 56	1 58	2 0	2 1	4	7	9	11	11	9	8	6
7	42	45	48	51	53	56	1 58	2 0	2 2	3	5	8	10	13	14	15	13	11	10
8	46	49	52	55	1 57	1 59	2 1	3	5	7	8	11	14	16	18	18	17	15	14
9	50	53	1 56	1 59	2 1	2 3	5	7	9	10	12	15	17	19	21	22	20	19	17
10	54	1 57	2 0	2 2	5	7	9	11	12	14	15	18	20	23	25	25	24	22	21
11	1 58	2 1	4	6	8	10	12	14	16	17	19	21	24	26	28	28	27	26	24
3 0	2 2	5	7	9	12	14	16	17	19	21	22	24	27	29	31	31	30	29	28
2	9	12	14	16	19	21	22	24	26	27	28	31	33	35	37	38	37	36	35
4	16	19	21	23	25	27	28	30	32	33	34	37	39	41	43	44	43	42	41
6	23	25	27	29	31	33	34	36	38	39	40	43	45	47	49	50	49	48	47
8	29	31	33	35	37	39	40	42	43	44	46	48	50	52	54	2 55	2 54	54	53
10	35	37	39	41	43	44	46	47	49	50	51	53	2 55	2 57	2 59	3 0	3 0	2 58	2 58
4 0	40	42	44	46	48	49	51	52	54	2 55	2 56	2 58	3 0	3 2	3 4	5	5	3 4	3 4
2	46	47	49	51	53	54	2 56	2 57	2 59	3 0	3 1	3 3	5	7	9	10	10	9	9
4	51	52	54	2 56	2 58	2 59	3 1	3 2	3 3	4	6	8	10	12	14	15	15	14	14
6	2 55	2 57	2 59	3 1	3 2	3 3	5	7	8	9	10	12	14	16	18	19	19	19	18
8	3 0	3 2	3 4	5	7	8	10	11	12	13	14	16	18	20	22	24	24	23	23
10	4	6	8	9	11	12	14	15	16	17	18	20	22	24	26	28	28	28	27
5 0	3 9	3 10	3 12	3 14	3 15	3 16	3 18	3 19	3 20	3 21	3 22	3 24	3 26	3 28	3 30	3 32	3 32	3 32	3 31

Length of the shadow	Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep.25	Sep.24 to Sep.22	Sep 21 to Sep.19	Sep.18 to Sep.13	Sep.12 to Sep. 7	Sep. 6 to Aug28	Aug27 to Aug16	Aug15 to Aug. 2	Aug. 1 to Jul. 19	Jul. 18 to Jul. 6	Jul. 5 to Jun 22
5 2	3 13	3 14	3 16	3 18	3 19	3 20	3 22	3 23	3 24	3 25	3 26	3 28	3 30	3 32	3 34	3 35	3 36	3 36	3 35
4	17	18	20	21	23	24	25	26	28	29	30	32	33	36	38	39	40	40	39
6	21	22	23	25	26	28	29	30	31	32	33	35	37	39	41	43	43	43	43
8	24	25	27	28	30	31	32	33	35	36	37	39	40	42	45	46	47	47	47
10	27	29	30	32	33	34	35	37	38	39	40	42	43	46	48	49	50	50	50
6 0	30	32	33	35	36	37	39	40	41	42	43	45	46	49	51	52	53	53	53
4	36	38	39	41	42	43	45	46	47	48	49	51	52	3 54	3 57	3 58	3 59	3 59	3 59
8	42	44	45	46	48	49	50	51	52	53	54	3 56	3 58	4 0	4 2	4 4	4 5	4 5	4 5
7 0	47	49	50	51	53	54	3 55	3 56	3 57	3 58	3 59	4 1	4 2	5	7	9	10	10	10
4	52	54	3 55	3 56	3 57	3 59	4 0	4 1	4 2	4 3	4 4	6	7	9	12	14	15	15	15
8	3 57	3 58	4 0	4 1	4 2	4 3	4	5	6	7	8	10	12	14	16	18	20	20	20
8 0	4 1	4 2	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	24	24
4	5	6	7	9	10	11	12	13	14	15	16	18	20	22	24	26	28	28	28
8	9	10	11	12	14	15	16	17	18	19	20	21	23	25	28	30	31	32	32
9 0	12	14	15	16	17	18	19	20	21	22	23	25	26	28	31	33	35	35	35
4	15	17	18	19	20	21	22	23	24	25	26	28	29	32	34	36	38	39	39
8	18	20	21	22	23	24	25	26	27	28	29	31	32	35	37	39	41	42	42
10 0	21	23	24	25	26	27	28	29	30	31	32	34	35	37	40	42	44	45	45
6	25	26	28	29	30	31	32	33	34	35	36	38	39	41	44	46	48	49	49
11 0	29	30	31	32	34	35	36	37	37	38	39	41	43	45	47	50	52	53	53
6	32	34	35	36	37	38	39	40	41	42	43	44	46	48	51	53	55	56	4 57
12 0	35	37	38	39	40	41	42	43	44	45	46	47	49	51	54	4 56	4 58	4 59	5 0
13 0	41	42	43	44	45	46	47	48	49	50	51	52	54	4 56	4 59	5 2	5 4	5 5	6
14 0	46	47	48	49	50	51	52	53	54	55	4 56	4 57	4 59	5 1	5 4	7	9	10	11
15 0	50	51	52	53	54	55	4 56	4 57	4 58	4 59	5 0	5 1	5 3	5	8	11	13	14	15
16 0	54	55	56	4 57	4 58	4 59	5 0	5 1	5 2	5 3	4	5	7	9	12	15	17	18	19
17 0	4 58	4 58	4 59	5 0	5 1	5 2	3	4	5	6	7	9	10	13	15	18	21	22	23
18 0	5 0	5 1	5 2	3	4	5	6	7	8	9	10	12	13	16	18	21	24	25	26
19 0	3	4	5	6	7	8	9	10	11	12	12	14	15	18	21	24	27	28	29
20 0	5 6	5 7	5 8	5 9	5 10	5 11	5 11	5 12	5 13	5 14	5 15	5 17	5 18	5 21	5 24	5 26	5 29	5 30	5 31
Declination.	9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	8° +	12° +	16° +	20° +	22° +	23½ +

Length of the shadow. f.	in.	Dec.22 to Dec.29 h. m.	Dec.30 to Jan. 4 h. m.	Jan. 5 to Jan. 8 h. m.	Jan. 9 to Jan.11 h. m.	Jan.12 to Jan.14 h. m.	Jan.15 to Jan.17 h. m.	Jan.18 to Jan.20 h. m.	Jan.21 to Jan.23 h. m.	Jan.24 to Jan.26 h. m.	Jan.27 to Jan.29 h. m.	Jan.30 to Jan.31 h. m.	Feb. 1 to Feb. 3 h. m.	Feb. 4 to Feb. 6 h. m.	Feb. 7 to Feb. 9 h. m.	Feb.10 to Feb.12 h. m.	Feb.13 to Feb.15 h. m.	Feb.16 to Feb.18 h. m.	Feb.19 to Feb.21 h. m.	Feb.22 to Feb.24 h. m.
1	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22
	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36
	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36	45
2	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36	46	0 54
	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 21	36	46	0 54	1 1
	2	.	.	.	.	.	.	.	.	.	.	.	.	.	0 20	36	47	0 55	1 2	8
	3	.	.	.	.	.	.	.	.	.	.	.	.	0 19	36	46	0 55	1 2	8	14
	4	.	.	.	.	.	.	.	.	.	.	.	0 16	35	46	0 55	1 3	9	14	19
	5	.	.	.	.	.	.	.	.	.	.	0 22	34	46	0 55	1 2	9	15	20	25
	6	.	.	.	.	.	.	.	.	0 6	0 27	37	45	0 55	1 3	9	15	21	25	30
	7	.	.	.	.	.	.	.	0 14	30	40	48	1 54	1 2	10	15	21	26	30	35
	8	.	.	.	.	.	.	0 20	34	43	50	0 57	1 2	9	16	21	27	31	35	39
	9	.	.	.	.	0 6	0 24	37	45	0 52	0 59	1 4	9	16	22	27	32	36	40	44
	10	.	.	.	0 19	31	39	48	0 55	1 1	1 6	11	16	22	27	32	37	41	45	48
	11	.	0 11	0 27	36	43	49	0 56	1 2	8	13	17	21	27	32	37	41	45	49	52
3	0	0 22	33	0 41	0 47	0 53	0 58	1 4	9	14	19	23	27	32	37	41	45	49	1 53	1 56
	2	0 49	0 54	1 0	1 4	1 8	1 12	17	21	26	30	33	37	42	46	50	1 54	1 57	2 1	2 4
	4	1 5	1 10	14	17	21	24	28	32	36	40	43	46	50	1 54	1 58	2 2	2 5	8	11
	6	18	22	25	29	32	35	39	42	45	48	51	1 54	1 58	2 2	2 6	9	12	15	18
	8	29	32	35	38	41	44	48	51	1 54	1 57	1 59	2 2	2 6	9	13	16	19	21	24
	10	39	42	45	47	50	1 52	1 56	1 59	2 1	2 4	2 7	9	13	16	19	22	25	27	30
4	0	48	50	1 53	1 55	1 58	2 0	2 3	2 6	8	11	14	16	19	22	25	28	31	33	36
	2	1 56	1 58	2 1	2 3	2 5	7	10	13	15	17	20	22	25	28	31	34	37	39	42
	4	2 3	2 5	8	10	12	14	17	19	21	23	26	28	31	34	37	40	42	44	47
	6	10	12	14	16	18	20	23	25	27	29	32	34	37	40	42	45	47	49	52
	8	16	18	20	22	24	26	29	31	33	35	37	39	42	45	47	50	52	54	56
	10	22	24	26	28	30	32	34	36	38	40	42	44	47	49	52	55	2 57	2 59	3 1
5	0	2 28	2 30	2 31	2 33	2 35	2 37	2 39	2 41	2 43	2 45	2 47	2 49	2 51	2 54	2 56	2 59	3 1	3 3	3 5

Length of the shadow	Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov 30 to Nov 28	Nov 27 to Nov 25	Nov 24 to Nov 22	Nov 21 to Nov 19	Nov 18 to Nov 17	Nov 16 to Nov 14	Nov 13 to Nov 11	Nov 10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct. 30	Oct. 29 to Oct. 27	Oct. 26 to Oct. 24	Oct. 23 to Oct. 21	Oct. 20 to Oct. 19
5 2	2 33	2 35	2 37	2 38	2 40	2 42	2 44	2 46	2 48	2 50	2 52	2 54	2 56	2 59	3 1	3 3	3 5	3 7	3 9
4	38	40	42	43	45	46	48	50	52	54	2 56	2 58	3 0	3 3	5	7	9	11	13
6	43	45	47	48	50	51	53	55	2 57	2 58	3 0	3 2	4	7	9	11	13	15	17
8	47	49	51	52	54	55	2 57	2 59	3 1	3 2	4	6	8	10	13	15	17	19	20
10	51	53	55	2 56	2 58	59	3 1	3 3	5	6	8	10	12	14	17	19	21	22	24
6 0	2 55	2 57	2 59	3 0	3 1	3 3	5	6	8	10	12	13	15	18	20	22	24	25	27
4	3 3	3 4	3 6	7	8	10	12	13	15	17	19	20	22	24	26	28	30	32	33
8	10	11	13	14	15	17	18	20	22	23	25	26	28	30	32	34	36	38	39
7 0	16	17	19	20	21	23	24	26	28	29	31	32	34	36	38	40	41	43	44
4	22	23	25	26	27	28	30	31	33	34	36	37	39	41	43	45	46	48	49
8	27	29	30	31	32	33	35	36	38	39	41	42	44	46	48	50	51	53	54
8 0	32	34	35	36	37	38	40	41	43	44	45	47	48	50	52	54	55	3 57	3 58
4	37	38	40	41	42	43	44	46	47	48	50	51	53	54	3 56	3 58	3 59	4 1	4 2
8	41	42	44	45	46	47	48	50	51	52	54	55	3 57	3 58	4 0	4 2	4 3	5	6
9 0	45	46	48	49	50	51	52	54	55	3 56	3 58	3 59	4 1	4 2	4	6	7	8	10
4	49	50	51	52	53	54	56	3 57	3 58	4 0	4 1	4 2	4	5	7	9	10	11	13
8	53	54	55	56	3 57	3 58	3 59	4 1	4 2	3	4	5	7	8	10	12	13	14	16
10 0	3 56	3 57	3 58	3 59	4 0	4 1	4 2	4	5	6	7	8	10	12	13	15	16	17	19
6	4 1	4 2	4 3	4 4	5	6	7	8	9	10	11	12	14	16	17	19	20	21	23
11 0	5	6	7	8	9	10	11	12	13	14	15	16	18	20	21	23	24	25	27
6	9	10	11	12	13	14	15	16	17	18	19	20	22	23	25	26	28	29	30
12 0	12	13	14	15	16	17	18	19	20	21	22	23	25	26	28	29	31	32	33
13 0	18	19	20	21	22	23	24	25	26	27	28	29	31	32	34	35	36	38	39
14 0	24	25	26	27	27	28	29	30	31	32	34	34	36	37	39	40	41	43	44
15 0	29	30	31	31	32	33	34	35	36	37	38	39	40	42	43	44	46	47	48
16 0	33	34	35	35	36	37	38	39	40	41	42	43	44	46	47	48	50	51	52
17 0	37	38	39	39	40	41	42	43	44	45	46	47	48	49	51	52	53	54	55
18 0	40	41	42	42	43	44	45	46	47	48	49	50	51	52	54	55	56	4 57	4 58
19 0	43	44	45	45	46	47	48	49	50	51	52	53	54	55	57	4 58	4 59	5 0	5 1
20 0	4 46	4 47	4 47	4 48	4 49	4 50	4 50	4 51	4 52	4 53	4 54	4 55	4 56	4 58	4 59	5 0	5 1	5 2	5 4
Declination.	23½ —	23° —	22½ —	22° —	21½ —	21° —	20⅓ —	19⅔ —	19° —	18⅓ —	17⅔ —	17° —	16° —	15° —	14° —	13° —	12° —	11° —	10° —

Applicable to Arcot, Arnee, Bangalore, Chingleput, Chittoor, Madras, Mangalore. Palaveram, Palmanair, Poonamallee, Pulicat, Seringapatam, St. Thomas' Mount, Vellore, [illegible]

13° North Latitude. Page 11.

Length of the shadow f.	in.	Feb.25 to Feb.26 h. m.	Feb 27 to Mar. 1 h. m.	Mar. 2 to Mar. 4 h. m.	Mar. 5 to Mar. 6 h. m.	Mar. 7 to Mar. 9 h. m.	Mar10 to Mar11 h. m.	Mar12 to Mar14 h. m.	Mar15 to Mar16 h. m.	Mar17 to Mar19 h. m.	Mar20 to Mar22 h. m.	Mar23 to Mar25 h. m.	Mar26 to Mar30 h. m.	Mar31 to Apr. 5 h. m.	Apr 6 to Apr10 h. m.	Apr 11 to Apr 19 h. m.	Apr 19 to May 1 h. m.	May 2 to May16 h. m.	May16 to May31 h. m.	Jun. 1 to Jun.22 h. m.
1	6	.	.	0 20	0 32	0 40	0 47	0 52	0 57	1 1	1 4	1 7	1 13	1 17	1 20	1 22	1 25	1 24	1 20	1 16
	7	.	0 20	33	41	48	0 54	0 58	1 3	7	10	13	17	21	24	27	29	28	24	21
	8	0 21	34	43	49	0 55	1 0	1 4	8	12	15	18	22	26	29	31	33	32	28	26
	9	35	44	51	0 56	1 2	6	10	14	17	20	22	27	30	33	35	37	37	33	30
	10	44	52	0 58	1 3	8	12	15	19	22	24	27	31	34	37	39	41	41	38	35
	11	0 53	0 59	1 5	9	13	17	21	24	27	29	31	35	39	41	43	45	45	42	39
2	0	1 0	1 6	11	15	19	22	26	28	31	34	36	40	43	45	47	49	49	46	44
	1	7	12	17	20	24	27	30	33	36	38	40	44	47	49	51	53	53	50	48
	2	13	17	22	25	29	32	35	37	40	42	44	48	51	53	55	1 57	1 57	54	52
	3	19	23	27	30	33	36	39	42	44	46	48	52	55	1 57	1 59	2 1	2 1	1 58	1 56
	4	24	28	31	35	38	41	43	46	48	50	52	55	1 58	2 1	2 2	4	4	2 2	2 0
	5	29	33	36	40	43	45	48	50	52	54	1 56	1 59	2 2	4	6	8	8	6	4
	6	34	37	41	44	47	49	52	54	1 56	1 58	2 0	2 3	6	8	10	12	12	10	8
	7	39	42	45	48	51	53	56	1 58	2 0	2 2	4	7	9	11	13	15	15	14	12
	8	43	46	49	52	55	1 57	1 59	2 2	4	5	7	10	13	15	16	19	19	17	16
	9	47	50	53	1 56	1 59	2 1	2 3	5	7	9	11	14	16	18	20	22	22	21	19
	10	51	54	1 57	2 0	2 2	5	7	9	11	13	14	17	19	22	23	25	26	24	23
	11	55	1 58	2 1	4	6	8	10	12	14	16	17	20	23	25	26	28	29	28	27
3	0	1 59	2 2	5	7	10	12	14	16	18	19	21	24	26	28	30	32	32	31	30
	2	2 7	9	12	14	17	19	21	22	24	26	27	30	32	34	36	38	38	37	36
	4	14	16	19	21	23	25	27	29	30	32	33	36	38	40	42	44	44	44	43
	6	21	23	25	27	29	31	33	35	36	38	39	42	44	46	47	49	50	49	49
	8	27	29	31	33	35	37	39	40	42	43	45	47	49	51	53	2 55	2 56	2 55	2 55
	10	33	35	37	39	41	43	44	46	48	49	50	52	2 55	2 56	2 58	3 0	3 1	3 1	3 0
4	0	38	40	42	44	46	48	50	51	53	54	2 55	2 58	3 0	3 1	3 3	5	6	6	5
	2	44	46	48	49	51	53	55	2 56	2 58	2 59	3 0	3 2	4	6	8	10	11	11	10
	4	49	51	53	54	2 56	2 58	2 59	3 1	3 2	3 4	5	7	9	11	12	14	16	16	15
	6	54	2 56	2 57	2 59	3 1	3 3	3 4	6	7	8	9	12	14	15	17	19	20	20	20
	8	2 58	3 0	3 2	3 4	5	7	8	10	11	12	14	16	18	20	21	23	25	25	25
	10	3 3	5	7	8	10	11	13	14	15	17	18	20	22	24	25	27	29	29	29
5	0	3 7	3 9	3 11	3 12	3 14	3 15	3 17	3 18	3 19	3 21	3 22	3 24	3 26	3 28	3 29	3 31	3 33	3 33	3 33

Length of the shadow	Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep 25	Sep.24 to Sep.22	Sep 21 to Sep.19	Sep.18 to Sep.13	Sep.12 to Sep. 8	Sep. 7 to Sep. 3	Sep. 2 to Aug25	Aug24 to Aug13	Aug12 to Jul. 29	Jul. 28 to Jul. 13	Jul. 12 to Jun 22
5 2	3 11	3 13	3 15	3 16	3 18	3 19	3 21	3 22	3 23	3 24	3 25	3 28	3 30	3 31	3 33	3 35	3 36	3 37	3 37
4	15	17	18	20	21	23	24	26	27	28	29	31	33	35	36	39	40	41	41
6	19	20	22	24	25	27	28	29	30	31	33	35	37	38	40	42	44	44	44
8	22	24	25	27	29	30	31	33	34	35	36	38	40	42	43	46	47	48	48
10	26	27	29	30	32	33	34	36	37	38	39	41	43	45	46	49	50	51	51
6 0	29	31	32	34	35	36	38	39	40	41	42	44	46	48	49	52	53	3 54	3 55
4	35	37	38	40	41	42	44	45	46	47	48	50	52	54	3 55	3 57	3 59	4 0	4 1
8	41	42	44	45	47	48	49	50	52	53	54	3 56	3 58	3 59	4 1	4 3	4 5	6	7
7 0	46	47	49	50	52	53	54	3 55	3 56	3 58	3 59	4 1	4 2	4 4	6	8	10	11	12
4	51	52	54	3 55	3 57	3 58	3 59	4 0	4 1	4 2	4 3	5	7	9	10	13	15	16	17
8	3 56	3 57	3 59	4 0	4 1	4 2	4 3	4	6	7	8	10	11	13	15	17	19	21	21
8 0	4 0	4 1	4 3	4	5	6	8	9	10	11	12	14	16	17	19	21	23	25	26
4	4	5	7	8	9	10	11	12	14	15	16	18	19	21	22	25	27	29	30
8	7	9	10	11	13	14	15	16	17	18	19	21	23	25	26	29	31	33	33
9 0	11	13	14	15	16	17	18	19	20	22	23	24	26	28	29	32	34	36	37
4	14	16	17	18	19	20	22	23	24	25	26	28	29	31	33	35	38	40	40
8	17	19	20	21	22	23	25	26	27	28	29	31	32	34	36	38	41	43	43
10 0	20	22	23	24	25	26	27	28	30	31	32	33	35	37	39	41	44	46	46
6	24	25	27	28	29	30	31	32	33	34	35	37	39	41	42	45	48	50	50
11 0	28	29	30	32	33	34	35	36	37	38	39	41	43	44	46	49	51	53	54
6	31	33	34	35	36	37	38	39	40	41	42	44	46	48	49	52	55	4 57	4 58
12 0	34	36	37	38	39	40	41	42	43	44	45	47	49	51	52	4 55	4 58	5 0	5 1
13 0	40	41	42	44	45	46	47	48	49	50	51	52	54	4 56	4 58	5 1	5 3	6	7
14 0	45	46	47	49	50	51	52	53	54	55	4 56	4 58	4 59	5 1	5 3	6	8	11	12
15 0	49	50	51	53	54	55	4 56	4 57	4 58	4 59	5 0	5 1	5 3	5	7	10	13	15	16
16 0	53	54	55	4 57	4 58	4 59	5 0	5 1	5 2	5 3	4	5	7	9	11	14	17	19	21
17 0	4 57	4 58	4 59	5 0	5 1	5 2	3	4	5	6	7	9	10	12	14	17	20	23	25
18 0	5 0	5 1	5 2	3	4	5	6	7	8	9	10	12	13	15	17	20	23	26	27
19 0	2	3	5	6	6	7	8	9	10	11	12	14	16	18	19	23	26	28	30
20 0	5 5	5 6	5 7	5 8	5 9	5 10	5 11	5 12	5 13	5 14	5 15	5 17	5 18	5 20	5 22	5 25	5 28	5 31	5 33
Declination.	9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	7° +	9° +	13° +	17° +	21° +	23° +

Applicable to Arcot, Arnee, Bangalore, Chingleput, Chittoor, Madras, Mangalore, Palavaram, Palmanair, Poonamallee, Pulicat

