SUPPLEMENT TO THE AMERICAN EPHEMERIS, 1918

TOTAL ECLIPSE OF THE SUN
JUNE 8, 1918

PUBLISHED BY THE NAUTICAL ALMANAC OFFICE, U. S. NAVAL OBSERVATORY, UNDER THE AUTHORITY OF THE SECRETARY OF THE NAVY,
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U. S. NAVAL OBSERVATORY.

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January, 1917.

PREFACE.

The present Supplement has been prepared partly from the tables and data given in the *American Ephemeris and Nautical Almanac* for 1918 and partly from data furnished through the courtesy of Professor C. F. Marvin, Chief of the U. S. Weather Bureau. The Supplement is designed especially for use along the path of totality in the United States, extending diagonally from the State of Washington to the State of Florida.

In preparing the large scale drawings, Charts III and IV, the data have been entered directly upon the map of the United States issued by the U. S. Geological Survey.

J. A. HOOGEWERFF,
Captain, U. S. N.,
Superintendent Naval Observatory.

Washington, *January, 1917.*

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PART I—METEOROLOGICAL DATA.

PART II—ASTRONOMICAL DATA AND CHARTS.

PART I.

METEOROLOGICAL DATA FURNISHED BY THE U. S. WEATHER BUREAU.

TABLE I.

AVERAGE WEATHER CONDITIONS IN JUNE.

Station.	Elevation.	Temperature.	Precipitation.	Percentage of Clear Days.	Percentage of Rainy Days.
Washington:	*Feet.*	°	*Inches.*		
Fort Simcoe	1427	64.5	0.45	63	7
Queets River	16	55.4	4.03	33	30
Seattle	248	60.1	1.72	27	33
Sixprong	1100	67.0	0.61	53	13
Tacoma	213	59.4	2.13	27	30
Oregon:					
Baker	3471	58.6	1.21	33	27
La Grande	2784	59.7	1.59	50	27
Pendleton	1070	64.3	1.01	47	20
Idaho:					
Boise City	2739	66.0	0.88	43	20
Cambridge	2739	63.6	1.09	53	23
Hailey	5347	58.9	1.00	33	23
Pierson	7000	50.9	1.19	50	17
Pocatello	4483	64.2	0.99	50	20
Wyoming:					
Afton	6200	55.0	1.51	27	27
Eden	6577	56.3	1.18	40	23
Encampment	7322	57.9	0.94	30	30
Colorado:					
Colorado Springs	6098	63.3	1.97	43	27
Denver	5272	66.4	1.47	40	27
Las Animas	3899	72.3	1.40	47	10
Pueblo	4734	69.0	1.47	43	23
Steamboat Springs	6701	55.8	1.62	70	27
Kansas:					
Ashland	1951	75.2	3.54	57	27
Coolidge	3348	72.1	2.21	50	20
Dodge City	2513	73.1	3.32	43	30
Oklahoma:					
Holdenville	900	75.5	4.36	80	20
Okeene	1194	76.9	3.79	73	30
Oklahoma City	1247	75.7	3.07	47	27

NOTE.—These averages are based upon observations for periods of 5 to 30 or more years.
Days on which the rainfall amounts to one hundredth of an inch or more are regarded as rainy days.

TABLE II.

PERCENTAGE OF SUNSHINE DURING THE FIRST 15 DAYS OF JUNE.

Station.	Time.	Local Standard Time. A. M. 9h–10h	10h–11h	11h–12h	P. M. 12h–1h	1h–2h	2h–3h	3h–4h	4h–5h	5h–6h
Seattle, Wash.	Pacific	54	64	69	79	77	75	70	66	58
Baker, Oreg.	Pacific	81	84	86	84	80	70	61	51	44
Boise City, Idaho	Mountain	88	92	94	93	91	85	85	80	75
Pocatello, Idaho	Mountain	78	82	84	79	78	71	60	54	46
Denver, Colo.	Mountain	83	84	82	73	72	65	59	49	44
Pueblo, Colo.	Mountain	86	89	89	87	88	80	71	63	54
Dodge City, Kans.	Central	73	81	83	85	86	86	83	77	67
Oklahoma City, Okla.	Central	81	84	85	83	83	81	76	74	59

NOTE.—These averages are based upon observations for the five years 1911–1915, except that those for Dodge City are based upon observations for the ten years 1906–1915.

TABLE III.

PREVAILING HOURLY WIND DIRECTION DURING THE FIRST 15 DAYS OF JUNE.

Station.	Time.	Local Standard Time. A. M. 9h–10h	10h–11h	11h–12h	P. M. 12h–1h	1h–2h	2h–3h	3h–4h	4h–5h	5h–6h
Seattle, Wash.	Pacific	S.	NW.	NW.	NW.	NW.	W.	NW.	N.	N.
Baker, Oreg.	Pacific	N.	N.	N.	N.	N.	NW.	NW.	NW.	N.
Boise City, Idaho	Mountain	..	..	..	NW.	..	..	..	..	..
Pocatello, Idaho	Mountain	SE.	SW.	W.	SW.	W.	SW.	SW.	SW.	SW.
Denver, Colo.	Mountain	SW.	NE.	NE.	NE.	NE.	NE.	E.	SE.	NE.
Pueblo, Colo.	Mountain	SE.	SE.	SE.	SE.	SE.	SE.	SE.	SE.	SE.
Dodge City, Kans.	Central	S.	S.	S.	S.	S.	S.	S.	S.	S.
Oklahoma City, Okla.	Central	S.	S.	S.	S.	S.	S.	S.	S.	S.

NOTE.—These averages are based upon observations for the five years 1911–1915, except that that for Boise City is based upon observations for the five years 1882–1886.

TABLE IV.

AVERAGE HOURLY WIND VELOCITY IN MILES DURING THE FIRST 15 DAYS OF JUNE.

Station.	Time.	Local Standard Time.								
		A. M.			P. M.					
		9h–10h	10h–11h	11h–12h	12h–1h	1h–2h	2h–3h	3h–4h	4h–5h	5h–6h
Seattle, Wash.	Pacific	9	9	9	10	10	10	11	11	11
Baker, Oreg.	Pacific	6	6	7	8	8	8	8	8	7
Boise City, Idaho	Mountain	6	7	8	8	8	8	9	8	8
Pocatello, Idaho	Mountain	8	8	8	9	9	9	10	9	9
Denver, Colo.	Mountain	8	9	10	11	11	11	11	11	10
Pueblo, Colo.	Mountain	6	7	8	9	10	11	11	11	11
Dodge City, Kans	Central	14	14	14	14	14	14	15	15	14
Oklahoma City, Okla.	Central	16	16	16	16	16	16	16	16	15

NOTE.—These averages are based upon observations for the five years 1911–1915.

TABLE V.

MEAN HOURLY TEMPERATURES FROM JUNE 6 TO JUNE 10, INCLUSIVE.

Station.	Time.	Local Standard Time.					
		P. M.					
		12h–1h	1h–2h	2h–3h	3h–4h	4h–5h	5h–6h
		°	°	°	°	°	°
Seattle, Wash.	Pacific	61	63	64	64	63	62
Baker, Oreg.	Pacific	66	67	67	66	65	64
Boise City, Idaho	Mountain	68	70	70	70	71	70
Pocatello, Idaho	Mountain	69	70	69	69	68	66
Denver, Colo.	Mountain	71	72	71	71	70	70
Pueblo, Colo.	Mountain	74	75	76	76	75	74
Dodge City, Kans.	Central	75	77	78	78	77	75
Oklahoma City, Okla.	Central	81	82	83	83	83	81

NOTE.—These averages are based upon observations for the five years 1911–1915.

PART II.

ASTRONOMICAL DATA AND CHARTS.