Length of the shadow		Dec.22 to Dec.29		Dec.30 to Jan. 4		Jan. 5 to Jan. 8		Jan. 9 to Jan.11		Jan.12 to Jan.14		Jan.15 to Jan.17		Jan.18 to Jan.20		Jan.21 to Jan.23		Jan.24 to Jan.26		Jan.27 to Jan.29		Jan.30 to Jan.31		Feb. 1 to Feb. 3		Feb. 4 to Feb. 6		Feb. 7 to Feb. 9		Feb.10 to Feb.12		Feb.13 to Feb.15		Feb.16 to Feb.18		Feb.19 to Feb.21		Feb.22 to Feb.24	
f.	in.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.
1	6		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.
	7		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.
	8		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.
	9		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.
	10		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	0	22
	11		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	0	23		36
2	0		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	0	22		36		45
	1		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	0	21		36		46	0	54
	2		.		.		.		.		.		.		.		.		.		.		.		.		.		.	0	20		36		47	0	55	1	2
	3		.		.		.		.		.		.		.		.		.		.		.		.		.	0	19		36		46	0	55	1	2		8
	4		.		.		.		.		.		.		.		.		.		.		.		.	0	16		35		46	0	55	1	2		9		14
	5		.		.		.		.		.		.		.		.		.		.		.	0	13		34		46	0	55	1	2		9		15		20
	6		.		.		.		.		.		.		.		.		.		.	0	20		33		46	0	55	1	3		9		15		21		26
	7		.		.		.		.		.		.		.		.		.	0	24		36		44	0	54	1	3		9		15		21		26		31
	8		.		.		.		.		.		.		.	0	3	0	28		39		47	0	54	1	2		9		16		21		27		31		35
	9		.		.		.		.		.		.	0	15		31		41		49	0	56	1	2		9		16		22		27		32		36		40
	10		.		.		.		.		.	0	20		34		43		51	0	58	1	4		9		16		22		27		32		37		41		45
	11		.		.		.	0	12	0	27		36		45	0	53	0	59	1	5		10		15		21		27		32		37		41		45		49
3	0		.		.	0	22		33		41	0	48	0	55	1	1	1	7		12		17		21		27		32		37		41		46		49	1	53
	2	0	33	0	42	0	48	0	54	0	59	1	4	1	10		15		20		24		28		32		37		41		46		50	1	54	1	57	2	1
	4	0	55	1	0	1	5	1	9	1	14		17		22		26		31		34		38		41		46		50	1	54	1	58	2	2	2	5		8
	6	1	10		14		18		22		25		28		33		37		40		43		47		50	1	54	1	58	2	2	2	6		9		12		15
	8		22		26		29		32		35		38		42		46		49	1	52	1	55	1	58	2	2	2	6		9		13		16		19		22
	10		33		36		39		42		45		47		50	1	54	1	57	2	0	2	3	2	5		9		13		16		19		22		25		28
4	0		42		45		48		50	1	53	1	55	1	58	2	1	2	4		7		10		12		16		19		23		25		28		31		34
	2		50	1	53	1	56	1	58	2	0	2	3	2	5		8		11		14		16		19		22		25		29		31		34		37		39
	4	1	58	2	0	2	3	2	5		7		10		12		15		18		20		22		25		28		31		34		37		39		42		44
	6	2	5		7		10		12		14		16		19		21		24		26		28		31		34		37		39		42		45		47		49
	8		12		14		16		18		20		22		25		27		29		32		34		36		39		42		45		47		50		52		54
	10		18		20		22		24		26		28		31		33		35		37		39		41		44		47		49		52		54	2	57	2	59
5	0	2	24	2	26	2	28	2	29	2	31	2	33	2	36	2	38	2	40	2	42	2	44	2	46	2	49	2	51	2	54	2	56	2	59	3	1	3	3

Length of the shadow		Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5	2	2 29	2 31	2 33	2 35	2 36	2 38	2 40	2 43	2 45	2 47	2 49	2 51	2 53	2 56	2 58	3 1	3 3	3 5	3 7
	4	34	36	38	40	41	43	45	47	49	51	53	55	2 58	3 0	3 3	5	7	9	11
	6	39	41	43	44	46	48	50	52	54	2 56	2 57	2 59	3 2	4	7	9	11	13	15
	8	43	45	47	49	50	52	54	2 56	2 58	3 0	3 1	3 3	6	8	10	13	15	17	19
	10	48	50	51	53	54	2 56	2 58	3 0	3 2	4	5	7	10	12	14	17	19	21	23
6	0	2 52	2 54	2 55	2 57	2 58	3 0	3 2	4	6	7	9	11	13	15	18	20	22	24	26
	4	3 0	3 1	3 3	3 4	3 6	7	9	11	12	14	16	18	20	22	24	26	28	30	32
	8	7	8	10	11	13	14	16	17	19	21	22	24	26	28	30	32	34	36	38
7	0	13	14	16	17	19	20	22	23	25	27	28	30	32	34	36	38	40	41	43
	4	19	20	22	23	24	26	27	29	30	32	33	35	37	39	41	43	45	46	48
	8	25	26	27	28	29	31	32	34	35	37	38	40	42	44	46	48	50	51	53
8	0	30	31	32	33	34	36	37	39	40	42	43	44	46	48	50	52	54	55	3 57
	4	34	35	37	38	39	40	42	43	45	46	47	49	51	52	54	3 56	3 58	3 59	4 1
	8	39	40	41	42	43	44	46	47	49	50	51	53	55	3 56	3 58	4 0	4 2	4 3	5
9	0	43	44	45	46	47	48	50	51	53	54	55	3 57	3 59	4 0	4 2	4	6	7	9
	4	46	48	49	50	51	52	53	55	3 56	3 57	3 59	4 0	4 2	4	5	7	9	10	12
	8	50	51	52	53	55	56	3 57	3 58	4 0	4 1	4 2	3	5	7	8	10	12	13	15
10	0	53	54	3 55	3 57	3 58	3 59	4 0	4 1	3	4	5	6	8	10	11	13	15	16	18
	6	3 58	3 59	4 0	4 1	4 2	4 3	5	6	7	8	9	11	12	14	16	17	19	20	22
11	0	4 2	4 3	4	5	6	7	9	10	11	12	13	15	16	18	20	21	23	24	25
	6	6	7	8	9	10	11	13	14	15	16	17	19	20	22	23	25	26	28	29
12	0	10	11	12	13	14	15	16	17	18	19	20	22	23	25	26	28	29	31	32
13	0	16	17	18	19	20	21	22	23	24	25	26	28	29	31	32	34	35	36	38
14	0	22	23	23	24	25	26	27	28	30	31	32	33	34	36	37	39	40	41	43
15	0	27	28	28	29	30	31	32	33	34	35	36	37	39	40	42	43	44	46	47
16	0	31	32	32	33	34	35	36	37	38	39	40	41	43	44	46	47	48	50	51
17	0	35	36	36	37	38	39	40	41	42	43	44	45	47	48	49	51	52	53	54
18	0	38	39	39	40	41	42	43	44	45	46	47	48	50	51	52	54	55	56	4 57
19	0	41	42	42	43	44	45	46	47	48	49	50	51	52	54	55	57	4 58	4 59	5 0
20	0	4 43	4 44	4 45	4 46	4 47	4 48	4 49	4 50	4 51	4 52	4 53	4 54	4 55	4 56	4 58	4 59	5 0	5 1	5 3
Declination.		23½ —	23° —	22½ —	22° —	21½ —	21° —	20⅓ —	19⅔ —	19° —	18⅓ —	17⅔ —	17° —	16° —	15° —	14° —	13° —	12° —	11° —	10° —

Applicable to Chittledroog, Cuddapah, Honawar, Hurryhur, Nellore, Nuggur, &c. &c.

Length of the shadow	Feb.25 to Feb.26	Feb 27 to Mar. 1	Mar. 2 to Mar. 4	Mar. 5 to Mar. 6	Mar. 7 to Mar. 9	Mar10 to Mar11	Mar12 to Mar14	Mar15 to Mar16	Mar17 to Mar19	Mar20 to Mar22	Mar23 to Mar25	Mar26 to Mar30	Mar31 to Apr. 5	Apr 6 to Apr 12	Apr 13 to Apr 21	Apr 22 to May 4	May 5 to May18	May19 to June 2	Jun. 3 to Jun.22
f. in.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1 6	.	.	.	0 19	0 32	0 40	0 47	0 52	0 57	1 1	1 4	1 10	1 15	1 19	1 23	1 25	1 24	1 21	1 17
7	.	.	0 21	33	42	48	0 54	0 59	1 3	7	10	15	20	24	27	29	29	26	22
8	.	0 22	34	43	50	0 55	1 0	1 5	8	12	15	20	24	28	31	33	33	30	27
9	0 22	35	44	51	0 57	1 2	6	10	14	17	20	25	29	32	35	38	37	35	32
10	35	45	52	0 58	1 3	8	12	15	19	22	25	29	33	36	39	42	41	39	36
11	45	0 53	0 59	1 5	9	14	17	21	24	27	30	34	37	40	44	46	45	44	41
2 0	0 54	1 0	1 6	11	15	19	22	26	29	31	34	38	41	44	48	50	49	48	45
1	1 1	7	12	17	20	24	27	30	33	36	38	42	46	48	52	54	53	52	50
2	8	13	17	22	25	29	32	35	38	40	42	46	50	52	55	1 57	1 57	1 56	54
3	14	19	23	27	30	34	37	39	42	44	46	50	54	1 56	1 59	2 1	2 1	2 0	1 58
4	19	24	28	31	35	38	41	44	46	48	50	54	1 57	2 0	2 3	5	5	4	2 2
5	25	29	33	36	40	43	45	48	50	52	54	1 58	2 1	4	6	9	9	8	6
6	30	34	38	41	44	47	49	52	54	1 56	1 58	2 2	5	7	10	12	12	11	10
7	35	39	42	45	48	51	53	1 56	1 58	2 0	2 2	6	9	11	14	16	16	15	13
8	39	43	46	49	52	55	1 57	2 0	2 2	4	6	9	12	14	17	19	19	19	17
9	44	47	51	53	1 56	1 59	2 1	4	6	8	9	13	16	18	20	22	23	22	21
10	48	51	55	1 57	2 0	2 3	5	7	9	11	13	16	19	21	24	26	26	26	24
11	52	55	1 58	2 1	4	7	9	11	13	15	16	19	22	24	27	29	30	29	28
3 0	1 56	1 59	2 2	5	8	10	12	14	16	18	20	23	25	28	30	32	33	32	31
2	2 4	2 7	9	12	15	17	19	21	23	25	26	29	32	34	36	38	39	39	38
4	11	14	16	19	21	23	25	27	29	31	32	35	38	40	42	44	45	45	44
6	18	21	23	25	27	29	31	33	35	37	38	41	43	45	48	50	51	51	50
8	24	27	29	31	33	35	37	39	41	42	44	46	49	51	53	2 56	2 57	2 57	2 56
10	30	33	35	37	39	41	43	45	46	48	49	52	54	2 56	2 59	3 1	3 2	3 2	3 1
4 0	36	38	41	43	45	46	48	50	51	53	54	2 57	2 59	3 1	3 4	6	7	7	7
2	42	44	46	48	50	51	53	2 55	2 56	2 58	2 59	3 2	3 4	6	8	11	12	12	12
4	47	49	51	53	2 55	2 56	2 58	3 0	3 1	3 3	3 4	6	9	11	13	15	17	17	17
6	52	54	2 56	2 58	3 0	3 1	3 3	4	6	7	9	11	13	15	18	20	21	22	21
8	2 56	2 58	3 0	3 2	4	6	7	9	10	11	13	15	17	19	22	24	26	26	26
10	3 1	3 3	5	7	8	10	12	13	14	16	17	19	21	23	26	28	30	30	30
5 0	3 5	3 7	3 9	3 11	3 12	3 14	3 16	3 17	3 18	3 20	3 21	3 23	3 25	3 27	3 30	3 32	3 34	3 34	3 34

Length of the shadow		Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep 25	Sep.24 to Sep.22	Sep 21 to Sep.19	Sep.18 to Sep.13	Sep.12 to Sep. 8	Sep. 7 to Sep. 1	Aug31 to Aug22	Aug21 to Aug 9	Aug 9 to Jul. 27	Jul. 26 to Jul. 11	Jul. 10 to Jun 22
5	2	3 9	3 11	3 13	3 15	3 16	3 18	3 20	3 21	3 22	3 24	3 25	3 27	3 29	3 31	3 34	3 36	3 38	3 38	3 38
	4	13	15	17	19	20	22	23	25	26	27	29	31	33	35	37	40	41	42	42
	6	17	19	21	22	24	26	27	28	30	31	32	35	37	39	41	43	45	46	46
	8	21	22	24	26	27	29	30	32	33	34	35	38	40	42	44	47	48	49	49
	10	24	26	28	29	31	32	34	35	36	38	39	41	43	45	47	50	52	52	53
6	0	27	29	31	32	34	35	37	38	39	41	42	44	46	48	50	53	3 55	3 56	3 56
	4	33	35	37	38	40	41	43	44	45	47	48	50	52	54	3 56	3 59	4 1	4 1	4 2
	8	39	41	43	44	46	47	48	50	51	52	53	3 55	3 57	3 59	4 2	4 4	6	7	8
7	0	45	46	48	49	51	52	53	55	3 56	3 57	3 58	4 0	4 2	4 4	7	9	11	12	13
	4	50	51	53	54	3 56	3 57	3 58	3 59	4 1	4 2	4 3	5	7	9	11	14	16	17	18
	8	54	3 56	3 57	3 59	4 0	4 1	4 3	4 4	5	6	7	10	12	13	16	19	21	22	23
8	0	3 58	4 0	4 1	4 3	4	5	7	8	9	10	11	14	16	17	20	23	25	26	27
	4	4 2	4	5	7	8	9	11	12	13	14	15	18	20	21	24	26	29	30	31
	8	6	8	9	10	12	13	14	16	17	18	19	21	23	25	27	30	33	34	35
9	0	10	11	13	14	15	17	18	19	20	21	22	24	26	28	31	34	36	38	39
	4	13	14	16	17	18	20	21	22	23	24	25	27	29	31	34	37	39	41	42
	8	16	17	19	20	21	23	24	25	26	27	28	30	32	34	37	40	42	44	45
10	0	19	20	22	23	24	26	27	28	29	30	31	33	35	37	40	43	45	47	48
	6	23	24	26	27	28	29	31	32	33	34	35	37	39	41	43	46	49	51	52
11	0	27	28	30	31	32	33	34	35	37	38	39	41	43	45	47	50	53	55	4 56
	6	30	32	33	34	36	37	38	39	40	41	42	44	46	48	50	53	4 56	4 58	5 0
12	0	33	35	36	37	39	40	41	42	43	44	45	47	49	51	54	4 57	5 0	5 2	3
13	0	39	40	42	43	44	45	46	47	48	49	50	52	54	4 56	4 59	5 2	5	7	9
14	0	44	45	47	48	49	50	51	52	53	54	55	4 57	4 59	5 1	5 4	7	10	12	14
15	0	48	49	51	52	53	54	55	4 56	4 57	4 58	4 59	5 1	5 3	5	8	11	14	16	18
16	0	52	53	55	56	4 57	4 58	4 59	5 0	5 1	5 2	5 3	5	7	9	12	15	18	20	22
17	0	56	4 57	4 58	4 59	5 0	5 1	5 2	3	5	6	7	9	11	12	15	19	22	24	26
18	0	4 59	5 0	5 1	5 2	3	4	5	7	8	9	10	12	14	15	18	22	25	27	29
19	0	5 2	3	4	5	6	7	8	9	10	11	12	14	16	18	21	24	28	30	32
20	0	5 4	5 5	5 6	5 7	5 8	5 10	5 11	5 12	5 13	5 14	5 15	5 17	5 19	5 20	5 23	5 27	5 30	5 33	5 35
Declination.		9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	7° +	10° +	14° +	18° +	21° +	23½ +

Applicable to Chittledroog, Cuddapah, Honawar, Hurryhur, Nellore, Nuggur, &c. &c.

Length of the shadow		Dec.22 to Dec.29		Dec.30 to Jan. 4		Jan. 5 to Jan. 8		Jan. 9 to Jan.11		Jan.12 to Jan.14		Jan.15 to Jan.17		Jan.18 to Jan.20		Jan.21 to Jan.23		Jan.24 to Jan.26	
f.	in.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.
1	6		.		.		.		.		.		.		.		.		.
	7		.		.		.		.		.		.		.		.		.
	8		.		.		.		.		.		.		.		.		.
	9		.		.		.		.		.		.		.		.		.
	10		.		.		.		.		.		.		.		.		.
	11		.		.		.		.		.		.		.		.		.
2	0		.		.		.		.		.		.		.		.		.
	1		.		.		.		.		.		.		.		.		.
	2		.		.		.		.		.		.		.		.		.
	3		.		.		.		.		.		.		.		.		.
	4		.		.		.		.		.		.		.		.		.
	5		.		.		.		.		.		.		.		.		.
	6		.		.		.		.		.		.		.		.		.
	7		.		.		.		.		.		.		.		.		.
	8		.		.		.		.		.		.		.		.		.
	9		.		.		.		.		.		.		.		.	0	24
	10		.		.		.		.		.		.	0	2	0	28		39
	11		.		.		.		.		.	0	10		30		41		49
3	0		.		.		.		.	0	22		33	0	43	0	51	0	58
	2		.	0	22	0	33	0	41	0	48	0	54	1	1	1	7	1	12
	4	0	42	0	49	0	55	1	0	1	5	1	9		15		20		24
	6	1	0	1	5	1	10		14		18		22		26		30		34
	8		14		18		22		25		29		32		36		40		44
	10		25		29		32		35		38		41		45		49	1	52
4	0		35		39		42		45		47		50	1	53	1	57	2	0
	2		44		47		50	1	53	1	55	1	58	2	1	2	4		7
	4	1	52	1	55	1	58	2	0	2	3	2	5		8		11		14
	6	2	0	2	2	2	5		7		10		12		15		17		20
	8		7		9		11		14		16		18		21		23		26
	10		13		15		17		20		22		24		26		29		31
5	0	2	19	2	21	2	23	2	25	2	27	2	29	2	31	2	34	2	36

Length of the shadow		Jan.27 to Jan.29		Jan.30 to Jan.31		Feb. 1 to Feb. 3		Feb. 4 to Feb. 6		Feb. 7 to Feb. 9		Feb.10 to Feb.12		Feb.13 to Feb.15		Feb.16 to Feb.18		Feb.19 to Feb.21		Feb.22 to Feb.24	
f.	in.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.
1	6		.		.		.		.		.		.		.		.		.		.
	7		.		.		.		.		.		.		.		.		.		.
	8		.		.		.		.		.		.		.		.		.		.
	9		.		.		.		.		.		.		.		.		.		.
	10		.		.		.		.		.		.		.		.		.		.
	11		.		.		.		.		.		.		.		.		.	0	23
2	0		.		.		.		.		.		.		.		.	0	22		36
	1		.		.		.		.		.		.		.	0	22		36		46
	2		.		.		.		.		.		.	0	20		37		47	0	55
	3		.		.		.		.		.	0	19		36		47	0	55	1	2
	4		.		.		.		.	0	16		35		46	0	55	1	3		9
	5		.		.		.	0	12		34		46	0	55	1	3		10		15
	6		.		.	0	5		33		45	0	55	1	3		10		16		21
	7		.	0	14		30		44	0	54	1	3		10		16		22		26
	8	0	20		34		43	0	54	1	2		9		16		22		27		31
	9		36		45	0	53	1	2		9		16		22		27		32		36
	10		47	0	55	1	1		9		16		22		27		32		37		41
	11	0	56	1	2		8		15		22		27		32		37		42		45
3	0	1	4		9		14		21		27		32		37		42		46		49
	2		17		22		26		32		37		41		46		50	1	54	1	57
	4		28		32		36		41		46		50	1	54	1	58	2	2	2	5
	6		38		41		45		50	1	54	1	58	2	2	2	6		9		12
	8		47		50	1	53	1	58	2	2	2	6		9		13		16		19
	10	1	55	1	58	2	1	2	5		9		13		16		19		22		25
4	0	2	3	2	6		8		12		16		19		22		25		28		31
	2		10		13		15		19		22		25		28		31		34		37
	4		16		19		21		25		28		31		34		37		40		42
	6		22		25		27		31		34		37		40		42		45		47
	8		28		30		33		36		39		42		45		47		50		52
	10		33		36		38		41		44		47		50		52		55	2	57
5	0	2	38	2	41	2	43	2	46	2	49	2	51	2	54	2	57	2	59	3	1

Length of the shadow		Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5	2	2 25	2 27	2 29	2 31	2 33	2 34	2 37	2 39	2 41	2 43	2 46	2 48	2 50	2 53	2 56	2 59	3 1	3 3	3 5
	4	30	32	34	36	38	39	42	44	46	48	50	52	55	2 58	3 0	3 3	5	7	9
	6	35	37	39	41	43	44	47	49	51	53	55	2 56	2 59	3 2	4	7	9	11	13
	8	40	41	43	45	47	48	51	53	55	2 57	2 59	3 0	3 3	6	8	10	13	15	17
	10	44	46	48	49	51	53	55	2 57	2 59	3 1	3 3	4	7	10	12	14	17	19	21
6	0	48	50	52	2 53	2 55	2 57	2 59	3 1	3 3	4	6	8	11	13	15	18	20	22	24
	4	2 56	2 58	2 59	3 1	3 2	3 4	3 6	8	10	11	13	15	18	20	22	24	26	28	30
	8	3 3	3 5	3 6	8	9	11	13	15	16	18	20	21	24	26	28	30	32	34	36
7	0	10	11	13	14	15	17	19	21	22	24	26	27	30	32	34	36	38	40	41
	4	16	17	19	20	21	23	25	26	28	29	31	33	35	37	39	41	43	45	46
	8	21	23	24	25	27	28	30	31	33	34	36	38	40	42	44	46	48	50	51
8	0	26	28	29	30	32	33	35	36	38	39	41	42	44	46	48	50	52	54	56
	4	31	32	34	35	37	38	39	41	42	44	45	47	49	51	52	54	3 56	3 58	3 0
	8	36	37	38	39	41	42	43	45	46	48	49	51	53	55	3 56	3 58	4 0	4 2	4 3
9	0	40	41	42	43	45	46	47	49	50	52	53	55	3 57	3 59	4 0	4 2	4	6	7
	4	44	45	46	47	48	50	51	52	54	55	3 57	3 58	4 0	4 2	4	5	7	9	10
	8	47	49	50	51	52	53	55	56	3 57	3 59	4 0	4 1	3	5	7	8	10	12	13
10	0	51	52	53	54	3 55	3 56	3 58	3 59	4 0	4 2	3	4	6	8	10	12	13	15	16
	6	3 56	3 57	3 58	3 59	4 0	4 1	4 2	4 4	5	6	7	9	11	12	14	16	17	19	20
11	0	4 0	4 1	4 2	4 3	4	5	6	8	9	10	11	13	15	16	18	20	21	23	24
	6	4	5	6	7	8	9	10	12	13	14	15	17	19	20	22	23	25	26	28
12	0	7	8	9	10	11	12	14	15	16	17	19	20	22	23	25	26	28	29	31
13	0	13	14	15	16	17	18	20	21	22	23	25	26	28	29	31	32	34	35	37
14	0	19	20	21	22	23	24	25	27	28	29	30	31	33	34	36	37	39	40	42
15	0	24	25	26	27	28	29	30	31	32	34	35	36	37	39	40	42	43	45	46
16	0	28	29	30	31	32	33	34	35	36	38	39	40	41	43	44	46	47	49	50
17	0	32	33	34	35	36	37	38	39	40	41	42	43	45	47	48	49	51	52	53
18	0	36	36	37	38	39	40	41	42	43	44	45	46	48	50	51	52	54	55	56
19	0	39	39	40	41	42	43	44	45	46	47	48	49	51	52	54	55	57	4 58	4 59
20	0	4 41	4 42	4 43	4 44	4 45	4 46	4 47	4 48	4 49	4 50	4 51	4 52	4 53	4 55	4 56	4 58	4 59	5 0	5 2
Declination.		23½ —	23° —	22½ —	22° —	21½ —	21° —	20⅓ —	19⅔ —	19° —	18⅓ —	17⅔ —	17° —	16° —	15° —	14° —	13° —	12° —	11° —	10° —

Applicable to Anantapoor, Bellary, Dharwar, Goa, Gooty, Ongole, Sedashagur, Sircy, &c. &c.