EXPLANATION AND USE OF THE TABLES.

The Elements of the Eclipse, given in Table VI, are for the moment of conjunction of the Sun and Moon in right ascension, but the remaining data and tables are computed for the exact positions of these bodies at the several instants referred to.

The Circumstances of the Eclipse, given in Table VI, are as follows:

The line entitled "Eclipse begins" gives the Greenwich mean time at which the Moon's penumbra first touches the Earth, together with the latitude and longitude of the point of contact.

The line entitled "Central eclipse begins" gives the time when the axis of the Moon's shadow first touches the Earth, together with the latitude and longitude of the point of contact.

The line entitled "Central eclipse at local apparent noon" gives the time when the axes of the Earth and of the shadow cone lie in the same plane, together with the latitude and longitude of the point where the axis of the shadow cone then cuts the Earth's surface.

The lines entitled "Central eclipse ends" and "Eclipse ends" give, respectively, the times when and the localities where these events occur, the phenomena being the converse of those denoted by the similar phrases for the beginning.

Table VII contains the Besselian Elements, or the data from which accurate times of the phases may be computed for any station whose coördinates are known.

Tables VIII gives the latitude and longitude of points along the central line, and also of corresponding points on the northern and southern limits of the path of total phase for which mid-totality occurs at the moment indicated in the first column. The final column gives the duration of totality at the points on the central line.

Table IX gives, for each degree of longitude from 80° to 125° west from Greenwich, the latitude of points on the northern limit, central line, and southern limit, of the path of total phase. It also gives for each of these points on the central line the Greenwich mean times of the four contacts, the position angles from the north point and from the vertex, the duration of totality, the Sun's altitude at mid-totality, and the shortest distance to the edge of the path.

Tables X and XI give reductions for obtaining the times of contacts and the position angles for points in the path of the total phase but not on the central line.

Table XII gives the local circumstances at 73 cities scattered throughout the United States, and at Honolulu, Juneau, Nome, Panama, and San Juan.

Chart I gives a general outline of the whole eclipse.

Chart II gives the planets and stars in the vicinity of the eclipsed Sun.

Charts III and IV give, on a much larger scale than Chart I, the path of total eclipse, the first in the Western States and the other in the Eastern States. This path is crossed by a series of straight lines, which terminate in the northern and southern limits of totality, each line being approximately the locus of all points for which mid-totality occurs at the moment of Greenwich mean time indicated thereon. These charts contain also two series of long curved broken lines, each of the one series including all points for which the beginning and each of the other series including all points for which the ending of partial eclipse occurs at the moment indicated. Chart III contains, in addition, symbols indicating the probable meteorological conditions at the time of mid-eclipse for eight stations situated in or near the path of totality.

RIGOROUS COMPUTATION OF THE TIMES.

An accurate determination of the several phases as visible at any particular station may be obtained from the Besselian Elements which are given in Table VII for every ten minutes of Greenwich time. Their geometric signification is as follows:

Let us imagine a plane passing through the center of the Earth, perpendicular to the right line joining the centers of the Sun and Moon. This latter line is the axis of the Moon's shadow, and the plane is called the *fundamental plane* or plane of xy. We take the intersection of this plane with that of the Earth's equator as the axis of x, and the center of the Earth as the origin of coordinates. The axis of y is perpendicular to that of x, and directed toward the north; x and y are then the coordinates of the point in which the axis of the shadow intersects the fundamental plane, and they are here expressed in terms of the Earth's equatorial radius as unity. The angle d, of which the sine and cosine are both given, is the declination of that point of the celestial sphere toward which the axis of the shadow is directed; or, in other words, it is the declination of the center of the Sun as seen from the center of the Moon. The angle μ is the Greenwich hour-angle of this same point of the celestial sphere.

The quantities l_1 and l_2 are the radii of the shadow cones upon the fundamental plane, l_1, corresponding to the penumbra, and l_2 to the umbra. The notation is that of CHAUVENET's *Spherical and Practical Astronomy*, in which l_2 is regarded as positive for an annular and negative for a total eclipse.

The angles f_1 and f_2, the tangents of which are given, are the angles which the elements of the respective shadow cones make with the axis of the shadow; or, they are the semiangles of the two cones.

In order to facilitate interpolation to any required moment, the logarithms of x', y', and μ', which are the changes of x, y, and μ, in one minute of time, are given at the bottom of the table.

The method of computing an eclipse from its Besselian elements is based on the fact that the distance of the observer from the axis of the shadow cones is equal to the radius of the penumbra at the point of observation for the beginning and ending of the eclipse, and is equal to the radius of the umbra at the point of observation for the beginning and ending of totality or of the annular phase. To find this distance and radius in each case, we proceed as follows:

(1) The coordinates of the observer, ξ, η, and ζ, together with their variations in one minute, are computed for some assumed moment of Greenwich mean time, as near as practicable to the true time of the required phase.

(2) The coordinates x and y of the axis of the shadow, together with their variations in one minute. are taken for the same moment from the tables of elements.

(3) From (1) and (2) the position and motion of the observer relative to the axis of the shadow are found.

(4) The radius of the penumbra or umbra at a distance from the fundamental plane equal to that of the observer is also computed.

(5) Then, assuming the motions to be uniform, we determine the time required for the observer to be brought to a distance from the axis of the shadow equal to this radius.

The formulæ and directions for the several steps in the computation are as follows:

(1) Find $\rho \cos \varphi'$ and $\rho \sin \varphi'$, which are the geocentric coordinates of the station referred to the Earth's equator, ρ being the distance from the center of the Earth and φ' the geocentric latitude. These coordinates may be computed from the following table based on the compression of the Earth adopted at the Paris Conference of 1911, 1/297, by the formulæ—

$$\rho \cos \varphi' = F \cos \varphi$$
$$\rho \sin \varphi' = \frac{\sin \varphi}{G}$$

φ being, as usual, the geographic latitude.

Table for Computing the Geocentric Coordinates of a Place.

φ	Log F.		Log G.	
0°	0.00000		0.00293	
		1		1
5	0.00001		0.00292	
		3		3
10	0.00004		0.00289	
		6		6
15	0.00010		0.00283	
		7		7
20	0.00017		0.00276	
		9		9
25	0.00026		0.00267	
		11		11
30	0.00037		0.00256	
		11		11
35	0.00048		0.00245	
		12		13
40	0.00060		0.00232	
		13		12
45	0.00073		0.00220	
		13		13
50	0.00086		0.00207	
		12		12
55	0.00098		0.00195	
		12		12
60	0.00110		0.00183	
		10		10
65	0.00120		0.00173	
		9		9
70	0.00129		0.00164	
		8		8
75	0.00137		0.00156	
		5		5
80	0.00142		0.00151	
		3		3
85	0.00145		0.00148	
		1		2
90	0.00146		0.00146	

For the assumed Greenwich mean time of computation, take from the table of elements the values of sin d, cos d, and μ. Then, with λ for the longitude west from Greenwich, the coordinates of the observer will be—

$$\xi = \rho \cos \varphi' \sin (\mu - \lambda)$$
$$\eta = \rho \sin \varphi' \cos d - \rho \cos \varphi' \sin d \cos (\mu - \lambda) - \eta_1 - \eta_2$$
$$\zeta = \rho \sin \varphi' \sin d + \rho \cos \varphi' \cos d \cos (\mu - \lambda) - \zeta_1 + \zeta_2$$

and their variations in one minute of mean time will be—

$$\xi' = [7.63992]\, \rho \cos \varphi' \cos (\mu - \lambda)$$
$$\eta' = [7.63992]\, \rho \cos \varphi' \sin d \sin (\mu - \lambda) - [7.63992]\, \xi \sin d$$
ζ' is not needed.