15 North Latitude. Page 11.

Length of the shadow f. in.	Feb.25 to Feb.26 h. m.	Feb 27 to Mar. 1 h. m.	Mar. 2 to Mar. 4 h. m.	Mar. 5 to Mar. 6 h. m.	Mar. 7 to Mar. 9 h. m.	Mar10 to Mar11 h. m.	Mar12 to Mar14 h. m.	Mar15 to Mar16 h. m.	Mar17 to Mar19 h. m.	Mar20 to Mar22 h. m.	Mar23 to Mar25 h. m.	Mar26 to Mar30 h. m.	Mar31 to Apr. 5 h. m.	Apr 6 to Apr 10 h. m.	Apr 11 to Apr 16 h. m.	Apr 16 to Apr 24 h. m.	Apr 25 to May 8 h. m.	May 9 to May25 h. m.	May 26 to Jun.22 h. m.
1 6	.	.	.	.	0 20	0 32	0 40	0 47	0 52	0 57	1 1	1 8	1 13	1 17	1 21	1 23	1 25	1 24	1 20
7	.	.	.	0 20	33	41	48	0 54	0 59	1 3	7	13	18	22	25	27	30	29	25
8	.	.	0 21	34	43	50	0 55	1 0	1 5	8	12	18	23	26	29	32	34	33	30
9	.	0 22	35	44	51	0 57	1 2	6	10	14	17	23	27	31	34	36	38	38	34
10	0 22	35	45	52	0 58	1 3	8	12	16	19	22	27	31	35	38	40	42	42	39
11	36	45	0 53	0 59	1 5	9	14	18	21	24	27	32	36	39	42	44	46	46	43
2 0	46	0 54	1 0	1 6	11	15	19	23	26	29	32	36	40	43	46	48	50	50	47
1	0 54	1 1	7	12	17	21	24	27	30	33	36	41	44	47	50	52	54	54	52
2	1 2	8	13	17	22	26	29	32	35	38	40	45	48	51	54	1 56	1 58	1 58	1 56
3	8	14	19	23	27	31	34	37	40	42	45	49	52	55	1 58	2 0	2 2	2 2	2 0
4	14	19	24	28	32	35	38	41	44	46	49	53	1 56	1 59	2 1	3	5	6	4
5	20	25	29	33	36	40	43	46	48	50	53	1 57	2 0	2 3	5	7	9	9	8
6	26	30	34	38	41	44	47	50	52	54	1 57	2 1	4	6	9	11	13	13	12
7	31	35	39	42	45	48	51	54	1 56	1 58	2 1	4	7	10	12	14	16	17	15
8	35	39	43	46	49	52	55	1 58	2 0	2 2	4	8	11	14	16	18	20	20	19
9	40	44	47	51	54	1 56	1 59	2 1	4	6	8	11	14	17	19	21	23	24	23
10	45	48	52	55	1 58	2 0	2 3	5	7	9	11	15	18	21	23	24	27	27	26
11	49	52	56	1 59	2 1	4	7	9	11	13	15	18	21	24	26	28	30	30	29
3 0	1 53	1 56	1 59	2 2	5	8	10	12	14	16	18	22	24	27	29	31	33	34	33
2	2 1	2 4	2 7	10	12	15	17	19	21	23	25	28	31	33	35	37	39	40	39
4	8	11	14	17	19	21	24	26	28	29	31	34	37	39	41	43	45	46	46
6	15	18	21	23	25	28	30	32	34	35	27	40	43	45	47	49	51	52	52
8	22	24	27	29	31	34	36	38	39	41	43	46	48	50	52	54	2 56	2 57	2 57
10	28	30	33	35	37	40	42	44	45	47	48	51	54	2 56	2 58	2 59	3 2	3 3	3 3
4 0	34	36	38	41	43	45	47	49	50	52	53	56	2 59	3 1	3 3	3 4	7	8	8
2	39	42	44	46	48	50	52	54	2 55	2 57	2 58	2 1	3 3	6	8	9	12	13	13
4	45	47	49	51	53	2 55	2 57	2 59	3 0	3 2	3 3	3 6	8	10	12	14	16	18	18
6	50	52	54	2 56	2 58	3 0	3 2	3 4	5	6	8	11	13	15	17	18	21	22	23
8	54	2 57	2 59	3 1	3 2	4	6	8	9	11	12	15	17	19	21	23	25	27	27
10	2 59	3 1	3 3	5	7	9	10	12	13	15	16	19	21	23	25	27	29	31	32
5 0	3 3	3 5	3 7	3 9	3 11	3 13	3 14	3 16	3 17	3 19	3 20	3 23	3 25	3 27	3 29	3 31	3 33	3 35	3 36

Length of the shadow	Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep.25	Sep.24 to Sep.22	Sep 21 to Sep.19	Sep.18 to Sep.13	Sep.12 to Sep. 8	Sep. 7 to Sep. 3	Sep. 2 to Aug28	Aug27 to Aug19	Aug18 to Aug. 6	Aug 5 to Jul. 19	Jul. 18 to Jun 22
Declination.	9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	7° +	9° +	11° +	15° +	19° +	23½ +
5 2	3 7	3 9	3 11	3 13	3 15	3 17	3 18	3 20	3 21	3 23	3 24	3 27	3 29	3 31	3 33	3 34	3 37	3 39	3 40
4	11	13	15	17	19	21	22	24	25	26	28	30	33	35	36	38	41	43	44
6	15	17	19	21	23	24	26	27	29	30	32	34	36	38	40	42	44	46	47
8	19	21	23	24	26	28	29	31	32	33	35	37	39	41	43	45	48	50	51
10	23	25	26	28	30	31	33	34	35	37	38	41	43	45	47	48	51	53	54
6 0	26	28	29	31	33	34	36	37	39	40	41	44	46	48	50	51	3 54	3 56	3 57
4	32	34	35	37	39	40	42	43	44	46	47	50	52	54	3 56	3 57	4 0	4 2	4 3
8	38	40	41	43	44	46	47	49	50	51	53	3 55	3 57	3 59	4 1	4 3	6	8	9
7 0	43	45	46	48	50	51	52	54	3 55	3 56	3 58	4 0	4 2	4 4	6	8	11	13	15
4	48	50	51	53	55	3 56	3 57	3 59	4 0	4 1	4 2	5	7	9	11	12	15	18	20
8	53	55	3 56	3 58	3 59	4 1	4 2	4 3	4	6	7	9	11	13	15	17	20	22	24
8 0	3 57	3 59	4 0	4 2	4 3	5	6	7	9	10	11	13	15	17	19	21	24	26	28
4	4 1	4 3	4	6	7	9	10	11	13	14	15	17	19	21	23	25	28	30	32
8	5	7	8	10	11	12	14	15	16	17	18	21	23	25	27	28	31	34	36
9 0	9	10	12	13	15	16	17	19	20	21	22	24	26	28	30	32	35	38	40
4	12	13	15	16	18	19	20	22	23	24	25	27	29	31	33	35	38	41	43
8	15	16	18	19	21	22	23	25	26	27	28	30	32	34	36	38	41	44	46
10 0	18	19	21	22	24	25	26	27	29	30	31	33	35	37	39	41	44	47	49
6	22	23	25	26	28	29	30	31	33	34	35	37	39	41	43	45	48	51	53
11 0	26	27	29	30	31	33	34	35	36	37	38	41	43	45	47	48	52	55	4 57
6	29	31	32	33	35	36	37	38	40	41	42	44	47	48	50	52	55	4 58	5 1
12 0	32	34	35	36	38	39	40	41	43	44	45	47	50	51	53	4 55	4 58	5 1	4
13 0	38	39	41	42	43	45	46	47	48	49	50	52	55	4 56	4 58	5 0	5 4	7	10
14 0	43	44	46	47	48	50	51	52	53	54	55	4 57	4 59	5 1	5 3	5	9	12	15
15 0	47	48	50	51	52	54	55	4 56	4 57	4 58	4 59	5 1	5 3	5	7	9	13	16	20
16 0	51	52	54	55	4 56	4 58	4 59	5 0	5 1	5 2	5 3	5	7	9	11	13	17	20	24
17 0	55	56	4 57	4 58	5 0	5 1	5 2	3	4	5	6	9	11	13	15	17	20	24	27
18 0	4 58	4 59	5 0	5 1	3	4	5	6	7	8	9	12	14	16	18	20	23	27	30
19 0	5 1	5 2	3	4	5	7	8	9	10	11	12	14	16	18	20	22	26	30	33
20 0	5 3	5 4	5 5	5 7	5 8	5 9	10	5 11	5 12	5 13	5 15	5 17	5 19	5 21	5 23	5 25	5 29	5 32	5 36

Applicable to Anantapoor, Bellary, Dharwar, Goa, Gooty, Ongole, Sedashagur, Sircy, &c. &c.

Length of the shadow		Dec. 22 to Dec. 29	Dec. 30 to Jan. 4	Jan. 5 to Jan. 8	Jan. 9 to Jan. 11	Jan. 12 to Jan. 14	Jan. 15 to Jan. 17	Jan. 18 to Jan. 20	Jan. 21 to Jan. 23	Jan. 24 to Jan. 26	Jan. 27 to Jan. 29	Jan. 30 to Jan. 31	Feb. 1 to Feb. 3	Feb. 4 to Feb. 6	Feb. 7 to Feb. 9	Feb. 10 to Feb. 12	Feb. 13 to Feb. 15	Feb. 16 to Feb. 18	Feb. 19 to Feb. 21	Feb. 22 to Feb. 24
f.	in.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22
	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 22	36
	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 21	36	47
	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 19	36	47	0 55
	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 16	35	47	0 55	1 3
	5	.	.	.	.	.	.	.	.	.	.	.	.	.	0 12	34	46	0 55	1 3	10
	6	.	.	.	.	.	.	.	.	.	.	.	.	0 6	33	46	0 55	1 3	10	16
	7	.	.	.	.	.	.	.	.	.	.	.	.	30	44	0 54	1 2	10	16	22
	8	.	.	.	.	.	.	.	.	.	.	.	0 28	43	0 54	1 2	9	16	22	27
	9	.	.	.	.	.	.	.	.	.	0 14	0 31	41	0 52	1 2	9	16	22	27	32
	10	.	.	.	.	.	.	.	.	0 20	34	44	51	1 1	9	16	22	27	32	37
	11	.	.	.	.	.	.	.	0 22	36	45	0 53	0 59	8	15	21	27	32	37	42
3	0	.	.	.	.	.	.	0 26	38	0 47	0 55	1 1	1 7	14	21	27	32	37	42	46
	2	.	.	.	0 22	0 33	0 41	0 50	0 57	1 4	1 10	15	19	26	32	37	42	46	50	1 54
	4	0 21	0 33	0 42	0 49	0 55	1 0	1 6	1 12	17	22	26	30	36	41	46	50	1 55	1 58	2 2
	6	0 48	0 54	1 0	1 5	1 10	14	19	24	28	32	36	40	45	50	1 54	1 58	2 2	2 6	9
	8	1 4	1 9	14	18	22	25	30	34	38	42	45	49	1 53	1 58	2 2	2 6	9	13	16
	10	17	22	25	29	32	36	40	43	47	50	1 53	1 57	2 1	2 5	9	13	16	20	22
4	0	28	32	35	39	42	45	48	52	1 55	1 58	2 1	2 4	8	12	16	19	22	26	28
	2	38	41	44	47	50	1 53	1 56	1 59	2 2	2 5	8	11	15	19	22	25	28	32	34
	4	47	50	1 52	1 55	1 58	2 0	2 3	2 6	9	12	15	17	21	25	28	31	34	37	40
	6	1 55	1 57	2 0	2 2	2 5	7	10	13	16	18	21	23	27	31	34	37	40	42	45
	8	2 2	2 4	7	9	11	14	16	19	22	24	27	29	33	36	39	42	45	47	50
	10	8	11	13	15	17	20	22	25	28	30	32	35	38	41	44	47	50	52	55
5	0	2 14	2 17	2 19	2 21	2 23	2 25	2 28	2 30	2 33	2 35	2 37	2 40	2 43	2 46	2 49	2 51	2 54	2 57	2 59

Length of the shadow		Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov 14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5	2	2 20	2 23	2 25	2 27	2 29	2 31	2 33	2 35	2 38	2 40	2 42	2 44	2 47	2 50	2 53	2 56	2 59	3 1	3 3
	4	26	28	30	32	34	36	38	40	43	45	47	49	52	55	2 58	3 0	3 3	5	7
	6	31	33	35	37	39	41	43	45	47	50	52	53	2 56	2 59	3 2	4	7	9	11
	8	36	38	39	41	43	45	47	49	51	54	2 56	2 58	3 0	3 3	6	8	11	13	15
	10	40	42	44	46	47	49	51	53	2 55	2 58	3 0	3 2	4	7	10	12	15	17	19
6	0	44	46	48	50	52	2 53	2 55	2 57	3 0	3 2	3	5	8	11	13	15	18	20	22
	4	2 52	2 54	2 56	2 58	2 59	3 1	3 3	3 5	7	8	10	12	15	18	20	22	24	26	28
	8	3 0	3 2	3 3	3 5	3 6	8	10	12	13	15	17	19	21	24	26	28	30	32	34
7	0	7	8	10	11	12	14	16	18	19	21	23	25	27	30	32	34	36	38	40
	4	13	14	16	17	18	20	22	23	25	27	29	30	33	35	37	39	41	43	45
	8	18	20	21	23	24	25	27	29	30	32	34	35	38	40	42	44	46	48	50
8	0	23	25	26	28	29	30	32	34	35	37	38	40	42	44	46	48	50	52	54
	4	28	30	31	33	34	35	37	38	40	41	43	44	47	49	51	53	54	3 56	3 58
	8	33	34	35	37	38	39	41	42	44	45	47	48	51	53	55	3 57	3 58	4 0	4 2
9	0	37	38	40	41	42	43	45	46	48	49	51	52	55	3 57	3 59	4 1	4 2	4	6
	4	41	42	43	45	46	47	49	50	52	53	54	56	3 58	4 0	4 2	4	5	7	9
	8	45	46	47	48	50	51	52	54	55	3 57	3 58	3 59	4 1	3	5	7	9	10	12
10	0	48	49	50	52	53	54	3 55	3 57	3 58	4 0	4 1	4 2	4	6	8	10	12	13	15
	6	53	54	55	3 56	3 58	3 59	4 0	4 1	4 3	4	5	7	9	11	12	14	16	17	19
11	0	3 57	3 58	3 59	4 0	4 2	4 3	4	5	7	8	9	11	13	15	16	18	20	21	23
	6	4 1	4 2	4 3	4	6	7	8	9	11	12	13	15	17	19	20	22	24	25	27
12	0	5	6	7	8	9	10	11	13	14	15	17	18	20	22	23	25	27	28	30
13	0	11	12	13	14	15	16	17	19	20	21	23	24	26	28	29	31	33	34	36
14	0	17	18	19	20	21	22	23	24	26	27	28	29	31	33	34	36	38	39	41
15	0	22	23	24	25	26	27	28	29	30	32	33	34	36	37	39	40	42	43	45
16	0	26	27	28	29	30	31	32	33	34	36	37	38	40	41	43	44	46	47	49
17	0	30	31	32	33	34	35	36	37	38	40	41	42	43	45	47	48	50	51	52
18	0	33	34	35	36	37	38	39	40	41	43	44	45	46	48	50	51	53	54	55
19	0	36	37	38	39	40	41	42	43	44	45	47	48	49	51	52	54	55	57	4 58
20	0	4 39	4 40	4 41	4 42	4 43	4 44	4 45	4 46	4 47	4 48	4 49	4 50	4 52	4 53	4 55	4 56	4 58	4 59	5 1
Declination		23½ —	23° —	22½ —	22° —	21½ —	21° —	20⅓ —	19⅔ —	19° —	18⅓ —	17⅔ —	17° —	16° —	15° —	14° —	13° —	12° —	11° —	10° —

Applicable to Adoni, Belgaum, Cumbum, Guntoor, Kulladghee, Kurnool, Linga Soogoor, Masulipatam, Muctul, Vingorla, &c. &c.

16° North Latitude. Page II.

Length of the shadow f.	in.	Feb.25 to Feb.26 h. m.	Feb 27 to Mar. 1 h. m.	Mar. 2 to Mar. 4 h. m.	Mar. 5 to Mar. 6 h. m.	Mar. 7 to Mar. 9 h. m.	Mar10 to Mar11 h. m.	Mar12 to Mar14 h. m.	Mar15 to Mar16 h. m.	Mar17 to Mar19 h. m.	Mar20 to Mar22 h. m.	Mar23 to Mar25 h. m.	Mar26 to Mar30 h. m.	Mar31 to Apr. 5 h. m.	Apr 6 to Apr 10 h. m.	Apr 11 to Apr 17 h. m.	Apr 18 to Apr 28 h. m.	Apr 28 to May12 h. m.	May12 to May28 h. m.	May 29 to Jun.22 h. m.
1	6	.	.	.	.	.	0 20	0 32	0 40	0 47	0 52	0 57	1 5	1 11	1 16	1 19	1 23	1 26	1 25	1 22
	7	.	.	.	.	0 21	33	42	48	0 54	0 59	1 3	10	16	21	24	28	30	29	27
	8	.	.	.	0 22	34	43	50	0 56	1 1	1 5	9	15	21	25	28	32	34	34	31
	9	.	.	0 22	35	44	51	0 57	1 2	7	11	14	20	26	29	33	36	39	38	36
	10	.	0 22	35	45	52	0 58	1 4	8	12	16	19	25	30	33	37	40	43	42	40
	11	0 23	36	45	0 53	0 59	1 5	10	14	18	21	24	30	34	38	41	44	47	46	45
2	0	37	46	0 54	1 0	1 6	11	15	19	23	26	29	34	39	42	45	48	51	51	49
	1	46	0 54	1 1	7	12	17	21	24	28	31	34	39	43	46	49	52	55	55	53
	2	0 55	1 2	8	13	18	22	26	29	32	35	38	43	47	50	53	1 56	1 59	1 59	1 57
	3	1 2	8	14	19	23	27	31	34	37	40	43	47	51	54	1 57	2 0	2 2	2 2	2 1
	4	9	14	19	24	28	32	35	38	41	44	47	51	55	1 58	2 1	4	6	6	5
	5	15	20	25	29	33	37	40	43	46	48	51	55	1 59	2 2	5	8	10	10	9
	6	21	26	30	34	38	41	44	47	50	52	55	1 59	2 3	6	8	11	13	14	13
	7	26	31	35	39	43	46	49	51	54	1 56	1 59	2 3	6	9	12	15	17	17	17
	8	31	36	39	43	47	50	53	55	1 58	2 0	2 2	6	10	13	15	18	20	21	20
	9	36	41	44	48	51	54	1 57	1 59	2 2	4	6	10	13	16	19	22	24	24	24
	10	41	45	48	52	55	1 58	2 1	2 3	6	8	10	14	17	20	22	25	27	28	27
	11	46	49	52	1 56	1 59	2 2	4	7	9	11	13	17	20	23	25	28	31	31	31
3	0	50	1 53	1 56	2 0	2 3	5	8	10	13	15	17	20	24	26	29	31	34	35	34
	2	1 58	2 1	2 4	7	10	12	15	17	20	22	24	27	30	33	35	38	40	41	41
	4	2 5	8	11	14	17	19	22	24	26	28	30	33	36	39	41	44	46	47	47
	6	12	15	18	21	24	26	28	30	32	34	36	39	42	45	47	50	52	53	53
	8	19	22	25	27	30	32	34	36	38	40	42	45	48	50	52	2 55	2 57	2 59	2 59
	10	25	28	31	33	36	38	40	42	44	46	47	50	53	2 55	2 57	3 0	3 3	3 4	3 4
4	0	31	34	36	39	41	43	45	47	49	51	53	2 55	2 58	3 0	3 3	5	8	9	10
	2	37	40	42	44	46	48	50	52	54	2 56	2 57	3 0	3 3	5	7	10	13	14	15
	4	42	45	47	49	51	53	2 55	2 57	2 59	3 1	3 2	5	8	10	12	15	17	19	19
	6	47	50	52	54	2 56	2 58	3 0	3 2	3 4	5	7	10	12	15	17	19	22	24	24
	8	52	55	2 57	2 59	3 1	3 3	5	6	8	10	11	14	17	19	21	24	26	28	29
	10	2 57	2 59	3 2	3 4	6	7	9	11	12	14	15	18	21	23	25	28	30	32	33
5	0	3 1	3 4	3 6	3 8	3 10	3 11	3 13	3 15	3 16	3 18	3 19	3 22	3 25	3 27	3 29	3 32	3 34	3 36	3 37

Length of the shadow	Oct. 18 to Oct. 16	Oct. 15 to Oct. 13	Oct. 12 to Oct. 11	Oct. 10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep. 30	Sep. 29 to Sep. 28	Sep. 27 to Sep. 25	Sep. 24 to Sep. 22	Sep 21 to Sep. 19	Sep. 18 to Sep. 13	Sep. 12 to Sep. 8	Sep. 7 to Sep. 3	Sep. 2 to Aug 27	Aug 26 to Aug 16	Aug 15 to Aug. 2	Aug 1 to Jul. 16	Jul. 15 to Jun 22
5 2	3 6	3 8	3 10	3 12	3 14	3 15	3 17	3 19	3 20	3 22	3 23	3 26	3 29	3 31	3 33	3 36	3 38	3 40	3 41
4	10	12	14	16	17	19	21	23	24	26	27	30	32	34	36	39	42	44	45
6	14	16	18	19	21	23	25	27	28	30	31	33	36	38	40	43	46	48	49
8	17	19	21	23	25	26	28	30	31	33	34	37	39	42	43	46	49	51	52
10	21	23	25	27	28	30	32	33	35	36	37	40	42	45	47	49	52	54	56
6 0	24	26	28	30	31	33	35	36	38	39	41	43	45	48	50	52	3 55	3 58	3 59
4	30	32	34	36	37	39	41	42	44	45	47	49	51	54	3 56	3 58	4 1	4 4	4 5
8	36	38	40	42	43	45	46	48	49	51	52	3 55	3 57	3 59	4 1	4 4	7	9	11
7 0	42	44	45	47	48	50	51	53	54	3 56	3 57	4 0	4 2	4 4	6	9	12	14	16
4	47	49	50	52	53	3 55	3 56	3 58	3 59	4 1	4 2	4	7	9	11	14	17	19	21
8	52	53	55	3 57	3 58	4 0	4 1	4 3	4 4	5	7	9	11	13	15	18	21	24	26
8 0	3 56	3 57	3 59	4 1	4 2	4	5	7	8	9	11	13	15	17	19	22	25	28	30
4	4 0	4 1	4 3	5	6	8	9	11	12	13	15	17	19	21	23	26	29	32	34
8	4	5	7	8	10	11	13	14	15	17	18	20	23	25	27	30	33	36	38
9 0	8	9	11	12	14	15	16	18	19	20	22	24	26	28	30	33	37	40	42
4	11	12	14	15	17	18	19	21	22	23	25	27	29	31	33	36	40	43	45
8	14	15	17	18	20	21	22	24	25	26	28	30	32	34	36	39	43	46	48
10 0	17	18	20	21	23	24	25	27	28	29	30	33	35	37	39	42	46	49	51
6	21	22	24	25	27	28	29	31	32	33	34	36	39	41	43	46	50	53	55
11 0	25	26	28	29	30	32	33	34	36	37	38	40	43	45	47	50	53	4 57	4 59
6	28	30	31	33	34	35	37	38	39	40	42	44	46	48	50	53	4 57	5 0	5 3
12 0	31	33	34	36	37	38	40	41	42	43	45	47	49	51	53	4 56	5 0	3	6
13 0	37	38	39	41	42	44	45	46	48	49	50	52	4 55	4 57	4 59	5 2	6	9	12
14 0	42	43	44	46	47	49	50	51	53	54	55	4 57	5 0	5 2	5 4	7	11	14	17
15 0	46	48	49	50	52	53	54	55	4 57	4 58	4 59	5 1	4	6	8	11	15	18	21
16 0	50	52	53	54	56	4 57	4 58	4 59	5 1	5 2	5 3	5	8	10	12	15	19	22	25
17 0	54	55	56	4 58	4 59	5 0	5 2	5 3	4	5	6	9	11	13	15	18	22	26	29
18 0	4 57	4 58	4 59	5 1	5 2	3	5	6	7	8	9	12	14	16	18	21	25	29	32
19 0	5 0	5 1	5 2	3	5	6	7	8	9	11	12	14	16	19	21	24	28	32	35
20 0	5 2	5 3	5 5	5 6	5 7	5 8	5 10	5 11	5 12	5 13	5 14	5 17	5 19	5 21	5 23	5 26	5 30	5 34	5 37
Declination.	9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	7° +	9° +	12° +	16° +	20° +	23° +

Applicable to Adoni, Belgaum, Cumbum, Guntoor, Kulladghee, Kurnool, Linga Soogoor, Masulipatam, Muctul, Vingorla, &c. &c.

Length of the shadow f.	in.	Dec.22 to Dec.29 h.	m.	Dec.30 to Jan. 4 h.	m.	Jan. 5 to Jan. 8 h.	m.	Jan. 9 to Jan.11 h.	m.	Jan.12 to Jan.14 h.	m.	Jan.15 to Jan.17 h.	m.	Jan.18 to Jan.20 h.	m.	Jan.21 to Jan.23 h.	m.	Jan.24 to Jan.26 h.	m.
1	6	.		.		.		.		.		.		.		.		.	
	7	.		.		.		.		.		.		.		.		.	
	8	.		.		.		.		.		.		.		.		.	
	9	.		.		.		.		.		.		.		.		.	
	10	.		.		.		.		.		.		.		.		.	
	11	.		.		.		.		.		.		.		.		.	
2	0	.		.		.		.		.		.		.		.		.	
	1	.		.		.		.		.		.		.		.		.	
	2	.		.		.		.		.		.		.		.		.	
	3	.		.		.		.		.		.		.		.		.	
	4	.		.		.		.		.		.		.		.		.	
	5	.		.		.		.		.		.		.		.		.	
	6	.		.		.		.		.		.		.		.		.	
	7	.		.		.		.		.		.		.		.		.	
	8	.		.		.		.		.		.		.		.		.	
	9	.		.		.		.		.		.		.		.		.	
	10	.		.		.		.		.		.		.		.		.	
	11	.		.		.		.		.		.		.		.		0	11
3	0	.		.		.		.		.		.		.		0	16		33
	2	.		.		.		.		.		0	22	0	36	0	46	0	54
	4	.		.		0	20	0	33	0	42	0	49	0	56	1	3	1	9
	6	0	31	0	40	0	48	0	54	1	0	1	5	1	11		16		21
	8	0	53	0	59	1	4	1	9		14		18		23		28		32
	10	1	8	1	13		17		21		25		28		33		37		41
4	0		20		24		28		32		35		38		43		46		50
	2		31		34		37		41		44		47		51	1	54	1	58
	4		40		43		46		49		52	1	55	1	58	2	2	2	5
	6		48		51	1	54	1	57	1	59	2	2	2	5		9		12
	8	1	56	1	59	2	1	2	4	2	6		9		12		15		18
	10	2	3	2	6		8		11		13		15		18		21		24
5	0	2	9	2	12	2	14	2	17	2	19	2	21	2	24	2	26	2	29

Length of the shadow f.	in.	Jan.27 to Jan.29 h.	m.	Jan.30 to Jan.31 h.	m.	Feb. 1 to Feb. 3 h.	m.	Feb. 4 to Feb. 6 h.	m.	Feb. 7 to Feb. 9 h.	m.	Feb.10 to Feb.12 h.	m.	Feb.13 to Feb.15 h.	m.	Feb.16 to Feb.18 h.	m.	Feb.19 to Feb.21 h.	m.	Feb.22 to Feb.24 h.	m.
1	6	.		.		.		.		.		.		.		.		.		.	
	7	.		.		.		.		.		.		.		.		.		.	
	8	.		.		.		.		.		.		.		.		.		.	
	9	.		.		.		.		.		.		.		.		.		.	
	10	.		.		.		.		.		.		.		.		.		.	
	11	.		.		.		.		.		.		.		.		.		.	
2	0	.		.		.		.		.		.		.		.		.		.	
	1	.		.		.		.		.		.		.		.		.		0	22
	2	.		.		.		.		.		.		.		.		0	20		36
	3	.		.		.		.		.		.		.		0	19		36		47
	4	.		.		.		.		.		.		0	16		35		46	0	56
	5	.		.		.		.		.		0	13		34		46	0	55	1	3
	6	.		.		.		.		0	5		33		45	0	55	1	3		10
	7	.		.		.		.			30		44	0	54	1	2		10		16
	8	.		.		.		0	28		43	0	54	1	2		9		16		22
	9	.		.		0	24		41	0	53	1	2		9		16		22		27
	10	0	3	0	28		39		51	1	1		9		16		22		27		32
	11		30		41		49	0	59		8		15		21		27		32		37
3	0	0	43	0	51	0	58	1	7		14		21		27		32		37		42
	2	1	1	1	7	1	12		19		26		32		37		41		46		50
	4		15		20		24		30		36		41		46		50	1	54	1	58
	6		26		30		34		40		45		50	1	54	1	58	2	2	2	6
	8		36		40		44		49	1	53	1	58	2	2	2	6		9		13
	10		45		49	1	52	1	57	2	1	2	5		9		13		16		20
4	0	1	53	1	57	2	0	2	4		8		12		16		19		23		26
	2	2	1	2	4		7		11		15		19		22		25		29		32
	4		8		11		14		17		21		25		28		31		34		37
	6		15		17		20		23		27		31		34		37		40		43
	8		21		23		26		29		33		36		39		42		45		48
	10		27		29		31		35		38		41		44		47		50		53
5	0	2	32	2	34	2	36	2	40	2	43	2	46	2	49	2	52	2	54	2	57

Length of the shadow	Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov 14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
Declination	23½	23°	22½	22°	21½	21°	20⅓	19⅔	19°	18⅓	17⅔	17°	16°	15°	14°	13°	12°	11°	10°
5 2	2 15	2 18	2 20	2 23	2 25	2 27	2 29	2 32	2 34	2 37	2 39	2 41	2 44	2 48	2 51	2 54	2 56	2 59	3 1
4	21	23	25	28	30	32	34	37	39	41	44	46	49	52	55	2 58	3 0	3 3	5
6	26	28	30	33	35	37	39	42	44	46	48	50	53	2 56	2 59	3 2	4	7	9
8	31	33	35	37	39	41	44	46	48	50	53	55	2 58	3 0	3 3	6	8	11	13
10	36	38	40	42	44	46	48	50	52	54	2 57	2 59	3 2	4	7	10	12	15	17
6 0	40	42	44	46	48	50	2 52	2 54	2 56	2 58	3 0	3 2	5	8	11	13	16	18	20
4	48	50	2 52	2 54	2 56	2 58	3 0	3 2	3 4	3 6	7	9	12	15	18	20	22	25	27
8	2 56	2 58	3 0	3 1	3 3	3 5	7	9	11	13	14	16	19	21	24	26	28	31	33
7 0	3 3	3 5	6	8	9	11	13	15	17	19	20	22	25	27	30	32	34	36	38
4	9	11	12	14	15	17	19	21	23	24	26	28	30	33	35	37	39	41	43
8	15	17	18	20	21	22	24	26	28	29	31	33	35	38	40	42	44	46	48
8 0	20	22	23	25	26	27	29	31	33	34	36	38	40	42	44	47	49	51	53
4	25	27	28	30	31	32	34	36	37	39	41	42	44	47	49	51	53	55	3 57
8	30	31	32	34	35	36	38	40	42	43	45	46	48	51	53	55	3 57	3 59	4 0
9 0	34	35	37	38	39	40	42	44	46	47	49	50	52	55	3 57	3 59	4 1	4 3	4
4	38	39	41	42	43	44	46	48	49	51	52	54	56	3 58	4 0	4 2	4	6	7
8	42	43	44	46	47	48	50	51	53	54	56	3 57	3 59	4 1	3	5	7	9	11
10 0	45	46	48	49	50	51	53	54	3 56	3 57	3 59	4 0	4 2	4	6	8	10	12	14
6	50	51	52	54	55	3 56	3 58	3 59	4 1	4 2	4 3	5	7	9	11	12	14	16	18
11 0	54	55	3 57	3 58	3 59	4 0	4 2	4 3	5	6	7	9	11	13	15	16	18	20	22
6	3 58	3 59	4 1	4 2	4 3	4	6	7	8	10	11	13	15	17	19	20	22	24	25
12 0	4 2	4 3	4	5	6	8	9	11	12	13	15	16	18	20	22	23	25	27	28
13 0	8	9	10	11	13	14	15	17	18	19	21	22	24	26	28	29	31	33	34
14 0	14	15	16	17	19	20	21	22	24	25	26	27	29	31	33	34	36	38	39
15 0	19	20	21	22	24	25	26	27	28	30	31	32	34	36	37	39	41	42	44
16 0	24	25	26	27	28	29	30	31	33	34	35	36	38	40	41	43	45	46	48
17 0	28	29	30	31	32	33	34	35	37	38	39	40	42	43	45	47	48	50	51
18 0	31	32	33	34	35	36	37	38	40	41	42	43	45	46	48	50	51	53	54
19 0	34	35	36	37	38	39	40	41	43	44	45	46	48	49	51	53	54	56	4 57
20 0	4 37	4 38	4 39	4 40	4 41	4 42	4 43	4 44	4 45	4 46	4 48	4 49	4 50	4 52	4 54	4 55	4 57	4 58	5 0

Applicable to Beejapoor, Colapoor, Coringa, Ellore, Hyderabad, Rajahmundry, Samulcottah, Secunderabad, &c. &c.

17° North Latitude. Page 11.

Length of the shadow f. in.	Feb.25 to Feb.26 h. m.	Feb 27 to Mar. 1 h. m.	Mar. 2 to Mar. 4 h. m.	Mar. 5 to Mar. 6 h. m.	Mar. 7 to Mar. 9 h. m.	Mar10 to Mar11 h. m.	Mar12 to Mar14 h. m.	Mar15 to Mar16 h. m.	Mar17 to Mar19 h. m.	Mar20 to Mar22 h. m.	Mar23 to Mar25 h. m.	Mar26 to Mar30 h. m.	Mar31 to Apr. 5 h. m.	Apr 6 to Apr 10 h. m.	Apr 11 to Apr 19 h. m.	Apr 19 to May 1 h. m.	May 2 to May16 h. m.	May16 to June 2 h. m.	June 3 to Jun.22 h. m.
1 6	.	.	.	.	.	.	0 19	0 32	0 40	0 47	0 52	1 1	1 8	1 14	1 18	1 24	1 26	1 25	1 23
7	.	.	.	.	.	0 20	33	42	48	0 54	0 59	7	13	19	23	28	31	30	28
8	.	.	.	.	0 21	34	43	50	0 56	1 1	1 5	12	18	23	27	32	35	34	33
9	.	.	.	0 22	35	44	51	0 57	1 2	7	11	17	23	28	31	37	39	39	37
10	.	.	0 23	36	45	52	0 58	1 3	8	12	16	21	28	32	36	41	43	43	41
11	.	0 23	36	45	0 53	0 59	1 5	9	14	18	21	27	32	37	40	45	47	47	46
2 0	0 22	37	46	0 54	1 0	1 6	11	15	19	23	26	32	37	41	44	49	51	51	50
1	36	47	0 54	1 1	7	12	17	21	24	28	31	37	41	45	48	53	55	55	54
2	47	0 55	1 2	8	13	18	22	26	29	33	36	41	45	49	52	1 57	1 59	1 59	1 58
3	0 55	1 2	9	14	19	23	27	31	34	37	40	45	49	53	1 56	2 1	2 3	2 3	2 2
4	1 3	9	15	20	24	28	32	35	39	42	44	49	53	1 57	2 0	4	7	7	6
5	10	15	21	25	29	33	37	40	43	46	49	53	1 57	2 1	4	8	10	11	10
6	16	21	26	30	34	38	41	44	47	50	53	1 57	2 1	5	7	12	14	15	14
7	22	26	31	35	39	43	46	49	52	54	1 57	2 1	5	8	11	15	18	18	18
8	27	31	36	40	43	47	50	53	1 56	1 58	2 1	5	9	12	15	19	21	22	21
9	32	36	41	45	48	51	54	1 57	2 0	2 2	4	9	12	15	18	22	25	25	25
10	37	41	45	49	52	55	1 58	2 1	3	6	8	12	16	19	22	26	28	29	28
11	42	46	49	53	1 56	1 59	2 2	5	7	10	12	16	19	22	25	29	31	32	32
3 0	46	50	1 53	1 57	2 0	2 3	6	8	11	13	15	19	22	25	28	32	35	36	35
2	1 54	1 58	2 1	2 4	7	10	13	15	18	20	22	26	28	31	34	38	41	42	42
4	2 2	2 5	9	12	14	17	20	22	24	26	28	32	35	38	40	44	47	48	48
6	9	12	16	19	21	24	26	28	30	32	34	38	41	44	46	50	53	2 54	2 54
8	16	19	22	25	27	30	32	34	36	38	40	44	47	49	52	2 56	2 58	3 0	3 0
10	23	25	28	31	33	36	38	40	42	44	46	49	52	2 55	2 57	3 1	3 4	5	5
4 0	29	31	34	37	39	41	43	45	47	49	51	54	2 57	3 0	3 2	6	9	10	11
2	35	37	40	42	45	47	49	51	53	54	2 56	2 59	3 2	5	7	11	14	15	16
4	40	43	45	47	50	52	54	2 56	2 58	2 59	3 1	3 4	7	10	12	16	18	20	21
6	45	48	50	52	55	2 57	2 59	3 0	3 2	3 4	6	9	12	14	17	20	23	25	26
8	50	52	55	2 57	2 59	3 1	3 3	5	7	9	10	13	16	19	21	25	27	29	30
10	55	2 57	2 59	3 2	3 4	6	8	9	11	13	14	17	20	23	25	29	32	34	34
5 0	2 59	3 2	3 4	3 6	3 8	3 10	3 12	3 14	3 15	3 17	3 18	3 21	3 24	3 27	3 29	3 33	3 36	3 38	3 38

Length of the shadow	Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep.25	Sep.24 to Sep.22	Sep 21 to Sep.19	Sep.18 to Sep.13	Sep.12 to Sep. 8	Sep. 7 to Sep. 3	Sep. 2 to Aug25	Aug24 to Aug13	Aug12 to Jul.29	Jul. 28 to Jun 11	Jul. 10 to Jun 22
Declination.	9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	7° +	9° +	13° +	17° +	21° +	23½ +
5 2	3 4	3 6	3 8	3 10	3 12	3 14	3 16	3 18	3 19	3 21	3 22	3 25	3 28	3 31	3 33	3 36	3 39	3 42	3 42
4	8	10	12	14	16	18	20	21	23	25	26	29	32	34	36	40	43	45	46
6	12	14	16	18	20	22	23	25	27	28	30	33	35	38	40	44	47	49	50
8	15	17	19	21	23	25	27	29	30	32	33	36	39	41	43	47	50	52	53
10	19	21	23	25	27	29	30	32	34	35	37	40	42	44	47	50	53	56	3 57
6 0	22	24	26	28	30	32	34	35	37	38	40	43	45	48	50	53	3 57	3 59	4 0
4	29	31	32	34	36	38	40	41	43	44	46	49	51	54	3 56	3 59	4 3	4 5	6
8	35	37	38	40	42	44	45	47	48	50	51	54	3 57	3 59	4 1	4 5	8	11	12
7 0	40	42	44	46	47	49	50	52	53	3 55	3 56	3 59	4 2	4 4	6	10	13	16	18
4	45	47	49	51	52	54	3 55	3 57	3 58	4 0	4 1	4 4	6	9	11	15	18	21	23
8	50	52	54	3 55	3 57	3 59	4 0	4 2	4 3	4	6	9	11	13	15	19	23	26	27
8 0	54	3 56	3 58	4 0	4 1	4 3	4	6	7	9	10	13	15	17	19	23	27	30	32
4	3 58	4 0	4 2	4	5	7	8	10	11	13	14	16	19	21	23	27	31	34	36
8	4 2	4	6	7	9	11	12	13	15	16	18	20	23	25	27	31	35	38	39
9 0	6	8	9	11	13	14	16	17	18	20	21	23	26	28	30	34	38	41	43
4	9	11	13	14	16	17	19	20	21	23	24	27	29	31	34	38	41	45	46
8	12	14	16	17	19	20	22	23	24	26	27	30	32	34	37	41	44	48	50
10 0	15	17	19	20	22	23	25	26	27	29	30	33	35	37	40	44	47	51	53
6	19	21	23	24	26	27	29	30	31	33	34	37	39	41	43	48	51	55	4 57
11 0	23	25	26	28	29	31	32	34	35	36	38	40	43	45	47	51	55	4 59	5 1
6	27	29	30	32	33	35	36	37	39	40	41	44	46	48	50	55	4 59	5 2	4
12 0	30	32	33	35	36	38	39	40	42	43	44	47	49	51	54	4 58	5 2	5	8
13 0	36	37	39	40	42	43	45	46	47	48	50	52	4 55	4 57	4 59	5 3	7	11	14
14 0	41	42	44	45	47	48	50	51	52	53	55	4 57	5 0	5 2	5 4	8	12	16	19
15 0	45	47	48	50	51	52	54	55	4 56	4 57	4 59	5 1	4	6	8	13	17	21	23
16 0	49	51	52	54	55	4 56	4 58	4 59	5 0	5 1	5 3	5	8	10	12	17	21	25	27
17 0	53	54	56	4 57	4 58	5 0	5 1	5 2	4	5	6	8	11	13	15	20	24	28	31
18 0	56	4 57	4 59	5 0	5 1	3	4	5	7	8	9	12	14	16	19	23	27	31	34
19 0	4 59	5 0	5 1	3	4	5	7	8	9	11	12	14	17	19	21	26	30	34	37
20 0	5 1	5 2	5 4	5 5	5 7	5 8	5 9	5 10	5 12	5 13	5 14	5 17	5 19	5 21	5 24	5 28	5 33	5 37	5 40

Applicable to Beejapoor, Colapoor, Coringa, Ellore, Hyderabad, Rajahmundry, Samulcottah, Secunderabad, &c. &c.

Length of the shadow		Dec.22 to Dec.29		Dec.30 to Jan. 4		Jan. 5 to Jan. 8		Jan. 9 to Jan.11		Jan.12 to Jan.14		Jan.15 to Jan.17		Jan.18 to Jan.20		Jan.21 to Jan.23		Jan.24 to Jan.26		Jan.27 to Jan.29		Jan.30 to Jan.31		Feb. 1 to Feb. 3		Feb. 4 to Feb. 6		Feb. 7 to Feb. 9		Feb.10 to Feb.12		Feb.13 to Feb.15		Feb.16 to Feb.18		Feb.19 to Feb.21		Feb.22 to Feb.24	
f.	in.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.
1	6	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	
	7	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	
	8	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	
	9	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	
	10	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	
	11	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	
2	0	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	
	1	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.	
	2	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		0	20
	3	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		0	19		36
	4	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		0	16		35		47
	5	.		.		.		.		.		.		.		.		.		.		.		.		.		.		.		0	12		34		46	0	55
	6	.		.		.		.		.		.		.		.		.		.		.		.		.		.		0	6		33		45	0	55	1	3
	7	.		.		.		.		.		.		.		.		.		.		.		.		.		.			30		44	0	54	1	3		10
	8	.		.		.		.		.		.		.		.		.		.		.		.		.		0	28		43	0	54	1	2		10		16
	9	.		.		.		.		.		.		.		.		.		.		.		.		0	24		41	0	52	1	2		9		16		22
	10	.		.		.		.		.		.		.		.		.		.		.		0	19		39		51	1	1		9		16		22		27
	11	.		.		.		.		.		.		.		.		.		.		0	23		36		49	0	59		8		15		22		27		32
3	0	.		.		.		.		.		.		.		.		.		0	26		38	0	47	0	58	1	7		14		21		27		32		37
	2	.		.		.		.		.		.		0	8	0	30	0	41	0	50	0	57	1	4	1	12		20		26		32		37		42		46
	4	.		.		.		.		0	20	0	33	0	44	0	53	1	0	1	6	1	12		17		22		30		36		41		46		51	1	55
	6	.		0	16	0	31	0	40		48	0	54	1	0	1	8		14		19		24		28		35		40		45		50	1	54	1	59	2	3
	8	0	38	0	46	0	53	0	59	1	4	1	9		15		20		25		30		34		38		44		49	1	54	1	58	2	2	2	6		10
	10	0	57	1	3	1	8	1	13		17		21		26		31		35		39		43		47	1	52	1	57	2	1	2	5		9		13		17
4	0	1	11		16		20		24		28		32		36		40		44		48		52	1	55	2	0	2	4		8		12		16		20		23
	2		23		27		31		34		37		41		45		49	1	52	1	56	1	59	2	2		7		11		15		19		22		26		29
	4		33		37		40		43		46		49	1	53	1	57	2	0	2	3	2	6		9		14		18		21		25		28		31		35
	6		42		45		48		51	1	54	1	57	2	0	2	4		7		10		13		16		20		24		27		31		34		37		40
	8		50	1	53	1	56	1	59	2	1	2	4		7		10		13		16		19		22		26		29		33		36		39		42		45
	10	1	57	2	0	2	3	2	6		8		10		13		16		19		22		25		28		31		35		38		41		44		47		50
5	0	2	4	2	7	2	9	2	12	2	14	2	16	2	19	2	22	2	25	2	28	2	30	2	33	2	36	2	40	2	43	2	46	2	49	2	52	2	54

Length of the shadow	Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov 14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5 2	2 10	2 13	2 15	2 18	2 20	2 22	2 25	2 28	2 30	2 33	2 35	2 38	2 41	2 45	2 48	2 51	2 54	2 57	2 59
4	16	18	21	23	25	27	30	33	35	38	40	43	46	49	52	55	2 58	3 1	3 3
6	22	24	26	28	30	32	35	38	40	43	45	47	50	53	2 56	2 59	3 2	5	7
8	27	29	31	33	35	37	40	42	45	47	49	51	54	2 58	3 0	3 3	6	8	11
10	32	34	36	38	40	42	44	47	49	51	53	55	2 58	3 2	4	7	10	12	15
6 0	36	38	40	42	44	46	48	51	2 53	2 55	2 57	2 59	3 2	5	8	11	13	16	18
4	44	46	48	50	52	2 54	2 56	2 58	3 1	3 2	3 4	3 6	9	12	15	18	20	23	25
8	52	2 54	2 56	2 58	2 59	3 1	3 3	3 5	8	9	11	13	16	19	21	24	26	29	31
7 0	2 59	3 1	3 3	3 5	3 6	8	10	12	14	16	17	19	22	25	27	30	32	34	36
4	3 5	7	9	11	12	14	16	18	20	22	23	25	28	30	33	35	37	39	41
8	11	13	15	16	18	19	21	23	25	27	28	30	33	35	38	40	42	44	46
8 0	17	18	20	21	23	24	26	28	30	32	33	35	38	40	42	45	47	49	51
4	22	23	25	26	28	29	31	33	35	37	38	40	42	44	47	49	51	53	55
8	26	28	29	31	32	34	35	37	39	41	42	44	46	48	51	53	55	3 57	3 59
9 0	31	32	34	35	36	38	39	41	43	45	46	48	50	52	55	3 57	3 59	4 1	4 3
4	35	36	38	39	40	42	43	45	47	48	50	51	54	56	3 58	4 0	4 2	4	6
8	39	40	42	43	44	45	47	49	50	52	53	55	3 57	3 59	4 1	3	5	7	9
10 0	42	43	45	46	47	49	50	52	53	3 55	3 56	3 58	4 0	4 2	4	6	8	10	12
6	47	48	50	51	52	53	55	3 57	3 58	4 0	4 1	4 3	5	7	9	11	13	14	16
11 0	51	53	54	55	3 56	3 58	3 59	4 1	4 2	4	5	7	9	11	13	15	17	18	20
6	55	3 57	3 58	3 59	4 0	4 2	4 3	5	6	8	9	11	13	15	17	19	21	22	24
12 0	3 59	4 0	4 2	4 3	4	5	7	8	10	11	13	14	16	18	20	22	24	25	27
13 0	4 6	7	8	9	10	11	13	14	16	17	19	20	22	24	26	28	30	31	33
14 0	12	13	14	15	16	17	19	20	22	23	24	26	28	29	31	33	35	36	38
15 0	17	18	19	20	21	22	24	25	26	28	29	30	32	34	36	37	39	41	42
16 0	21	22	23	24	25	26	28	29	30	32	33	34	36	38	40	42	43	45	46
17 0	25	26	27	28	29	30	32	33	34	36	37	38	40	42	43	45	47	48	50
18 0	28	30	31	32	33	34	35	36	38	39	40	41	43	45	47	48	50	51	53
19 0	31	33	34	35	36	37	38	39	41	42	43	44	46	48	49	51	53	54	56
20 0	4 34	4 35	4 37	4 38	4 38	4 39	4 41	4 42	4 43	4 44	4 46	4 47	4 49	4 50	4 52	4 54	4 55	4 57	4 58
Declination	$23\frac{1}{2}$ —	23° —	$22\frac{1}{2}$ —	22° —	$21\frac{1}{2}$ —	21° —	$20\frac{1}{3}$ —	$19\frac{2}{3}$ —	19° —	$18\frac{1}{3}$ —	$17\frac{2}{3}$ —	17° —	16° —	15° —	14° —	13° —	12° —	11° —	10° —

Applicable to Chicacole, Poonah, Sattarah, Sholapoor, Vizagapatam, Vizianagrum, &c. &c.