(2) For the same assumed moment of Greenwich mean time, take from the tables of elements the coordinates x and y of the axis of the shadow, together with their variations for one minute, which are equal to one-tenth of the differences of two consecutive numbers. These variations are represented by x' and y', and their logarithms are given beneath the tables of x and y.

(3) The distance m and position-angle M of the axis of the shadow relative to the observer, and the relative motions, n and N, are computed by the formulæ—

$$m \sin M = x - \xi$$
$$m \cos M = y - \eta$$
$$n \sin N = x' - \xi'$$
$$n \cos N = y' - \eta'$$

(4) Both for the umbra and for the penumbra, the radius L at the distance ζ from the fundamental plane is computed by the formulæ—

$$L = l - \zeta \tan f$$

l and f being taken from the table of elements, and ζ computed in (1).

(5) If the time chosen for computation is exactly that of the beginning or ending of the eclipse, we shall have—

$$m = L$$

But, as this condition will rarely be fufilled on a first trial, a correction τ to the assumed time is computed thus: Find the angle ψ from the equation—

$$\sin \psi = \frac{m \sin (M - N)}{L}$$

There will be two values for this angle; the one for which cos ψ is negative must be taken for the beginning of the eclipse, or for the ending of the total phase, but the one for which cos ψ is positive must be taken for the ending of the eclipse, or for the beginning of the total phase. The correction τ to the assumed time will then be found, in minutes, from—

$$\tau = -\frac{m \cos (M - N)}{n} + \frac{L \cos \psi}{n}$$

However, only in case the value of τ does not exceed a few minutes can the time thus corrected be considered even fairly accurate. Therefore it is best to commence the computation by assuming times near the phenomena wanted. The times for the beginning and the ending of an eclipse may be derived from Chart I with sufficient exactness, the time for the total phase may then be assumed as midway between the times assumed for the beginning and the ending of the eclipse; or, in case of a partial eclipse, this time midway may be assumed as that of the maximum eclipse.

The more accurate times resulting from the computation as outlined above and as illustrated in the example below may now be taken in place of those originally assumed, and the whole computation may be repeated, thus leading to a value of τ in each case, which should be very small, and which should give a very accurate time of the phenomenon. Such a repetition of the computation will be advisable, moreover, for the reason that it will enable one to locate and eliminate any accidental numerical errors that may have occurred in the first computation.

As a result of this last approximation the computed times of contact will be theoretically exact within less than a second, but the uncertainties of the solar and lunar tables are such that an unavoidable error of several seconds may exist in the prediction.

If the given station is found upon Chart III or IV, the times of beginning, ending, and mid-totality may be taken from the chart to the nearest minute, and a second computation will be unnecessary unless desired as a check upon the accuracy of the numerical work.

Position-angle of Point of Contact.—The position-angle P, of the point of contact, reckoned from the north point of the Sun's limb toward the east, is found by the formula—

$$P=N+\psi$$

where the results of the last approximation are used.

The position-angle V, of the point of contact, reckoned from the vertex of the Sun's limb toward the east, is found by the formula—

$$V=P-C$$

where C is obtained from

$$\tan C=\frac{\xi}{\eta}$$

sin C having the same algebraic sign as ξ, and again the results of the last approximation are used.

Time of Maximum Eclipse.—For a partial eclipse, or for a central eclipse at a point at which the eclipse is only partial indicated by sin ψ greater than unity for the umbra, the correction to the assumed time to obtain the time of maximum eclipse is given by the formula—

$$\tau=-\frac{m\cos(M-N)}{n}$$

Magnitude of the Maximum Eclipse.—This is given by the formula—

$$D^*=\frac{L-\Delta}{2L-0.5446}$$

where $\Delta=\pm m\sin(M-N)$, always taken positive, and L is the radius of the penumbra. D is, in all cases, the ratio to the Sun's diameter of the straight line passing through the centers of the two disks and having for its extremities the Sun's limb that is nearest to the Moon's center and the Moon's limb that is nearest to the Sun's center. In a partial eclipse D is the fraction of the Sun's diameter covered by the Moon.