Length of the shadow	Feb.25 to Feb.26	Feb 27 to Mar. 1	Mar. 2 to Mar. 4	Mar. 5 to Mar. 6	Mar. 7 to Mar. 9	Mar10 to Mar11	Mar1 to Mar1·	Mar15 to Mar16	Mar17 to Mar19	Mar20 to Mar22	Mar23 to Mar25	Mar26 to Mar30	Mar31 to Apr. 5	Apr 6 to Apr 12	Apr 13 to Apr 21	Apr 22 to May 4	May 5 to May18	May19 to June 2	June 3 to Jun.22
f. in.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1 6	.	.	.	.	.	.	.	0 19	0 32	0 40	0 47	0 57	1 5	1 11	1 18	1 24	1 27	1 26	1 25
7	.	.	.	.	.	.	0 21	33	42	48	0 54	1 3	11	16	23	29	31	31	30
8	.	.	.	.	.	0 22	34	43	50	0 56	1 1	9	16	21	27	33	35	35	34
9	.	.	.	.	0 22	35	44	51	0 57	1 2	7	15	21	26	32	37	39	40	39
10	.	.	.	0 22	36	45	52	0 58	1 4	8	13	20	26	31	36	41	44	44	43
11	.	.	0 23	36	46	0 53	0 59	1 5	10	14	18	25	31	35	41	45	48	48	47
2 0	.	0 22	37	46	0 54	1 1	1 6	11	15	20	23	30	35	39	45	49	52	52	51
1	0 21	36	46	0 54	1 1	7	12	17	21	25	28	35	40	44	49	53	1 56	1 56	1 56
2	36	47	0 55	1 2	8	13	18	22	26	30	33	39	44	48	53	1 57	2 0	2 0	2 0
3	46	0 55	1 2	9	14	19	23	27	31	34	38	43	48	52	1 57	2 1	4	4	4
4	0 55	1 3	9	15	20	24	28	32	36	39	42	47	52	1 56	2 1	5	7	8	7
5	1 3	10	15	20	25	29	33	37	41	43	46	51	1 56	2 0	4	9	11	12	11
6	10	16	21	26	30	34	38	42	45	48	50	55	2 0	4	8	12	15	16	15
7	16	22	27	31	35	39	43	46	49	52	54	1 59	4	8	12	16	19	19	19
8	22	27	32	36	40	44	47	50	53	1 56	1 58	2 3	7	11	15	19	22	23	23
9	27	32	37	41	45	48	51	54	1 57	2 0	2 2	7	11	15	19	23	26	26	26
10	32	37	41	45	49	52	55	1 58	2 1	4	6	11	15	18	22	26	29	30	30
11	37	42	46	49	53	1 56	1 59	2 2	5	8	10	15	18	21	26	30	32	33	33
3 0	42	46	50	1 54	1 57	2 0	2 3	6	8	11	13	18	21	25	29	33	35	36	36
2	50	1 55	1 58	2 2	2 5	8	10	13	15	18	20	25	28	31	35	39	42	43	43
4	1 58	2 3	2 6	9	12	15	17	20	22	25	27	31	34	37	41	45	48	49	49
6	2 6	10	13	16	19	22	24	26	29	31	33	37	40	43	47	51	54	2 55	2 55
8	13	16	19	22	25	28	30	32	35	37	39	42	46	49	53	2 57	2 59	3 1	3 1
10	20	23	26	28	31	34	36	38	41	43	45	48	51	54	2 58	3 2	3 5	6	7
4 0	26	29	32	34	37	39	42	44	46	48	50	53	2 56	2 59	3 3	7	10	11	12
2	32	35	38	40	43	45	47	49	51	53	2 55	2 58	3 1	3 4	8	12	15	16	17
4	37	40	43	45	48	50	52	54	2 56	2 58	3 0	3 3	6	9	13	17	20	21	22
6	43	45	48	50	53	55	2 57	2 59	3 1	3 3	5	8	11	14	17	21	24	26	27
8	48	50	53	2 55	2 57	2 59	3 2	3 4	6	7	9	12	15	18	22	26	29	30	31
10	53	55	2 58	3 0	3 2	3 4	6	8	10	12	13	17	20	22	26	30	33	34	35
5 0	2 57	2 59	3 2	3 4	3 6	3 8	3 10	3 12	3 14	3 16	3 18	3 21	3 24	3 26	3 30	3 34	3 37	3 39	3 40

5	2	3 1	3 4	3 6	3 8	3 10	3 12	3 14	3 16	3 18	3 20	3 22	3 25	3 27	3 30	3 34	3 38	3 41	3 43	3 44
	4	5	8	10	12	14	16	18	20	22	24	25	28	31	34	37	41	44	46	48
	6	9	12	14	16	18	20	22	24	26	27	29	32	35	38	41	45	48	50	51
	8	13	16	18	20	22	24	26	27	29	31	32	35	38	41	44	48	52	53	55
	10	17	19	21	23	25	27	29	31	33	34	36	39	42	44	48	52	55	3 57	3 58
6	0	20	23	25	27	29	30	32	34	36	37	39	42	45	47	51	3 55	3 58	4 0	4 2
	4	27	29	31	32	35	36	38	40	42	43	45	48	51	53	3 57	4 1	4 4	6	8
	8	33	35	37	39	41	42	44	46	48	49	51	54	3 56	3 59	4 2	6	10	12	14
7	0	38	40	42	44	46	48	49	51	53	54	3 56	3 59	4 1	4 4	7	11	15	17	19
	4	43	45	47	49	51	53	54	3 56	3 58	3 59	4 1	4 4	6	9	12	16	20	22	24
	8	48	50	52	54	3 56	3 58	3 59	4 1	4 2	4 4	5	8	11	13	17	21	24	27	28
8	0	53	55	3 56	3 58	4 0	4 2	4 3	5	6	8	9	12	15	17	21	25	29	31	33
	4	3 57	3 59	4 0	4 2	4	6	7	9	10	12	13	16	19	21	25	29	33	35	37
	8	4 1	4 3	4	6	8	9	11	13	14	16	17	20	22	25	28	33	36	39	41
9	0	5	6	8	10	12	13	15	16	18	19	20	23	26	28	32	36	40	42	44
	4	8	10	11	13	1[illegible]	16	18	19	21	22	24	26	29	31	35	39	43	46	48
	8	11	13	14	16	18	19	21	22	24	25	27	29	32	34	38	42	46	49	51
10	0	14	16	17	19	21	22	24	25	27	28	30	32	35	37	41	45	49	52	54
	6	18	20	21	23	25	26	28	29	31	32	34	36	39	41	45	49	53	4 56	4 58
11	0	22	24	25	27	29	30	32	33	35	36	37	40	43	45	49	53	4 57	5 0	5 2
	6	26	27	29	31	32	34	35	37	38	39	41	43	46	48	52	4 56	5 0	3	6
12	0	29	30	32	34	35	37	38	40	41	42	44	47	49	52	4 55	5 0	4	7	9
13	0	35	36	38	39	41	42	44	45	47	48	49	52	4 55	4 57	5 1	5	9	13	15
14	0	40	41	43	44	46	47	49	50	52	53	54	4 57	5 0	5 2	6	10	14	18	20
15	0	44	46	47	49	50	52	53	54	4 56	4 57	4 59	5 1	4	6	10	14	19	22	25
16	0	48	50	51	53	54	56	4 57	4 58	5 0	5 1	5 3	5	8	10	14	18	23	26	29
17	0	52	53	55	56	4 58	4 59	5 0	5 2	3	5	6	8	11	13	17	22	26	30	33
18	0	55	56	4 58	4 59	5 1	5 2	3	5	6	8	9	11	14	16	20	25	29	33	37
19	0	4 58	4 59	5 1	5 2	3	5	6	8	9	10	12	14	17	19	23	28	32	36	39
20	0	5 0	5 1	5 3	5 4	5 6	5 7	5 9	5 10	5 11	5 13	5 14	5 17	5 19	5 22	5 25	5 30	5 35	5 38	5 41
Length of the	shadow	Oct. 18 to Oct. 16	Oct. 15 to Oct. 13	Oct. 12 to Oct. 11	Oct. 10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep. 30	Sep. 29 to Sep. 28	Sep. 27 to Sep. 25	Sep. 24 to Sep. 22	Sep. 21 to Sep. 19	Sep. 18 to Sep. 13	Sep. 12 to Sep. 8	Sep. 7 to Sep. 1	Aug 31 to Aug 22	Aug 21 to Aug 9	Aug 8 to Jul. 27	Jul. 26 to Jul. 11	Jul. 10 to Jun 22
Declination.		9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	7° +	10° +	14° +	18° +	21° +	23½ +

Applicable to Chicacole, Poonah, Sattarah, Sholapoor, Vizagapatam, Vizianagrum, &c. &c.

15° North Latitude. Page I.

Length of the shadow f.	in.	Dec.22 to Dec.29 h.	m.	Dec.30 to Jan. 4 h.	m.	Jan. 5 to Jan. 8 h.	m.	Jan. 9 to Jan.11 h.	m.	Jan.12 to Jan.14 h.	m.	Jan.15 to Jan.17 h.	m.	Jan.18 to Jan.20 h.	m.	Jan.21 to Jan.23 h.	m.	Jan.24 to Jan.26 h.	m.	Jan.27 to Jan.29 h.	m.
1	6		.		.		.		.		.		.		.		.		.		.
	7		.		.		.		.		.		.		.		.		.		.
	8		.		.		.		.		.		.		.		.		.		.
	9		.		.		.		.		.		.		.		.		.		.
	10		.		.		.		.		.		.		.		.		.		.
	11		.		.		.		.		.		.		.		.		.		.
2	0		.		.		.		.		.		.		.		.		.		.
	1		.		.		.		.		.		.		.		.		.		.
	2		.		.		.		.		.		.		.		.		.		.
	3		.		.		.		.		.		.		.		.		.		.
	4		.		.		.		.		.		.		.		.		.		.
	5		.		.		.		.		.		.		.		.		.		.
	6		.		.		.		.		.		.		.		.		.		.
	7		.		.		.		.		.		.		.		.		.		.
	8		.		.		.		.		.		.		.		.		.		.
	9		.		.		.		.		.		.		.		.		.		.
	10		.		.		.		.		.		.		.		.		.		.
	11		.		.		.		.		.		.		.		.		.		.
3	0		.		.		.		.		.		.		.		.		.		.
	2		.		.		.		.		.		.		.		.	0	21	0	36
	4		.		.		.		.		.		.	0	25	0	39	0	48	0	56
	6		.		.		.	0	16	0	31	0	40	0	50	0	58	1	5	1	11
	8	0	6	0	27	0	38	0	46	0	53	0	59	1	6	1	12		18		23
	10	0	43	0	51	0	57	1	3	1	8	1	13		19		24		29		33
4	0	1	1	1	6	1	11		16		20		24		29		34		38		42
	2		14		19		23		27		31		34		38		43		47		50
	4		25		29		33		36		40		43		47		51	1	55	1	58
	6		34		38		42		45		48		51	1	55	1	58	2	2	2	5
	8		43		47		50	1	53	1	56	1	59	2	2	2	5		9		12
	10		51	1	54	1	57	2	0	2	3	2	6		9		12		15		18
5	0	1	58	2	1	2	4	2	6	2	9	2	12	2	15	2	18	2	21	2	24

Length of the shadow f.	in.	Jan.30 to Jan.31 h.	m.	Feb. 1 to Feb. 3 h.	m.	Feb. 4 to Feb. 6 h.	m.	Feb. 7 to Feb. 9 h.	m.	Feb.10 to Feb.12 h.	m.	Feb.13 to Feb.15 h.	m.	Feb.16 to Feb.18 h.	m.	Feb.19 to Feb.21 h.	m.	Feb.22 to Feb.24 h.	m.
1	6		.		.		.		.		.		.		.		.		.
	7		.		.		.		.		.		.		.		.		.
	8		.		.		.		.		.		.		.		.		.
	9		.		.		.		.		.		.		.		.		.
	10		.		.		.		.		.		.		.		.		.
	11		.		.		.		.		.		.		.		.		.
2	0		.		.		.		.		.		.		.		.		.
	1		.		.		.		.		.		.		.		.		.
	2		.		.		.		.		.		.		.		.		.
	3		.		.		.		.		.		.		.		.	0	18
	4		.		.		.		.		.		.		.	0	16		35
	5		.		.		.		.		.		.	0	13		34		46
	6		.		.		.		.		.	0	6		33		45	0	55
	7		.		.		.		.		.		30		44	0	54	1	3
	8		.		.		.		.	0	28		43	0	54	1	2		10
	9		.		.		.	0	24		41	0	52	1	2		9		16
	10		.		.	0	20		39		51	1	1		9		16		22
	11		.	0	11		36		49	0	59		8		15		22		27
3	0	0	16		33	0	47	0	58	1	7		14		21		27		32
	2	0	46	0	54	1	4	1	12		20		26		32		37		42
	4	1	3	1	9		17		24		31		36		41		46		51
	6		16		21		28		34		40		45		50	1	54	1	59
	8		27		32		38		44		49	1	54	1	58	2	2	2	6
	10		37		41		47	1	52	1	57	2	1	2	5		9		13
4	0		46		50	1	55	2	0	2	4		8		12		16		20
	2	1	54	1	58	2	2		7		11		15		19		22		26
	4	2	2	2	5		9		14		18		21		25		28		32
	6		9		12		16		20		24		27		31		34		37
	8		15		18		22		26		29		33		36		39		42
	10		21		24		28		31		35		38		41		44		47
5	0	2	26	2	29	2	33	2	36	2	40	2	43	2	46	2	49	2	52

Length of the shadow		Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov 14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
Declination.		23½ —	23° —	22½ —	22° —	21½ —	21° —	20⅓ —	19⅔ —	19° —	18⅓ —	17⅔ —	17° —	16° —	15° —	14° —	13° —	12° —	11° —	10° —
5	2	2 5	2 7	2 10	2 12	2 15	2 18	2 21	2 24	2 26	2 29	2 32	2 34	2 38	2 41	2 45	2 48	2 51	2 54	2 57
	4	11	13	16	18	21	23	26	29	31	34	37	39	43	46	49	52	55	2 58	3 1
	6	17	19	22	24	26	28	31	34	36	39	42	44	47	51	54	2 57	2 59	3 2	5
	8	22	24	27	29	31	33	36	38	41	43	46	48	51	55	2 58	3 1	3 3	6	9
	10	27	29	32	34	36	38	41	43	45	48	50	52	2 55	2 59	3 2	5	7	10	13
6	0	32	34	36	38	40	42	45	47	49	52	2 53	2 56	3 0	3 3	6	8	11	14	16
	4	40	42	44	46	48	50	2 53	2 55	2 57	2 59	3 2	3 4	7	10	12	15	18	21	23
	8	48	50	52	2 54	2 56	2 58	3 0	3 2	3 4	3 6	9	11	13	16	19	22	24	27	29
7	0	2 55	2 57	2 59	3 1	3 3	3 4	7	9	11	13	15	17	19	22	25	28	30	33	35
	4	3 2	3 4	3 5	7	9	10	13	15	17	19	21	23	25	28	30	33	35	38	39
	8	8	10	11	13	15	16	18	20	22	24	26	28	30	33	35	38	40	43	45
8	0	13	15	17	18	20	21	23	25	27	29	31	33	35	38	40	43	45	47	49
	4	18	20	22	23	25	26	28	30	32	34	36	37	40	42	45	47	49	51	53
	8	23	25	26	28	29	31	33	34	36	38	40	42	44	46	49	51	53	55	3 57
9	0	28	29	31	32	33	35	37	38	40	42	44	46	48	50	53	55	3 57	3 59	4 1
	4	32	33	35	36	37	39	41	42	44	46	48	49	52	54	3 56	3 58	4 0	4 2	4
	8	36	37	39	40	41	43	45	46	48	50	51	53	55	3 57	4 0	4 2	4	6	8
10	0	39	40	42	43	45	46	48	49	51	53	54	3 56	3 58	4 0	3	5	7	9	11
	6	44	45	47	48	50	51	53	54	3 56	3 58	3 59	4 1	4 3	5	7	9	11	13	15
11	0	48	50	51	52	54	55	3 57	3 58	4 0	4 2	4 3	5	7	9	11	13	15	17	19
	6	52	54	55	3 56	3 58	3 59	4 1	4 2	4	6	7	8	11	13	15	17	19	21	23
12	0	3 56	3 58	3 59	4 0	4 2	4 3	4	6	7	9	10	12	14	16	18	20	22	24	26
13	0	4 3	4 4	4 5	7	8	9	10	12	13	15	16	18	20	22	24	26	28	30	32
14	0	9	10	11	13	14	15	16	18	19	21	22	24	26	28	30	31	33	35	37
15	0	14	15	16	18	19	20	21	23	24	26	27	28	30	32	34	36	38	40	41
16	0	19	20	21	22	23	24	26	27	28	30	31	33	34	36	38	40	42	44	45
17	0	23	24	25	26	27	28	30	31	32	34	35	37	38	40	42	44	46	47	49
18	0	26	27	28	29	30	31	33	34	36	37	38	40	41	43	45	47	49	50	52
19	0	29	30	31	32	33	34	36	37	39	40	41	43	44	46	48	50	52	53	55
20	0	4 32	4 33	4 34	4 35	4 36	4 37	4 39	4 40	4 41	4 43	4 44	4 45	4 47	4 49	4 51	4 52	4 54	4 56	4 57

Applicable to Ahmednuggur, Berhampore, Bombay, Ganjam, Itchapoor, Jeypoor, Mominabad, &c. &c.

19° North Latitude. Page 11.

Length of the shadow (f. in.)	Feb.25 to Feb.26 (h. m.)	Feb 27 to Mar. 1 (h. m.)	Mar. 2 to Mar. 4 (h. m.)	Mar. 5 to Mar. 6 (h. m.)	Mar. 7 to Mar. 9 (h. m.)	Mar 10 to Mar 11 (h. m.)	Mar 12 to Mar 14 (h. m.)	Mar 15 to Mar 16 (h. m.)	Mar 17 to Mar 19 (h. m.)	Mar 20 to Mar 22 (h. m.)	Mar 23 to Mar 25 (h. m.)	Mar 26 to Mar 30 (h. m.)	Mar 31 to Apr. 5 (h. m.)	Apr 6 to Apr 10 (h. m.)	Apr 11 to Apr 16 (h. m.)	Apr 16 to Apr 25 (h. m.)	Apr 25 to May 8 (h. m.)	May 9 to May 25 (h. m.)	May 26 to Jun. 22 (h. m.)
1 6	.	.	.	.	.	.	.	.	0 19	0 32	0 40	0 53	1 2	1 9	1 14	1 19	1 24	1 27	1 27
7	.	.	.	.	.	.	.	0 21	33	42	48	0 59	7	14	19	23	29	31	31
8	.	.	.	.	.	.	0 22	34	43	50	0 56	1 5	13	19	24	28	33	36	36
9	.	.	.	.	.	0 22	35	44	51	0 57	1 3	11	18	24	28	32	38	40	40
10	.	.	.	.	0 22	36	45	52	0 58	1 4	9	17	23	28	33	37	42	44	44
11	.	.	.	0 23	36	46	0 53	0 59	1 5	10	15	22	28	33	37	41	46	48	49
2 0	.	.	0 22	37	46	0 54	1 1	1 6	11	16	20	27	33	38	42	45	50	52	53
1	.	0 21	36	47	0 54	1 1	7	12	17	21	25	32	37	42	46	49	54	1 56	1 57
2	0 21	36	47	0 55	1 2	8	13	18	22	26	30	36	41	46	50	53	1 58	2 0	2 1
3	36	46	0 55	1 2	9	14	19	24	27	31	35	41	46	50	54	1 57	2 2	4	5
4	47	0 55	1 3	9	15	20	24	29	32	36	39	45	50	54	1 58	2 1	6	8	9
5	0 55	1 3	10	15	20	25	30	34	37	41	44	49	54	1 58	2 2	5	9	12	13
6	1 3	10	16	21	26	30	35	38	42	45	48	53	1 58	2 2	6	9	13	16	17
7	10	16	22	27	31	35	40	43	46	49	52	1 57	2 2	6	9	12	17	19	30
8	16	22	27	32	36	40	44	47	50	53	1 56	2 1	6	10	13	16	20	23	24
9	22	27	32	37	41	45	48	52	55	1 57	2 0	5	9	13	17	20	24	26	27
10	27	32	37	41	45	49	52	1 56	1 59	2 1	4	9	13	17	20	23	27	30	31
11	32	37	42	46	50	53	1 56	2 0	2 3	5	8	13	17	20	23	26	30	33	34
3 0	37	42	46	50	1 54	1 57	2 0	3	6	9	11	16	20	24	27	29	34	36	38
2	46	51	1 54	1 58	2 2	2 5	8	11	13	16	18	23	26	30	33	36	40	43	44
4	1 53	1 59	2 2	2 6	9	12	15	18	20	23	25	29	33	36	39	42	46	49	50
6	2 3	2 6	9	13	16	19	22	24	27	29	31	35	39	42	45	48	52	2 55	2 56
8	10	13	16	20	23	25	28	30	33	35	37	41	45	48	51	53	2 57	3 0	3 2
10	17	20	23	26	29	31	34	36	39	41	43	47	50	53	2 56	2 59	3 3	6	8
4 0	23	26	29	32	35	37	40	42	44	46	48	52	2 56	2 59	3 1	3 4	8	11	13
2	29	32	35	38	41	43	45	48	50	52	54	2 57	3 1	3 4	6	9	13	16	18
4	35	38	40	43	46	48	50	53	2 55	2 57	2 59	3 2	6	9	11	14	18	21	23
6	40	43	45	48	51	53	2 55	2 57	3 0	3 1	3 3	7	10	13	16	18	22	25	28
8	45	48	50	53	2 55	2 58	3 0	3 2	4	6	8	11	15	17	20	23	27	30	32
10	50	53	2 55	2 58	3 0	3 3	5	7	9	10	12	16	19	22	24	27	31	34	37
5 0	2 55	2 57	3 0	3 2	3 4	3 7	3 9	3 11	3 13	3 15	3 16	3 20	3 23	3 26	3 28	3 31	3 35	3 38	3 41

Length of the shadow	Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep 25	Sep.24 to Sep.22	Sep 21 to Sep.19	Sep.18 to Sep.13	Sep.12 to Sep. 8	Sep. 7 to Sep. 3	Sep. 2 to Aug28	Aug27 to Aug19	Aug18 to Aug 6	Aug 5 to Jul. 19	Jul. 18 to Jun 22
Declination.	9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	7° +	9° +	11° +	15° +	19° +	23½ +
5 2	2 59	3 2	3 4	3 6	3 9	3 11	3 13	3 15	3 17	3 19	3 20	3 24	3 27	3 30	3 32	3 35	3 39	3 42	3 45
4	3 3	6	8	10	13	15	17	19	21	23	24	28	31	33	36	38	43	46	49
6	7	10	12	14	17	19	21	23	24	26	28	31	34	37	40	42	46	49	52
8	11	14	16	18	20	22	24	26	28	30	31	35	38	41	43	45	50	53	56
10	15	18	20	22	24	26	28	30	31	33	35	38	41	44	46	49	53	3 56	3 59
6 0	18	21	23	25	27	29	31	33	35	36	38	41	44	47	49	52	3 56	4 0	4 2
4	25	27	29	31	33	35	37	39	41	42	44	47	50	53	3 55	3 58	4 2	6	8
8	31	33	35	37	39	41	43	45	47	48	50	53	3 56	3 59	4 1	4 3	8	11	14
7 0	37	39	41	43	45	47	48	50	52	53	3 55	3 58	4 1	4 4	6	8	13	17	20
4	42	44	46	48	50	52	53	3 55	3 57	3 58	4 0	4 3	6	9	11	13	18	22	25
8	47	49	51	53	54	3 56	3 58	4 0	4 1	4 3	5	8	10	13	15	18	22	26	29
8 0	51	53	55	3 57	3 59	4 1	4 2	4	6	7	9	12	14	17	20	22	26	30	34
4	55	3 57	3 59	4 1	4 3	5	6	8	10	11	13	16	18	21	24	26	30	34	38
8	3 59	4 1	4 3	5	7	8	10	12	13	15	16	19	22	25	27	30	34	38	42
9 0	4 3	5	7	9	10	12	14	15	17	18	20	23	26	28	31	33	38	42	45
4	6	8	10	12	14	15	17	19	20	22	23	26	29	31	34	36	41	45	49
8	10	11	13	15	17	18	20	22	23	25	26	29	32	34	37	39	44	48	52
10 0	13	14	16	18	20	21	23	25	26	28	29	32	35	37	40	42	47	51	55
6	17	19	20	22	24	25	27	29	30	32	33	36	39	41	44	46	51	55	4 59
11 0	21	23	24	26	28	29	31	32	34	35	37	40	42	45	48	50	55	4 59	5 3
6	25	26	28	30	31	33	34	36	37	39	40	43	46	48	51	53	4 58	5 3	7
12 0	28	29	31	33	34	36	37	39	41	42	43	46	49	52	4 54	4 57	5 1	6	10
13 0	34	35	37	38	40	42	43	45	46	48	49	52	4 55	4 57	5 0	5 2	7	11	16
14 0	39	40	42	43	45	47	48	50	51	53	54	4 57	5 0	5 2	5	7	12	17	21
15 0	43	45	46	48	49	51	52	54	55	4 57	4 58	5 1	4	6	9	11	16	21	26
16 0	47	49	50	52	53	55	4 56	4 58	4 59	5 1	5 2	5	8	10	13	15	20	25	30
17 0	51	52	54	55	4 57	4 58	5 0	5 1	5 3	4	5	8	11	14	16	19	24	29	33
18 0	54	55	4 57	4 58	5 0	5 1	3	4	6	7	9	11	14	17	19	22	27	32	37
19 0	56	4 58	5 0	5 1	3	4	6	7	9	10	11	14	17	19	21	24	30	35	40
20 0	4 59	5 1	5 2	5 4	5 5	5 7	5 8	5 10	5 11	5 12	5 14	5 17	5 19	5 22	5 25	5 27	5 32	5 37	5 42

Applicable to Ahmednuggur, Berhampore, Bombay, Ganjam, Itchapoor, Jeypoor, Mominabad, &c. &c.

20° North Latitude. Page 1.

Length of the shadow f.	in.	Dec. 22 to Dec. 29	Dec. 30 to Jan. 4	Jan. 5 to Jan. 8	Jan. 9 to Jan. 11	Jan. 12 to Jan. 14	Jan. 15 to Jan. 17	Jan. 18 to Jan. 20	Jan. 21 to Jan. 23	Jan. 24 to Jan. 26	Jan. 27 to Jan. 29	Jan. 30 to Jan. 31	Feb. 1 to Feb. 3	Feb. 4 to Feb. 6	Feb. 7 to Feb. 9	Feb. 10 to Feb. 12	Feb. 13 to Feb. 15	Feb. 16 to Feb. 18	Feb. 19 to Feb. 21	Feb. 22 to Feb. 24
f.	in.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 16
	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 12	34
	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 6	33	45
	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	30	44	0 54
	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 28	43	0 54	1 2
	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0 24	41	0 53	1 2	9
	10	.	.	.	.	.	.	.	.	.	.	.	.	.	0 19	39	51	1 1	9	16
	11	.	.	.	.	.	.	.	.	.	.	.	.	0 11	36	49	0 59	8	15	22
3	0	.	.	.	.	.	.	.	.	.	.	.	.	33	0 47	0 58	1 7	15	21	27
	2	.	.	.	.	.	.	.	.	.	0 8	0 30	0 41	0 54	1 4	1 12	20	26	32	37
	4	.	.	.	.	.	.	.	0 14	0 33	0 44	0 53	1 0	1 9	17	24	31	36	42	46
	6	.	.	.	.	.	0 16	0 34	0 45	0 54	1 2	1 8	14	21	28	35	40	45	50	1 54
	8	.	.	0 6	0 27	0 38	0 44	0 55	1 2	1 9	15	20	25	32	38	44	49	1 54	1 58	2 2
	10	0 21	0 34	0 43	0 51	0 57	1 3	1 10	16	21	26	31	35	41	47	1 52	1 57	2 2	2 6	9
4	0	0 47	0 54	1 1	1 6	1 11	16	22	27	31	36	40	44	50	1 55	2 0	2 4	9	13	16
	2	1 4	1 9	14	19	23	27	32	36	40	45	49	1 52	1 58	2 2	7	11	15	19	23
	4	16	21	25	29	33	36	41	45	49	1 53	1 57	2 0	2 5	9	14	18	22	25	29
	6	27	31	34	38	42	45	49	1 53	1 57	2 0	2 4	7	12	16	20	24	28	31	35
	8	36	40	43	47	50	1 53	1 57	2 0	2 4	7	10	13	18	22	26	30	33	36	40
	10	45	48	51	1 54	1 57	2 0	2 4	7	10	13	16	19	24	28	32	35	38	41	45
5	0	1 52	1 55	1 58	2 1	2 4	2 6	2 10	2 13	2 16	2 19	2 22	2 25	2 29	2 33	2 37	2 40	2 43	2 46	2 49

Length of shadow		Dec 22 to Dec 15	Dec 14 to Dec. 9	Dec. 8 to Dec. 5	Dec. 4 to Dec. 1	Nov30 to Nov28	Nov27 to Nov25	Nov24 to Nov22	Nov21 to Nov19	Nov18 to Nov17	Nov16 to Nov 14	Nov13 to Nov11	Nov10 to Nov. 8	Nov. 7 to Nov. 5	Nov. 4 to Nov. 2	Nov. 1 to Oct.30	Oct.29 to Oct.27	Oct.26 to Oct.24	Oct.23 to Oct.21	Oct.20 to Oct.19
5	2	1 59	2 2	2 5	2 7	2 10	2 12	2 16	2 19	2 22	2 25	2 28	2 30	2 34	2 38	2 42	2 45	2 48	2 51	2 54
	4	2 5	8	11	13	16	18	21	24	27	30	33	35	39	43	46	49	53	2 56	2 58
	6	11	14	17	19	21	24	27	29	32	35	38	40	44	47	51	54	2 57	3 0	3 2
	8	17	19	22	24	26	29	32	34	37	40	42	45	48	52	55	2 58	3 1	4	6
	10	22	24	27	29	31	34	37	39	42	44	47	49	52	2 56	2 59	3 2	5	8	10
6	0	27	29	32	34	36	38	41	43	46	48	51	2 53	2 56	3 0	3 3	6	8	11	14
	4	36	38	40	42	44	46	49	51	2 54	2 56	2 59	3 1	3 4	7	10	13	15	18	21
	8	44	46	48	50	52	2 54	2 56	2 59	3 1	3 3	3 6	8	11	14	17	19	22	24	27
7	0	51	2 53	2 55	2 57	2 59	3 1	3 3	3 6	8	10	12	14	17	20	23	25	28	30	33
	4	2 58	3 0	3 2	3 4	3 5	7	9	12	14	16	18	20	23	25	28	31	33	36	38
	8	3 4	6	8	10	11	13	15	17	19	21	23	25	28	30	33	36	38	41	43
8	0	10	12	13	15	17	18	20	22	24	26	28	30	33	35	38	40	43	45	47
	4	15	17	18	20	22	23	25	27	29	31	33	35	38	40	43	45	47	49	52
	8	20	21	23	25	26	28	30	32	34	35	37	39	42	44	47	49	51	53	3 56
9	0	24	26	27	29	30	32	34	36	38	39	41	43	46	48	51	53	55	3 57	4 0
	4	28	30	31	33	34	36	38	40	42	43	45	47	49	52	54	3 56	3 59	4 1	3
	8	32	34	35	37	38	40	41	43	45	47	49	50	53	55	3 58	4 0	4 2	4	6
10	0	36	37	39	40	42	43	45	47	49	50	52	54	3 56	3 58	4 1	3	5	7	9
	6	41	42	44	45	47	48	50	51	53	55	3 57	3 58	4 1	4 3	5	7	9	11	13
11	0	45	47	48	50	51	52	54	3 56	3 58	3 59	4 1	4 2	5	7	9	11	13	15	17
	6	50	51	52	54	55	3 56	3 58	4 0	4 2	4 3	5	6	9	11	13	15	17	19	21
12	0	3 54	3 55	3 56	3 58	3 59	4 0	4 2	4	5	7	8	10	12	14	16	18	20	22	24
13	0	4 0	4 2	4 3	4 4	4 5	7	8	10	11	13	14	16	18	20	22	24	26	28	30
14	0	6	8	9	10	11	13	14	16	17	19	20	22	24	26	28	30	32	34	36
15	0	11	13	14	15	16	18	19	21	22	24	25	27	29	31	33	35	37	38	40
16	0	16	17	18	20	21	22	23	25	26	28	29	31	33	35	37	39	41	42	44
17	0	20	21	22	24	25	26	27	29	30	32	33	35	37	39	41	42	44	46	48
18	0	24	25	26	27	28	29	31	32	34	35	36	38	40	42	44	45	47	49	51
19	0	27	28	29	30	31	32	34	35	37	38	39	41	43	44	46	48	50	52	54
20	0	4 30	4 31	4 32	4 33	4 34	4 35	4 37	4 38	4 39	4 41	4 42	4 43	4 45	4 47	4 49	4 51	4 53	4 55	4 56
Declination		$23\frac{1}{2}$ —	23° —	$22\frac{1}{2}$ —	22° —	$21\frac{1}{2}$ —	21° —	$20\frac{1}{3}$ —	$19\frac{2}{3}$ —	19° —	$18\frac{1}{3}$ —	$17\frac{2}{3}$ —	17° —	16° —	15° —	14° —	13° —	12° —	11° —	10° —

Applicable to Aurungabad, Cuttack, Goomsoor, Hingolee, Jaulnah, Malligaum, Russelcondah, &c. &c.

20° North Latitude. Page II.

Length of the shadow f. in.	Feb.25 to Feb.26 h. m.	Feb 27 to Mar. 1 h. m.	Mar. 2 to Mar. 4 h. m.	Mar. 5 to Mar. 6 h. m.	Mar. 7 to Mar. 9 h. m.	Mar10 to Mar11 h. m.	Mar12 to Mar14 h. m.	Mar15 to Mar16 h. m.	Mar17 to Mar19 h. m.	Mar20 to Mar22 h. m.	Mar23 to Mar25 h. m.	Mar26 to Mar30 h. m.	Mar31 to Apr. 5 h. m.	Apr 6 to Apr 10 h. m.	Apr 11 to Apr 17 h. m.	Apr 18 to Apr 28 h. m.	Apr 28 to May12 h. m.	May12 to May30 h. m.	May31 to Jun.22 h. m.
1 6	.	.	.	.	.	.	.	.	.	0 20	0 32	0 47	0 58	1 6	1 12	1 19	1 25	1 28	1 27
7	.	.	.	.	.	.	.	.	0 21	33	42	0 54	1 4	11	17	24	29	32	32
8	.	.	.	.	.	.	.	0 22	35	43	50	1 1	10	16	22	28	34	37	36
9	.	.	.	.	.	.	0 22	35	44	51	0 57	7	15	21	27	33	38	41	41
10	.	.	.	.	.	0 22	36	45	0 52	0 59	1 4	13	20	26	31	37	42	45	45
11	.	.	.	.	0 22	36	46	0 53	1 0	1 5	10	19	25	31	36	42	46	49	49
2 0	.	.	.	0 23	37	46	0 54	1 1	7	12	16	24	30	36	40	46	51	53	54
1	.	.	0 21	37	47	0 54	1 1	7	13	17	21	29	35	40	44	50	55	1 57	1 58
2	.	0 20	36	47	0 55	1 2	8	13	18	23	27	34	39	44	49	54	1 59	2 1	2 2
3	0 19	36	47	0 55	1 2	9	14	19	24	28	32	38	44	49	53	1 58	2 2	5	6
4	35	47	0 55	1 3	9	15	20	25	29	33	36	43	48	53	1 57	2 2	6	9	10
5	46	0 55	1 3	9	15	21	26	30	34	38	41	47	52	1 57	2 1	6	10	13	14
6	0 55	1 3	10	16	21	26	31	35	39	42	45	51	1 56	2 1	5	9	14	17	17
7	1 3	10	16	22	27	31	36	40	43	47	50	55	2 0	4	8	13	17	20	21
8	10	16	22	27	32	36	40	44	48	51	54	1 59	4	8	12	17	21	24	25
9	16	22	27	32	37	41	45	49	52	55	1 58	2 3	8	12	16	20	24	27	28
10	22	28	33	37	42	46	49	53	1 56	1 59	2 2	7	12	16	19	24	28	31	32
11	28	33	38	42	46	50	53	1 57	2 0	2 3	6	11	15	19	23	27	31	34	35
3 0	33	38	42	46	50	1 54	1 58	2 1	4	7	9	14	19	23	26	30	35	37	39
2	42	47	51	1 55	1 58	2 2	2 5	8	11	14	16	21	35	29	32	37	41	44	45
4	51	1 55	1 59	2 3	2 6	9	12	15	18	21	23	28	32	35	39	43	47	50	51
6	1 59	2 3	2 7	10	13	16	19	22	25	27	30	34	38	41	45	49	53	2 56	2 57
8	2 6	10	14	17	20	23	26	28	31	33	36	40	44	47	50	2 54	2 59	3 2	3 3
10	13	17	20	23	26	29	32	34	37	39	42	46	49	53	2 56	3 0	3 4	7	9
4 0	20	23	26	29	32	35	38	40	43	45	47	51	2 55	2 58	3 1	5	9	12	14
2	26	29	32	35	38	41	43	46	48	50	52	2 56	3 0	3 3	6	10	14	17	19
4	32	35	38	41	43	46	48	51	53	2 55	2 57	3 1	5	8	11	15	19	22	24
6	38	41	43	46	49	51	53	2 56	2 58	3 0	3 2	6	10	13	16	20	24	27	29
8	43	46	48	51	54	2 56	2 58	3 1	3 3	5	7	10	14	17	20	24	28	31	33
10	48	51	53	2 56	2 58	3 1	3 3	5	7	9	11	15	18	21	24	28	32	36	38
5 0	2 52	2 55	2 58	3 0	3 3	3 5	3 7	3 9	3 11	3 1[illegible]	3 15	3 19	3 22	3 25	3 28	3 32	3 36	3 40	3 42

Length of the shadow	Oct.18 to Oct.16	Oct.15 to Oct.13	Oct.12 to Oct.11	Oct.10 to Oct. 8	Oct. 7 to Oct. 5	Oct. 4 to Oct. 3	Oct. 2 to Sep.30	Sep.29 to Sep.28	Sep.27 to Sep.25	Sep.24 to Sep.22	Sep 21 to Sep.19	Sep.18 to Sep.13	Sep.12 to Sep. 8	Sep. 7 to Sep. 3	Sep. 2 to Aug27	Aug26 to Aug16	Aug15 to Aug 2	Aug 1 to Jul. 1[illegible]	Jul.14 to [illegible]un 22
5 2	2 57	3 0	3 2	3 5	3 7	3 9	3 11	3 13	3 15	3 1[illegible]	3 19	3 23	3 26	3 29	3 32	3 36	3 40	3 44	3 46
4	3 1	4	6	9	11	13	15	17	19	21	23	27	30	33	36	40	44	47	50
6	5	8	10	13	15	17	19	21	23	25	27	31	34	37	39	43	48	51	54
8	9	12	14	16	19	21	23	25	27	29	30	34	37	40	43	47	51	55	3 57
10	13	15	18	20	22	24	26	28	30	32	34	37	40	43	46	50	54	3 58	4 1
6 0	16	19	21	23	26	28	30	32	34	35	37	41	44	47	49	53	3 57	4 1	4
4	23	25	28	30	32	34	36	38	40	41	43	47	50	53	3 55	3 59	4 3	7	10
8	29	31	34	36	38	40	42	44	46	47	49	52	3 55	3 58	4 1	4 5	9	13	16
7 0	35	37	39	41	43	45	47	49	51	52	54	3 57	4 0	4 3	6	10	14	18	21
4	40	42	44	46	48	50	52	54	3 56	3 57	3 59	4 2	5	8	11	15	19	23	26
8	45	47	49	51	53	3 55	3 57	3 59	4 1	4 2	4 4	7	10	13	16	19	24	28	31
8 0	50	52	54	3 56	3 58	4 0	4 1	4 3	5	6	8	11	14	17	20	24	28	32	36
4	54	3 56	3 58	4 0	4 2	4	5	7	9	10	12	15	18	21	24	27	32	36	40
8	3 58	4 0	4 2	4	6	7	9	11	13	14	16	19	22	25	27	31	36	40	44
9 0	4 2	4	6	7	9	11	13	15	16	18	19	22	25	28	31	35	40	44	47
4	5	7	10	11	12	14	16	18	19	21	23	26	29	31	34	38	43	47	51
8	8	10	13	14	16	17	19	21	22	24	26	29	32	34	37	41	46	50	54
10 0	11	13	15	17	19	20	22	24	25	27	29	32	35	37	40	44	49	53	4 57
6	15	17	19	21	23	24	26	28	29	31	33	36	39	41	44	48	53	4 57	5 1
11 0	19	21	23	25	27	28	30	32	33	35	36	39	42	45	48	52	4 57	5 1	5
6	23	25	27	29	30	32	34	35	36	38	40	43	46	48	51	55	5 0	5	9
12 0	26	28	30	32	33	35	37	38	40	42	43	46	49	52	4 54	4 58	3	8	12
13 0	32	34	36	38	39	41	43	44	46	47	49	52	4 55	4 57	5 0	5 4	9	14	18
14 0	37	39	41	43	44	46	48	49	51	52	54	4 57	5 0	5 2	5	9	14	19	23
15 0	42	44	45	47	49	50	52	53	55	4 56	4 58	5 1	4	7	9	13	18	23	28
16 0	46	48	49	51	53	54	56	4 57	4 59	5 0	5 2	5	8	11	13	17	22	28	32
17 0	50	51	53	55	56	4 58	4 59	5 1	5 2	4	5	8	11	14	17	21	26	31	36
18 0	53	54	56	4 58	4 59	5 1	5 2	4	5	7	8	11	14	17	20	24	29	34	39
19 0	55	4 57	4 59	5 0	5 2	4	5	7	8	10	11	14	17	20	22	27	32	37	42
20 0	4 58	5 0	5 1	5 3	5 4	5 6	5 8	5 9	5 11	5 12	5 14	5 17	5 19	5 22	5 25	5 29	5 34	5 40	5 44
Declination.	9° —	8° —	7° —	6° —	5° —	4° —	3° —	2° —	1° —	0	1° +	3° +	5° +	7° +	9° +	12° +	16° +	20° +	23½ +

Applicable to Aurungabad, Cuttack, Goomsoor, Hingolee, Jaulnah, Malligaum, Russelcondah, &c. &c.

GENERAL TABLES,

FOR THE DETERMINATION OF TIME, APPLICABLE TO ANY PART OF BRITISH INDIA.

RULE.

Having measured the shadow of a rod of four feet held perpendicularly on the ground, take out the following numbers from Tables I, II, and IV. viz:

From Table I, the number answering to the length of the measured shadow.

From Table II, that answering to the given day and latitude in the case of the Sun, but given declination and latitude in the case of the Moon and Stars.

From Table IV. the same as from Table II.

Then, to the quantity from Table I, add that from Table II, and find the natural number answering to the sum from Table III. Add to, or subtract from it, the number from Table IV, according as the declination is South or North. Finally, look for this sum or difference in Table V, when the corresponding time will be supplied by the upper and left hand columns if the observation be made in the forenoon; and by the lower and left hand columns, if in the afternoon.

The following examples are subjoined as exercises additional to those in article (38).

EXERCISES.

1. At Candy in lat. 7° 23′ N. given the shadow $12^{f.}$ 10^{in}, on the 16th of April; required the time.

   Ans. $7^{h.}$ $5^{m.}$ A.M. or $4^{h.}$ $55^{m.}$ P.M.

2. At Moulmein in lat. 11° 45′ N. given the shadow $7^{f.}$ 8^{in}, on the 21st of May; required the time.

   Ans. $7^{h.}$ $37^{m.}$ A.M. or $4^{h.}$ $15^{m.}$ P.M.

3. At Colombo in lat. 7° 2′ N. given the dark shadow $12^{f.}$ 7^{in}, on the 10th of October; required the time.

   Ans. $7^{h.}$ $1^{m.}$ A.M. or $4^{h.}$ $33^{m.}$ P.M.

4. At Trincomalee in lat. 8° 31′ N. given the dark shadow $4^{f.}$ $3\frac{1}{2}^{in}$, on the 5th of December; required the time.

   Ans. $9^{h.}$ $25^{m.}$ A.M. or $2^{h.}$ $17^{m.}$ P.M.

TABLE I. *Shewing the values of log. sin. A. for every inch of Shadow from 0 to 20 feet.*

Feet.	0 in.	1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.
0	10·0000	9·9999	9·9996	9·9991	9·9985	9·9977	9·9966	9·9954	9·9940	9·9925	9·9908	9·9889
1	9·9868	·9846	·9823	·9798	·9771	·9743	·9714	·9684	·9652	·9619	·9586	·9551
2	·9515	·9479	·9441	·9403	·9364	·9324	·9283	·9243	·9201	·9159	·9116	·9074
3	·9030	·8987	·8943	·8899	·8854	·8809	·8765	·8720	·8675	·8630	·8584	·8539
4	·8494	·8448	·8403	·8358	·8313	·8268	·8223	·8178	·8133	·8088	·8043	·7999
5	·7955	·7911	·7867	·7823	·7779	·7736	·7693	·7650	·7607	·7564	·7522	·7480
6	·7438	·7396	·7355	·7313	·7272	·7232	·7191	·7151	·7110	·7071	·7031	·6992
7	·6952	·6913	·6875	·6836	·6798	·6760	·6722	·6685	·6647	·6610	·6573	·6537
8	·6500	·6464	·6428	·6392	·6357	·6322	·6287	·6252	·6217	·6183	·6149	·6115
9	·6081	·6047	·6014	·5981	·5948	·5915	·5883	·5850	·5818	·5786	·5754	·5722
10	·5691	·5660	·5629	·5598	·5567	·5536	·5506	·5476	·5446	·5416	·5386	·5357
11	·5328	·5299	·5270	·5241	·5212	·5184	·5156	·5128	·5100	·5072	·5044	·5016
12	·4989	·4962	·4935	·4908	·4881	·4854	·4828	·4802	·4776	·4750	·4724	·4698
13	·4672	·4646	·4621	·4596	·4571	·4546	·4521	·4496	·4471	·4447	·4422	·4398
14	·4374	·4350	·4326	·4302	·4278	·4255	·4232	·4209	·4186	·4163	·4140	·4117
15	·4091	·4071	·4049	·4026	·4003	·3981	·3959	·3937	·3915	·3894	·3872	·3850
16	·3828	·3807	·3786	·3765	·3744	·3723	·3702	·3681	·3660	·3639	·3618	·3598
17	·3578	·3558	·3537	·3517	·3497	·3477	·3457	·3437	·3417	·3398	·3378	3358
18	·3339	·3320	·3300	·3281	·3262	·3243	·3225	·3206	·3187	·3168	·3149	3130
19	·3112	·3094	·3075	·3057	·3039	·3021	·3003	·2985	·2967	·2949	·2931	2913

TABLE II. *Giving the significant parts*

Days of the year answering to the Sun's declination.	March 21	March 23	March 26	March 28	March 31	April 3	April 5	April 8	April 11	April 13	April 16	April 19	April 22
	Sept. 23	Sept. 21	Sept. 18	Sept. 16	Sept. 13	Sept. 10	Sept. 8	Sept. 5	Sept. 2	Aug. 30	Aug. 28	Aug. 25	Aug. 22
Lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
6	24	24	26	30	34	40	48	56	66	78	90	104	120
7	32	33	35	38	43	49	56	65	75	86	99	113	128
8	42	43	45	48	53	59	66	75	85	96	109	123	138
9	54	54	56	60	64	70	78	86	96	108	120	134	150
10	66	67	69	72	77	83	91	99	109	120	133	147	162
11	80	81	83	86	91	97	101	113	12[illegible]	134	147	161	176
12	96	97	99	103	106	112	120	128	138	150	162	176	192
13	113	113	115	119	123	129	137	145	155	167	179	193	209
14	131	132	134	137	141	147	155	163	173	185	197	211	227
15	151	151	153	156	161	167	174	183	193	204	217	231	246
16	172	172	174	177	181	188	195	204	214	225	238	252	267
17	194	195	197	200	205	211	218	226	236	248	260	275	290
18	218	219	221	224	228	234	242	250	260	272	284	298	314
19	243	244	246	249	254	260	267	276	286	297	310	324	339
20	270	271	273	276	281	287	294	303	313	324	337	351	366
21	298	299	301	304	309	315	322	331	341	352	365	379	394
22	328	329	331	334	339	345	352	361	371	382	395	409	424
23	360	360	362	366	370	376	384	392	402	413	426	440	456
24	393	393	395	399	405	409	417	425	435	446	459	473	489
25	427	428	430	433	438	444	451	460	470	481	495	508	523
26	463	464	466	469	474	480	487	496	506	517	530	544	559
27	501	502	504	507	512	518	525	534	544	555	568	582	597
28	541	541	543	547	551	557	564	573	583	594	607	621	637
29	582	582	584	588	592	598	606	614	624	636	648	662	678
30	625	625	627	631	635	641	648	657	667	678	691	705	721
31	669	670	672	675	680	686	693	702	712	723	736	750	765
32	716	716	718	722	726	732	740	748	758	770	782	796	812
33	764	765	767	770	775	781	788	797	807	818	831	845	860
34	814	815	817	820	825	831	838	847	857	868	881	895	910
35	866	867	869	872	877	883	890	899	909	920	933	945	963
Days of the year answering to the Sun's declination.	Sept. 23	Sept. 26	Sept. 28	Oct. 1	Oct. 4	Oct. 6	Oct. 9	Oct. 11	Oct. 14	Oct. 17	Oct. 19	Oct. 22	Oct. 25
	March 21	March 18	March 16	March 13	March 11	March 8	March 5	March 3	Feb. 28	Feb. 26	Feb. 23	Feb. 20	Feb. 17

of the logarithmic values of sec. L. sec. D.

Days of the year answering to the Sun's declination.	April 25	April 28	May 1	May 5	May 8	May 12	May 16	May 21	May 26	June 1	June 10	The Sun attains 23° 28′ N. on June 22.
	Aug. 19	Aug. 16	Aug. 12	Aug. 9	Aug. 5	Aug. 2	July 28	July 24	July 19	July 12	July 3	
Lat.	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°
6	137	155	174	195	218	242	267	294	322	352	384	417
7	145	163	183	204	226	250	276	303	331	361	392	425
8	155	173	193	214	236	260	286	313	341	371	402	435
9	167	185	204	225	248	272	297	324	352	382	413	446
10	179	197	217	238	260	284	310	337	365	395	426	459
11	193	211	231	252	275	298	324	351	379	409	440	473
12	209	227	246	267	290	314	339	366	394	424	456	489
13	225	244	263	284	307	331	356	383	411	441	472	505
14	244	262	281	302	325	349	374	401	429	459	491	524
15	263	281	301	322	345	368	394	421	449	479	510	543
16	284	302	322	343	366	389	415	442	470	500	531	564
17	307	325	345	366	388	412	437	464	492	522	554	587
18	331	349	368	389	412	436	461	488	516	546	578	611
19	356	374	394	415	437	461	487	513	542	572	603	636
20	383	401	421	442	464	488	513	540	569	598	630	663
21	411	429	449	470	492	516	542	569	597	627	658	691
22	441	459	479	500	522	546	572	598	627	657	687	721
23	472	491	510	531	554	578	603	630	658	687	719	752
24	505	524	543	564	587	611	636	663	691	721	752	783
25	540	558	578	599	621	645	670	697	726	756	787	820
26	576	594	614	635	657	681	707	733	762	792	823	856
27	614	632	652	673	695	719	744	771	800	829	861	894
28	653	672	691	712	735	759	784	811	839	869	900	933
29	695	713	732	753	776	800	825	852	880	910	941	974
30	737	756	775	796	819	843	868	895	923	953	984	1017
31	782	800	820	841	863	887	913	939	967	998	1029	1062
32	829	847	866	887	910	934	959	986	1014	1044	1075	1108
33	877	895	915	936	958	982	1007	1034	1063	1092	1124	1157
34	927	945	965	986	1008	1032	1058	1084	1113	1143	1174	1207
35	979	997	1017	1038	1060	1084	1110	1136	1165	1195	1226	1259
Days of the year answering to the Sun's declination.	Oct. 28	Oct. 31	Nov. 3	Nov. 6	Nov. 10	Nov. 13	Nov. 17	Nov. 22	Nov. 27	Dec. 3	Dec. 11	The Sun attains 23° 28′ S. on December 22.
	Feb. 14	Feb. 11	Feb. 8	Feb. 5	Feb. 2	Jan. 29	Jan. 25	Jan. 21	Jan. 16	Jan. 10	Jan. 2	

TABLE III. TABLE OF ANTILOGARITHMS.

											Proportional parts.								
Log.	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
·00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
·01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
·02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
·03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
·04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
·05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
·06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
·07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
·08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
·09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
·10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
·11	1288	1292	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
·12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
·13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
·14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
·15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
·16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
·17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
·18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
·19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
·20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
·21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
·22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3

·23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
·24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
·25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
·26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
·27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
·28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
·29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
·30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
·31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
·32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
·33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
·34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
·35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
·36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
·37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
·38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
·39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
·40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
·41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
·42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
·43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
·44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
·45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
·46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
·47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
·48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
·49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6

Logarithms from ·0000 to ·4999 — *Proportional parts.*

TABLE III. TABLE OF ANTILOGARITHMS.

Proportional parts.

Log.	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
·50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
·51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	1	2	3	4	5	5	6	7
·52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
·53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
·54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
·55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
·56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
·57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
·58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
·59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
·60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
·61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
·62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
·63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
·64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
·65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
·66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
·67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
·68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
·69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
·70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
·71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
·72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11

·73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
·74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
·75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
·76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
·77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
·78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
·79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
·80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
·81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
·82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
·83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
·84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
·85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
·86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
·87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
·88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
·89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
·90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
·91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
·92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
·93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
·94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
·95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
·96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
·97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
·98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
·99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20

Logarithms from ·5000 to ·9999 — *Proportional parts.*

TABLE IV. *Giving the significant parts*

Days of the year answering to the Sun's declination.	March 21	March 23	March 26	March 28	March 31	April 3	April 5	April 8	April 11	April 13	April 16	April 19	April 22
	Sept. 23	Sept. 21	Sept. 18	Sept. 16	Sept. 13	Sept. 10	Sept. 8	Sept. 5	Sept. 2	Aug. 30	Aug. 28	Aug. 25	Aug. 22
Lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
6	0	18	37	55	73	92	110	129	148	166	185	204	223
7	0	21	43	64	86	107	129	151	173	194	216	239	261
8	0	24	49	74	98	123	148	173	197	223	248	273	299
9	0	28	55	83	111	139	165	194	223	251	279	308	337
10	0	31	62	92	123	154	185	216	248	279	311	343	375
11	0	34	68	102	136	170	204	239	273	308	343	378	413
12	0	37	74	111	149	186	223	261	299	337	375	413	452
13	0	40	81	121	161	202	243	283	324	366	407	449	491
14	0	43	87	131	174	218	262	306	350	395	440	485	530
15	0	47	94	140	187	234	282	329	377	424	473	521	569
16	0	50	100	150	200	251	301	353	403	454	506	557	609
17	0	53	107	160	214	267	321	375	430	484	539	594	650
18	0	57	113	170	227	284	341	399	457	516	573	632	691
19	0	60	120	180	241	301	362	423	484	545	607	669	732
20	0	63	127	191	254	318	382	447	511	576	642	707	774
21	0	67	124	201	268	336	403	471	539	608	677	746	816
22	0	70	141	212	282	353	425	496	568	640	712	785	859
23	0	74	148	222	297	371	446	521	597	672	748	825	902
24	0	78	155	233	311	389	468	547	626	705	785	865	946
25	0	81	163	244	326	408	490	573	655	739	822	906	991
26	0	85	170	256	341	427	513	599	685	772	860	948	1037
27	0	89	178	267	356	446	535	626	716	807	898	990	1083
28	0	93	186	279	372	465	559	653	747	842	937	1033	1130
29	0	97	194	290	388	485	583	681	779	878	977	1077	1178
30	0	101	202	303	404	505	607	709	811	914	1018	1122	1227
31	0	105	210	315	420	526	631	738	844	952	1059	1168	1277
32	0	109	218	327	437	547	657	767	878	990	1102	1215	1328
33	0	113	227	340	454	568	683	797	913	1029	1145	1262	1380
34	0	118	235	353	472	590	709	828	948	1068	1189	1311	1434
35	0	122	244	367	490	613	736	860	984	1109	1235	1361	1488
Days of the year answering to the Sun's declination.	Sept. 23	Sept. 26	Sept. 28	Oct. 1	Oct. 4	Oct. 6	Oct. 9	Oct. 11	Oct. 14	Oct. 17	Oct. 19	Oct. 22	Oct. 25
	March 21	March 18	March 16	March 13	March 11	March 8	March 5	March 3	Feb. 28	Feb. 26	Feb. 23	Feb. 20	Feb. 17

*of the natural values of tan. L. tan. D.**

Days of the year answering to the Sun's declination.	April 25	April 28	May 1	May 5	May 8	May 12	May 16	May 21	May 26	June 1	June 10	The Sun attains 23° 28′ N. on June 22.
	Aug. 19	Aug. 16	Aug. 12	Aug. 9	Aug. 5	Aug. 2	July 28	July 24	July 19	July 12	July 3	
Lat.	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°
6	243	262	282	301	321	341	362	382	403	425	446	468
7	283	306	329	352	375	399	423	447	471	496	521	547
8	324	350	377	403	430	457	484	511	539	568	597	626
9	366	395	424	454	484	515	545	576	608	640	672	705
10	407	440	473	506	539	573	607	642	677	712	748	785
11	449	485	521	557	594	632	669	707	746	785	825	865
12	491	530	569	609	650	691	732	774	816	859	902	946
13	533	576	619	662	706	750	795	840	886	933	980	1028
14	576	622	668	715	762	810	858	907	957	1007	1058	1110
15	619	668	718	768	819	871	923	975	1029	1083	1137	1193
16	662	715	768	822	877	932	987	1044	1101	1159	1217	1277
17	706	762	819	877	935	993	1053	1113	1174	1235	1298	1361
18	750	810	871	932	993	1056	1119	1183	1247	1813	1379	1447
19	795	858	923	987	1053	1119	1186	1253	1322	1391	1462	1533
20	840	907	975	1044	1113	1183	1253	1325	1397	1470	1545	1620
21	886	957	1029	1101	1174	1247	1322	1397	1473	1551	1629	1709
22	933	1007	1083	1159	1235	1313	1391	1470	1551	1632	1715	1799
23	980	1058	1137	1217	1298	1379	1462	1545	1629	1715	1802	1890
24	1028	1110	1193	1277	1361	1447	1533	1602	1709	1799	1890	1982
25	1077	1163	1249	1337	1426	1515	1606	1697	1790	1884	1979	2076
26	1126	1216	1307	1399	1491	1585	1679	1775	1872	1971	2070	2171
27	1176	1270	1365	1461	1558	1656	1754	1854	1956	2059	2163	2279
28	1227	1326	1425	1525	1626	1728	1831	1935	2041	2148	2257	2367
29	1280	1382	1485	1589	1695	1801	1909	2017	2128	2240	2358	2468
30	1333	1439	1547	1656	1765	1876	1988	2101	2216	2333	2451	2570
31	1387	1498	1610	1723	1837	1952	2069	2187	2306	2428	2550	2675
32	1443	1558	1674	1792	1911	2030	2152	2274	2399	2525	2652	2782
33	1499	1619	1740	1862	1985	2110	2236	2364	2493	2624	2757	2891
34	1557	1682	1807	1934	2062	2192	2322	2455	2589	2725	2863	3003
35	1617	1746	1876	2008	2141	2275	2411	2549	2688	2829	2972	3117
Days of the year answering to the Sun's declination.	Oct. 28	Oct. 31	Nov. 3	Nov. 6	Nov. 10	Nov. 13	Nov. 17	Nov. 22	Nov. 27	Dec. 3	Dec. 11	The Sun attains 23° 28′ S. on December 22.
	Feb. 14	Feb. 11	Feb. 8	Feb. 5	Feb. 2	Jan. 29	Jan. 25	Jan. 21	Jan. 16	Jan. 10	Jan. 2	

TABLE V. *Showing the natural values*

Min.	6^h	7^h	8^h	9^h	10^h	11^h	*Min.*
0	0	2588	5000	7071	8660	9659	60
1	44	2630	5038	7102	8682	9670	59
2	87	2672	5075	7132	8704	9681	58
3	131	2714	5113	7163	8725	9692	57
4	174	2756	5150	7193	8746	9703	56
5	218	2798	5188	7224	8767	9713	55
6	262	2840	5225	7254	8788	9724	54
7	305	2882	5262	7284	8809	9734	53
8	349	2924	5299	7313	8829	9744	52
9	393	2965	5336	7343	8850	9753	51
10	436	3007	5373	7373	8870	9763	50
11	480	3049	5410	7402	8890	9772	49
12	523	3090	5446	7431	8910	9781	48
13	567	3132	5483	7461	8930	9790	47
14	610	3173	5519	7490	8949	9799	46
15	654	3214	5556	7518	8969	9808	45
16	698	3256	5592	7547	8988	9816	44
17	741	3297	5628	7576	9007	9824	43
18	785	3338	5664	7604	9026	9832	42
19	828	3379	5700	7632	9044	9840	41
20	872	3420	5736	7660	9063	9848	40
21	915	3461	5771	7688	9081	9856	39
22	958	3502	5807	7716	9100	9863	38
23	1002	3543	5842	7744	9118	9870	37
24	1045	3584	5878	7771	9135	9877	36
25	1089	3624	5913	7799	9153	9884	35
26	1132	3665	5948	7826	9171	9890	34
27	1175	3706	5983	7853	9188	9896	33
28	1219	3746	6018	7880	9205	9903	32
29	1262	3786	6053	7907	9222	9909	31
Min.	5^h	4^h	3^h	2^h	1^h	0^h	*Min.*

for cos. h. for every minute of time.

Min.	6^h	7^h	8^h	9^h	10^h	11^h	*Min.*
30	1305	3827	6088	7933	9239	9914	30
31	1348	3867	6122	7960	9255	9920	29
32	1392	3907	6157	7986	9272	9925	28
33	1435	3947	6191	8013	9288	9931	27
34	1478	3987	6225	8039	9304	9936	26
35	1521	4027	6259	8064	9320	9941	25
36	1564	4067	6293	8090	9336	9945	24
37	1607	4107	6327	8116	9351	9950	23
38	1650	4147	6361	8141	9367	9954	22
39	1693	4187	6394	8166	9382	9958	21
40	1736	4226	6428	8191	9397	9962	20
41	1779	4266	6461	8216	9412	9966	19
42	1822	4305	6494	8241	9426	9969	18
43	1865	4344	6528	8266	9441	9972	17
44	1908	4384	6561	8290	9455	9976	16
45	1951	4423	6593	8315	9469	9979	15
46	1994	4462	6626	8339	9483	9981	14
47	2036	4501	6659	8363	9497	9984	13
48	2079	4540	6691	8387	9511	9986	12
49	2122	4579	6724	8410	9524	9988	11
50	2164	4617	6756	8434	9537	9990	10
51	2207	4656	6788	8457	9550	9992	9
52	2249	4695	6820	8480	9563	9994	8
53	2292	4733	6852	8503	9576	9995	7
54	2334	4772	6883	8526	9588	9997	6
55	2377	4810	6915	8549	9600	9998	5
56	2419	4848	6947	8572	9613	9998	4
57	2462	4886	6978	8594	9625	9999	3
58	2504	4924	7009	8616	9636	10000	2
59	2546	4962	7040	8638	9648	10000	1
Min.	5^h	4^h	3^h	2^h	1^h	0^h	*Min.*

APPENDIX.

Containing some useful particulars.

No. 1.

TABLE. *Showing the altitudes corresponding to the length of the shadow of a rod of four feet, corrected for atmospheric refraction.*

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

N. B. The atmospheric refractions inserted in the first column, correspond to the shadow inserted in the *second*, or the altitudes in the *third* column.

No. 2.

To draw a Meridian line.

The tracing of the meridian line, or the determination of the North point is an important problem, useful for many purposes. The common method of effecting it, is as follows.

Drive a thin staff or picket vertically in a level piece of ground, and describe three or four concentric circles about it with different radii. Observe the points of each circle which the shadow thrown by the picket touches both in the fore-noon and afternoon. Bisect the arcs contained between these points, and draw a line from the picket through the mean of the several bisections, and it will trace the meridian nearly.

Another method more commonly used is by means of a compass needle, but the magnetic North differs so considerably from the true point, and the amount of variation is so uncertain, that this method cannot be depended on to any degree of accuracy.

At night, the North point may be determined very nearly by observing the Pole star* at the instant of its upper or lower culmination which may be easily computed by the rules given in this work; or, by the upper culmination of a southern star which may not be far from the horizon at the time.

It will be observed, however, that these methods while giving the meridian line with sufficient accuracy for common purposes, do not enable us to find that line at any particular moment it may be required. The method we now propose to explain obviates this difficulty.

Place a table on a level piece of ground in sun-light and suspend a plummet over it attached to a fine string. When the lead has become steady, note two points of the shadow projected by the string on the table, and at the same instant find the shadow of a rod of four feet as directed in article (14). Then, the sun's azimuth (Z) or the angle which the meridian makes with the line drawn through these points may be computed by the formula

$$\text{Cos. } Z. = \pm \sin D. \sec. L. \sec. A. - \tan. L. \tan A.$$

where the upper or lower sign is to be used according as the declination is North or South.

The above formula, it will be perceived, is symmetrical with that at page 23, and if we substitute A for D, and D for

* The Mean right ascension of the Pole Star (α Ursæ Minoris) for Jan. 1 1848 is 1h. 4m·4 the annual variation being + 0m·29.

A in the former, and find log. sin. D from any Trigonometrical tables, the rest of the computations might be performed by means of the general Tables given in this work, when the Sun's altitude does not exceed 35°, or the measured shadow is not *less* than 5f. 9in. For instance,

Let it be required to find the Sun's azimuth, when the shadow measured on the 4th March 1848, at Madras, is 10f. 5in.

Here $A = 20° 58'$ (From No. 1 of the Appendix.)
$L = 13° 5$ (from page 22.)
$D = 6° 21'$ S. (from the Madras Almanac.)

Considering A as D, and D as A, we have the folllowing computation.

Log. sin 6° 21′ (from Trig. Tables)........................	9·0438
Number from Table II answering to 13° 5′ and 20° 58′	411
Sum................	9·0849
Natural number answering to it from Table III (being negative because the declination is South).....	—1216
Number from Table IV, answering to 13° 5′ and 20° 58′ (to be always subtracted).........................	— 891
Result............	—2107

The quantity answering to 2107 from Table V is either $6^h\ 48^m.7$ or $5^h\ 11^m.3$, but as the sign of 2107 is negative we must take the former quantity. Reducing $48^m.7$ to degrees and minutes, and adding 90° thereto on account of the 6^h, we get 102° 10′ for the Sun's azimuth at the time of observation.

Hence, by drawing a line making this angle with that indicating the position of the shadow of the string on the Table, we shall obtain the direction of the meridian required.

In applying the formula to particular cases, due regard must be paid to the signs of the terms of the second member. When the declination is North, the first term is positive, and may be numerically greater or less than the second term. In the former case, cos. Z is *positive*, and therefore Z is *less* than 90°. In the latter case, it is *negative*, and therefore Z is *greater* than 90°. When the terms are equal cos. $Z = 0$, and $Z = 90°$ showing that the Sun is then in the prime vertical. Again, when the declination is South, cos. Z is always negative; therefore, the resulting value of Z is always greater than 90°.

The remarks made in art. (76) hold equally good with reference to cases arising from the practical applications of this problem.

No. 3.

On the Principles of Dialling.

A dial is a plane surface on which a system of lines is drawn in such a manner that the shadow of a wire, or of the upper edge of another plane erected perpendicularly on the former shows the true or apparent time of the day.

2. The edge of the plane by which the time of the day is found is called the *stile, gnomon,* or *axis* of the dial; the line on which the plane is erected, the *substile*; the angle included between these two, the *elevation* of the stile; and the system of lines, *hour-lines.*

3. Dials are distinguished from each other according to the position of their planes with reference to the horizon, or any other great circle of the celestial sphere. When the plane is parallel to the horizon, the dial is said to be *horizontal,* and when it is perpendicular, *vertical.* If the plane of the dial facing the north and south, is perpendicular to the Meridian and makes an oblique angle with the horizon, it is termed *inclining.*

4. When the dial is vertical, but inclined at an oblique angle to the plane of the Meridian, it is termed *declining.* In dials of this description, the substile always makes an angle with the 12 o'clock hour line, or *meridian of the dial.*

5. A dial whose plane is neither parallel nor vertical to the horizon, nor perpendicular to the Meridian, is called an *oblique* dial.

6. When the plane coincides with the Meridian, it is called an *east* or *west dial,* and sometimes a *Meridian dial.* The hour lines on such a dial should be described on both faces; because both sides are illuminated by the Sun daily.

7. When the plane is perpendicular to the Meridian, and parallel to the Earth's axis, the dial is termed *polar,* because if produced, it would pass through the celestial poles. This dial does not differ from that adverted to in the preceding article except in its position, as will be shown hereafter.

8. The nature of all dials whatever may be their form or figure, may be easily explained by supposing the earth to be transparent, the equator to be divided into 24 equal parts by meridian circles, and the axis of the earth to be opaque. It is obvious that when the sun is situated on any of these meridians, the shadow of the axis would fall on the opposite half of that circle, so that if we conceive a plane to pass through the centre of the earth parallel to the plane of the

dial which we wish to construct, and showing the intersections of the meridian planes with it, we shall have the representation of a true dial on which the shadow of the earth's axis would exhibit the correct time of the day. In reality, however, we have neither a transparent earth, nor is it possible to draw a plane through its centre. We can therefore only approximate to the position of such a natural dial, by making the plane and axis of the artificial one correspond in direction to those of the former; and although the situations of the two dials would differ by half the diameter of the earth, yet this difference is so minute compared with the distance of the Sun, that no perceptible variation would arise in the direction of the hour-lines on the latter.

9. Dials may be constructed by means of a terrestrial globe, by dialling scales, by stereographic projection, and by the rules of Geometry and Spherical Trigonometry. but we shall touch upon such methods only, as with reference to the accuracy and expeditiousness of construction may appear most suitable.

Problem 1.

10. To construct a horizontal dial.

If we elevate the pole of a terrestrial globe to the latitude of a place, and bring any meridian under the zenith, the points where the other meridians cut the artificial horizon will give the angles from the north point at which the hour lines on a horizontal dial ought to be inclined to its meridian. But the arc of the horizon contained between the North point and any meridian is obviously one side of a right-angled spherical triangle, the other side of which is the elevation of the pole or the latitude of the given place, and the hypothenuse, the arc of the meridian contained between the pole and the horizon. Hence, we have in such a triangle, one of the sides, and the angle included by it and the hypothenuse, given, viz. the hour distance of the Sun from noon. Consequently, the other side, or the angle which the corresponding hour-line would make with the meridian of a horizontal dial, may be computed by the formula,*

$$\text{Rad.} \times \sin. L = \text{cotan.} H \times \tan. h.$$

where L denotes the latitude of the place, H the horary distance of the Sun from Noon, and h the angle corresponding to that distance on the dial.

By transposition and reduction, the above formula becomes,

$$\text{Rad.} \times \tan. h = \sin. L \times \tan. H. \qquad (1)$$

* Deduced immediately from Napier's Rule.

Or, in logarithms,

$$\text{Log. tan. } h = \text{log. sin. } L + \text{log. tan. } H - \text{log. rad.}$$

EXAMPLE.

Let it be required to construct a horizontal dial for the latitude of Madras.

The latitude of Madras being 13° 5′, the computation for the hour line of XI in the forenoon, or I in the afternoon would be as follows.

Log. tan. horary angle 15°	9·42805
Log. sin. lat. 13° 5′	9·35481
Log. tan. 3° 28′	8·78286

Hence the hour lines for XI in the forenoon, and I in the afternoon, must each make with the meridian of the dial, an angle of 3° 28′.

In the same manner, the angles which the remaining hour-lines make with the meridian of the dial may be computed, and will be as follows;

Hour lines of X and II	7°	27′
IX and III	12	45
VIII and IV	21	25
VII and V	40	12
VI and VI	90	0

11. As the sun rises between five and six in the morning and sets between six and seven in the evening, while he moves through the northern half of the ecliptic, it will be necessary to show the hour lines for V in the morning, and VII in the evening, or those half or quarter hour lines between them and the VI o'clock line, that may be considered sufficient. These lines may be drawn by simply producing the corresponding hour lines on the opposite side of the VI o'clock line, or drawing parallels thereto, as the circumstances of the case may require.

12. To construct a horizontal dial for Madras, therefore, assume any line *AB* for its meridian, and any point *B* for the centre of the dial; and by means of a scale of chords, or a common protractor lay off the angles *AB* I and *AB* XI *AB* II and *AB* X, *AB* III and *AB* IX, &c. respectively equal to 3° 28′, 7° 27′, 12° 45′ &c. which will give the hour-lines between VI in the morning, and VI in the evening. Then, produce the hour-lines for V and VII, and the corresponding lines for V in the morning and VII in the evening will be obtained. Describe any border round the lines; insert the characters for the hours; erect a stile at

Fig. 1. The dotted lines in the diagram refer to Art. 17.

an elevation of 13° 5′, and fix the dial on some horizontal surface with its meridian pointing due North, and South;—when it will be complete.

13. When the stile of a dial has any thickness, two meridian lines should be drawn, with a space between them equal to the thickness of the stile, and the angles laid off on both sides from the corresponding meridian. In this case it is to be observed that the hour lines below the VI o'clock line will not be continuations of the same lines above it, but parallel to them. (See Fig. 2).

14. From the analytical expression (1) in art. (10), we obtain the following proportion;

Radius.

: The sine of the latitude.

: : The tangent of the horary angle between noon and the Sun

: The tangent of the angle, which the hour line on the dial makes with its meridian;

which leads to the following neat Geometrical constructions.

Fig. 2. 15. Assume any double line AA' BB' for the meridian of the dial, BB' being its centre, or the point through which the VI o'clock hour line passes.

From B' draw the straight line $B'C$ making the angle $A'B'C$ equal to the latitude of the place; draw AD perpendicular to $B'C$, and make AE equal to $A'D$. From E as a centre with a radius equal to AE describe the quadrant AEF, and divide its arc into six equal parts in the points a, b, c, d, e. Join Ea, Eb, Ec, Ed, and Ee, and produce those lines till they cut Ae' (a perpendicular to AB at the point A) in the points a', b', c', d', e'. Finally, draw the lines Ba', Bb', Bc', Bd', and Be', and they will be the hour lines for one side of the dial.

16. To demonstrate the truth of the above construction, draw BG, parallel to any of the lines Ea', Eb', Ec', &c. say Eb'. Then the angle AEb' will be equal to the angle ABG. Also because the triangles AEb' and ABG, are similar, $AB : AG :: AE : Ab'$, or $AB : AE :: AG : Ab'$. But to radius AB, AE $(= A'D) =$ sin. L; also $AG =$ tan. H, and Ab' = tan. h. Consequently, rad : sin. L : : tan. H : tan. h, and therefore the construction is correct as regards the line Bb', or B II. In the same way it may be shown that all the other lines are rightly determined.

17. When the size of the surface, on which the dial is to be constructed is not large enough to admit of the intersection of the lines Ae' and Be' being shown thereon, the following method may be adopted. Having drawn the meridian line AB, and the stile line BC, describe a quadrant DE with any convenient radius cutting AB in D, and BE (a perpendicular to AB) in E. Draw DF perpendicular to BC, and from B as a centre with a radius equal to DF, describe a quadrant GH. Divide the arcs DE and GH each into 6 equal parts in the points a, b, c, d, e, and a', b', c', d', e', respectively. Then from the corresponding points aa', bb', cc', dd', ee', draw lines respectively parallel to AB and BE, and the intersections of every pair of these lines, will give the points a'', b'', c'', d'', e'', through which the hour lines must be drawn, for one side of the dial. Fig. 1.

18. By joining B to any of the points on the outer quadrant as d, and producing dd'' to cut BD in K, we shall have $Bd : Bd' :: Kd : Kd''$, i. e. rad : sin L :: tan. H : tan. h, and therefore the construction is correct.

19. If a horizontal dial constructed for any place be taken to another on the surface of the earth, and there set up with its plane parallel to the horizon of the former and its axis directed to the pole of the heavens, it would, at the second place, show the time of the first as truly as it did prior to its removal. This fact is easily accounted for by the circumstance that the whole earth is but a point compared with its distance from the Sun, and that therefore it is of no importance on what part of its surface a dial is placed, provided its parts are similar in position to the planes of the celestial sphere which they are intended to represent.

20. If the second place differ in longitude from the first, the time shown by the dial there would not be the local time, for the plane of the instrument would be inclined to its meridian; but the difference of time would be constant and equal to the difference of longitude, and if we suppose the dial to revolve on its axis, till it is perpendicular to that circle, it would then become a true inclining dial for that place. It is on this principle that horizontal dials constructed for the latitude of London, and exported to this country, serve as universal dials; for to adapt them to any particular place, it is only necessary to rectify the instrument, and fix the plane of the dial circle so that its axis may point to the pole.

Problem II.

21. To construct a prime vertical dial.

A prime vertical dial is that delineated on the plane of a great circle passing through the zenith and the east and west points of the horizon. The elevation of the stile therefore in such a dial is equal to the co-latitude of the place; but in northern latitudes when the dial faces the south, the direction of the stile would be *below* the VI o'clock hour line; and *above* it, when the plane faces the north.—(See Figs. 3 and 4.)

22. As a horizontal dial would be vertical at a place situated on the same meridian, but distant from it by 90°, and *vice versâ* (art. 19), the formula given in art (10) would apply to vertical dials by simply substituting the co-latitude for the latitude. We shall then have

$$\text{log. tan. } h = \text{log. cos. } L + \text{log. tan. } H - \text{log. rad.} \ldots (2)$$

Thus, the angles which the several hour-lines make with the meridian of a prime vertical dial for Madras, beginning with the nearest, would be 14° 37′, 29° 21′, 44° 15′, 59° 21′, 74° 37′, and 90° 0′ respectively.

23. The geometrical construction of prime vertical dials is precisely the same as that for horizontal dials, using only the co-latitude for the latitude of the place. The method of construction given in art. (17) is shown in Fig. 4 as applied to a vertical dial.

24. The remarks made in art. (19) hold equally good with reference to vertical dials, and in fact, to dials of every description. If therefore we construct a prime vertical dial for the Equator, and set it up at any given place, with its axis pointing to the pole (which would make its plane recline from the Zenith by an angle equal to the latitude of the place) we shall have a correct dial of the simplest and easiest description; for in such a dial, the stile may be only a pin driven perpendicularly through its centre, and the hour lines would make equal angles with each other, and may therefore be found by describing a semicircle round the centre of the dial, dividing it into 12 equal parts, and drawing lines through the several divisions to the border of the dial.

Problem III.

25. To construct a vertical declining dial.

The declination of a vertical dial is always reckoned from the east or west points of the horizon towards the pole opposite to that which the dial faces.

26. The nature of a vertical declining dial may be thus explained by the globe. Elevate the pole to the latitude of the given place, screw the quadrant of altitude to the zenith, and bring its edge to that part of the horizon which the plane of the dial would intersect were it produced to the heavens. This done, bring any one of the 24 meridians under the graduated edge of the brass circle, and count from the zenith the number of degrees on the quadrant at which the other meridians cut it. These arcs will give the measure of the angles for one side of the dial, which the corresponding hour lines ought to make with the 12 o'clock line. Set the quadrant to the opposite point of the horizon, and proceed as before, when the hour lines for the other side of the dial will be obtained. But, as in a declining dial, the substile makes an angle with the 12 o'clock line, it is necessary to ascertain the amount of that angle, as also the elevation of the stile. For this purpose, holding the quadrant in its first position, bring any of the meridians to that part of the horizon, which a perpendicular to the plane of the dial would cut, and which would therefore be 90° distant from the extremity of the quadrant. Then, this meridian and quadrant would cross each other at right angles at a point (A), the distance of which from the zenith (Z) would be the measure of the angle made by the substile and meridian of the dial, and its distance of the pole (P), the elevation of the stile, or latitude of the dial.

27. The great circles passing through the points A, Z, P, obviously form a right-angled spherical triangle; the hypothenuse ZP the colatitude of the place, and the angle AZP the complement of the given declination (D), being known. The remaining parts may, therefore, be thus found, considering the radius as unity.

$$\text{Sin. } AP \text{ (latitude of dial)} = \cos. L \times \cos. D.$$

$$\text{Tan. } AZ \left\{\begin{matrix}\text{angle made by the} \\ \text{substile and vertical}\end{matrix}\right\} = \cot. L \times \sin. D.$$

$$\text{Cot. } APZ \left\{\begin{matrix}\text{dif. of longitude} \\ \text{of dial..............}\end{matrix}\right\} = \sin. L \times \cot. D.$$

28. Hence, it appears that the dial would be horizontal at a place of which the sine of the latitude is cos. L. cos. D, and the cotangent of its difference of longitude equal to sin. L. cot. D; and therefore the dial may be easily constructed by the rules given for horizontal dials; but it is to be borne in mind that the horary angle H to be used in the calculations must not be taken as 15°, 30°, 45°, &c. but

what it would be if the hour-line were made that number of degrees distant from the XII o'clock line. Thus, if it is found that the difference of longitude of the dial in a S. W. decliner is 35°, the horary angles to be used for the I, II, III, &c. hour-lines would be 20°, 5°, 10°, &c. respectively, and those for the XI, X, IX, &c. hour-lines, 50°, 65°, 80°, &c.

29. In all vertical dials, whatever the declination be, the XII o'clock line is always perpendicular to the horizon.

30. When the dial faces the south, and declines towards the east, the substile would fall among the forenoon hours, but when it declines to the west, among the afternoon hours. In N. W. and N. E. decliners, the hour lines correspond with those on the opposite face of the dial exactly as if the dial were transparent and they were seen through, but the axis would be a continuation of that on the southern side.

EXAMPLE.

Let it be required to construct a vertical south dial for Madras, declining eastward 25° degrees.

Lat. of dial.		Dif. of long. of dial.	
cos. 13° 5′ ...	9·98858......	sin. 13° 5′ ...	9·35481
cos. 25° 0′ ...	9·95728......	cot. 25° 0 ..	10·33133
sin. 61° 59′ ..	9·94586	cot. 64° 6′ ...	9·68614

Angle between subs. and ver.

cot. 13° 5′	10·63376
sin. 25° 0	9·62595
tan. 61° 12′	10·25971

31. Thus, the problem is reduced to constructing a horizontal dial for a place of which the latitude is 61° 59′ S. and difference of longitude from Madras 64° 6′ eastward. The method of procedure would therefore be as follows. Fig. 5. Assume any line *AB* for the meridian of the dial, and as the dial is to be a S. E. decliner, make the angle *BAC* equal to 61° 12′, *to the left of AB*, then *AC* will be the substile of the dial. Draw *AD* perpendicular to *AC*, and it will be the VI o'clock hour-line for the place to which the dial would be horizontal. Now, deducting 15° from 64° 6′ continually, we get the remainders 49° 6′, 34° 6′, 19° 6′, 4° 6′, for the horary angles of the Sun from noon for the

XI, X, IX, and VIII o'clock hour-lines. Deduct 4° 6′ from 15°, the remainder 10° 54′ will be the horary angle for the VII o'clock hour-line, which will fall on the other side of the substile. Add 15° to 10° 54′; the sum 25° 54′ will be the horary angle for the VI o'clock hour-line. Again, add 15° to 64° 6′, and the sum 79° 6′ will be the horary angle for the I o'clock hour-line. With these angles, therefore, as the values of H, and 61° 59′ as that of L, compute, by the formula of art. (10), the corresponding values of h, which will be found to be those marked in the margin. Then draw the hour-lines, put any convenient border round the dial, erect the stile with an elevation equal to 61° 59′, and set up the dial with the 12 o'clock hour-line vertical to the horizon, and with its plane declining according to the hypothesis.

	°	′
VI.	23	12
VII.	9	39
VIII.	3	37
IX.	17	0
X.	30	52
XI.	45	33
I.	77	42
II.	94	38

32. In a dial of this description, the illumination of its surface by the Sun in the afternoon, will depend upon the position of that orb in the ecliptic. When he is in the northern tropic it will be the shortest day at the place to which the dial is horizontal; he will therefore, set there at 2^h 21^m P.M. apparent time, which will correspond to 10^h 5^m A.M. at Madras. Consequently, on the 22d of June, the Sun will not shine upon the dial after that hour. Again, when he is in the southern tropic, it will be the longest day at the place in question; he will therefore not set there till about 9^h 39^m P.M., which will correspond to 5^h 23^m P.M. at Madras. Consequently, on the 22d of December, the plane of the dial will be illuminated till that hour. These considerations must be duly attended to, in drawing the afternoon hour-lines of the dial.

33. If the dial declines towards the west instead of the east, the Sun will not begin to shine upon it till 1^h 55^m P.M. on the 22d of June; but on the 22d of December, it will be illuminated *very nearly* the whole day.

34. The geometrical construction of declining dials may be easily deduced from the formulæ in art. (27). We shall here give one method without any demonstration, which we shall leave to the ingenuity of our readers.

35. Assume any line AB for the meridian of the dial, and with any convenient radius describe the circle $CDLK$ intersecting AB in the point C. Make the angle CAD equal to the co-latitude of the given place, or to the supplement of the co-latitude, according as the dial faces the South, or North; and from the point D, draw DE perpendi- Fig. 6.

cular to AC. Make $DEF =$ the complement of the given declination, the line $EF = AD$, and from F drop the perpendicular FG. Through G draw the line AH, and it will be the substile of the dial; consequently, AK perpendicular to AH will be the VI o'clock hour-line at the place for which the dial is horizontal. Again, produce BA to the point L. Draw AN perpendicular to AD, NO to AL, and AM parallel to EF. Make also $AP = AO$, and draw PQ perpendicular to AL. Then from the centre A, with a radius $= AQ$, describe the quadrant RS. Draw NR perpendicular to NO, and OR parallel to AM intersecting NR in the point R, and in the line KB perpendicular to AK at the point K, take $KS = NR$. Join AS, cutting the two quadrants in the points a, a' respectively. Then the angle HAS will be equal to the difference of longitude of the dial. From the point a, lay off on both sides of it, the arcs, ab, bc, ah, hm, &c. each equal to the sixth part of the quadrant HK, and mark off in like manner on both sides of the point a', the arcs $a'b'$, $b'c'$, $a'h'$, &c. each equal to the sixth part of the quadrant RS. Also, from the points on the larger quadrant draw lines parallel to AK, and from those on the smaller, lines parallel to AH intersecting the former in the points b'', c'', h'', &c. Join Ab'', Ac'', Ah'', &c., and they will be the hour-lines of the dial. It is not necessary to draw the lines from the points aa', because they would meet on the line AC which is already determined.

36. To find the elevation of the stile, draw a line from the point S, parallel to AH cutting the circumference of the circle $KCDL$ in the point T. Then if AT be joined, the angle HAT will be equal to that elevation.

Problem IV.

37. To construct an oblique dial.

This problem, it is manifest, will be reduced to the preceding one, if we could find the latitude of the place at which the required dial would be vertical, and the amount of its declination (d) there. Now a great circle passing through the east point of the horizon perpendicular to the plane of the dial, would form with those two circles, a right angled spherical triangle, in which the hypotheruse would be equal to the given declination, and one of the adjacent angles to the given inclination.* The remaining angle would be the

* The inclination of a dial is the angle which its plane makes with the horizon. When that angle is greater than 90°, the dial is said to recline.

difference of latitude between the given place and that at which the dial would be vertical, and the side adjacent to that angle would be the declination of the dial at the latter place. These elements may, therefore, be calculated by the formulas,

$$\text{sin. } d = \text{sin. } I. \text{ sin. } D;$$
$$\text{and, cot. diff. of lat.} = \text{tan. } I. \text{ cos. } D.$$

whence, the latitude of the place where the dial would be vertical, as also its declination there being found, these quantities may be substituted for L and D in the formulas given under art (27) and the dial constructed as a vertical declining dial.

Example.

Let it be required to construct a North dial for Madras, that declines eastward 10°, and reclines 15° from the Zenith.

To find d.	To find the dif. of lat.
sin. (90°+15°=) 105°...9·98494	tan. 105°.......10·57195
sin. 10°......................9.23967	cos. 10°......... 9·99335
sin. 9° 39′=d.............9·22461	cot. 15° 13′....10·56530

Hence the latitude of the place where the dial would be vertical is (13° 5′ — 15° 13′ =) 2° 8′ S, and the declination of the plane there 9° 39′ E. Therefore, substituting 2° 8′ for L, and 9° 39′ for D in the formulæ of art (27) we get 80° 7′ N. for the latitude of the dial, 77° 28′ for the angle made by the substile and XII o'clock line, and 77° 39′ for the difference of longitude. Consequently, the dial may be constructed as a horizontal one. (See Fig. 7.)

Problem V.

38. To construct a vertical east or west dial.

In art. (24) we stated that if a prime vertical dial constructed for the equator were set up at any place with its axis pointing to the celestial pole, and therefore its plane coinciding with the equinoctial, it would become a true dial for the place. Now let us suppose another plane to intersect it at right angles in some line parallel to the meridian of the dial, then it is obvious that the shadow of the axis would be projected on this plane in straight lines parallel to each other, and that the distance of these lines from the VI o'clock line, would be the tangents of 15°, 30° 45°, &c. multiplied by the distance of the intersecting plane from the meridian of the dial. If the axis were now considered a tached to the perpendicular plane and the dial be remove we shall have a correct east or west dial according as its fac is turned towards the east or west.

Figs. 8 and 9 39. The construction of such a dial would therefore b as follows. On the east or west vertical plane, assume an line *AB* for the VI o'clock hour-line. Make *BE* equal to th breadth of the rectangular plane *ABCD*, whose edge *C* is to serve as the axis of the dial, and from the centre *B* wit a radius equal to *BE* describe a quadrant *EG*; divide into six equal parts in the points *a*, *b*, *c*, *d*, *e* and join *B* *Bb*, *Bc*, *Bd*, *Be*. Produce these lines to cut *EF* (a pe pendicular to *AB* at the point *E*) in the points *a′*, *b′*, *c* *d′*, *e′*, and through *a′*, *b′*, *c′*, *d′*, *e′*, draw lines parallel t *AB*, and they will be the hour-lines of the dial. Then erect the plane *ABCD* perpendicularly to the plane of th dial on the line *AB*, finish the dial as shown in the dia gram, and set it up with the axis pointing to the pole which will be the case when a line *EH* making an angl with *EF* equal to the latitude of the place, is vertical to th horizon.

Problem VI.

40. To construct a polar dial.

If in art. (38) we consider the position of the intersectin plane to be not *parallel* to the meridian of the dial but *perpendicular* to it, and the hour-lines to be produced till they cut its surface, we shall have the representation of a *polar* dial.

41. The construction of such a dial would therefore be as follows. Assume any line *AB* for the 12 o'clock hour

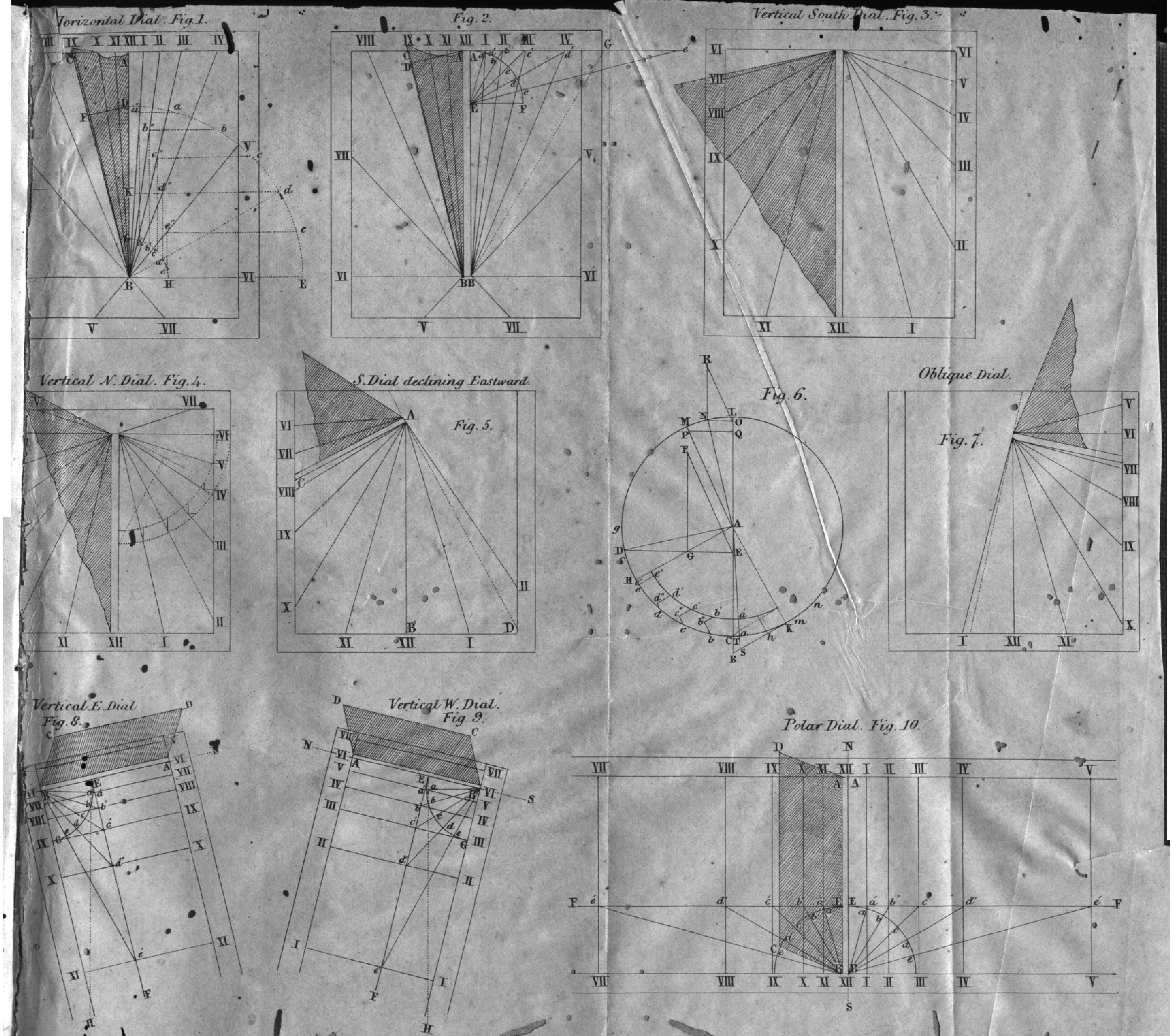
Fig. 10. line, or meridian of the dial. Make *BE* equal to the breadth of the plane *ABCD*, whose edge *CD* is to serve as the axis of the dial, and from the centre *B* with a radius equal to *BE* describe the quadrant *BG*. Divide it into six equal parts in the points *a*, *b*, *c*, *d*, *e*, and join *Ba*, *Bb*, *Bc*, *Bd*, *Be*. Produce these lines to cut *EF* (a perpendicular to *AB* at the point *E*) in the points *a′*, *b′*, *c′*, *d′*, *e′*, and through *a′*, *b′*, *c′*, *d′*, *e′*, draw lines parallel to *AB*, and they will be the hour-lines of the dial. Then erect the plane *ABCD* perpendicularly to the plane of the dial on the line *AB*, finish the dial as shown in the diagram, and set it up with the axis pointing to the pole, and therefore the plane of the dial inclined to the horizon at an angle equal to the latitude of the place.

42. It is obvious that this dial differs from an east or west dial only in its position, and that if the latter be supposed to revolve on its axis through an arc of 90°, it would become a *polar* dial.

43. The dials treated of in the 5th and 6th Problems will show time from a little after six in the morning to a little before six in the evening, provided they are of sufficient extent to admit of the shadow meeting their planes. At the hours of six in the morning or evening, their planes pass through the Sun, and will therefore not be illuminated.

44. There are dials of various other descriptions, which our limits do not permit us to enter upon, but the principles involved in their construction are the same as those already treated of, so that any one who fully understands the latter will not be at a loss to comprehend the former. See the articles on Dialling in the Encyclopædia Metropolitana, and in the Edinburgh Encyclopædia.

FINIS.



Asiatic Lith. Press Madras

Dumphy & Sinclair Lith.