*Since, in obtaining this formula, the angles of the two shadow cones are considered the same, the value obtained therefrom should be increased by $\frac{1}{230}$th of itself.

Computation of the Solar Eclipse of June 8, 1918, for Denver, Colo.

The position of Denver is—

	° ′ ″
Latitude, $\varphi =$	+ 39 40 36
Longitude, $\lambda =$	+104 56 56

and its geocentric coordinates are—

$\rho \sin \varphi' = 9.80280$

$\rho \cos \varphi' = 9.88689$

From the eclipse chart we find the approximate times of the phases to be—

		d h m	
Beginning	June	8 10 10	Greenwich Mean Time.
Middle		8 11 20	
Ending		8 12 30	

	Beginning.	Middle.	Ending.
T June 8	10h 10m	11h 20m	12h 30m
	° ′ ″	° ′ ″	° ′ ″
μ	152 48 30	170 18 24	187 48 24
λ	104 56 56	104 56 56	104 56 56
$\mu-\lambda$	47 51 34	65 21 28	82 51 28
$\log \rho \cos \varphi'$	9.88689	9.88689	9.88689
$\log \sin (\mu-\lambda)$	9.87011	9.95853	9.99662
$\log \xi$	9.75700	9.84542	9.88351
$\log \cos d$	9.96454	9.96453	9.96451
$\log \rho \sin \varphi'$	9.80280	9.80280	9.80280
$\log \sin d$	9.58899	9.58907	9.58915
$\log \eta_1$	9.76734	9.76733	9.76731
$\log \zeta_1$	9.39179	9.39187	9.39195
$\log \sin d$	9.58899	9.58907	9.58915
$\log \rho \cos \varphi'$	9.88689	9.88689	9.88689
$\log \cos (\mu-\lambda)$	9.82669	9.62008	9.09459
$\log \cos d$	9.96454	9.96453	9.96451
$\log \eta_2$	9.30257	9.09604	8.57063
$\log \zeta_2$	9.67812	9.47150	8.94599
η_1	+0.58525	+0.58524	+0.58521
$-\eta_2$	−0.20071	−0.12475	−0.03721
ζ_1	+0.24648	+0.24653	+0.24658
ζ_2	+0.47657	+0.29614	+0.08831
ζ	+0.72305	+0.54267	+0.33489
$\log \rho \cos \varphi'$	9.88689	9.88689	9.88689
$\log \cos (\mu-\lambda)$	9.82669	9.62008	9.09459
log const.	7.63992	7.63992	7.63992
$\log \xi$	9.75700	9.84542	9.88351
$\log \sin d$	9.58899	9.58907	9.58915
$\log \xi'$	7.35350	7.14689	6.62140
$\log \eta'$	6.98591	7.07441	7.11258
x	+0.02408	+0.67310	+1.32200
ξ	+0.57148	+0.70052	+0.76473
$x-\xi$	−0.54740	−0.02742	+0.55727
y	+0.46574	+0.46362	+0.46098
η	+0.38454	+0.46049	+0.54800
$y-\eta$	+0.08120	+0.00313	−0.08702
x'	+0.009273	+0.009273	+0.009269
ξ'	+0.002257	+0.001402	+0.000418
$x'-\xi'$	+0.007016	+0.007871	+0.008851
y'	−0.000027	−0.000034	−0.000041
η'	+0.000968	+0.001187	+0.001296
$y'-\eta'$	−0.000995	−0.001221	−0.001337

	Beginning.	Middle.	Ending.
$\log m \sin M$	9.73830*n*	8.43807*n*	9.74607
log sin or cos M	9.99527*n*	9.99719*n*	9.99477
$\log m \cos M$	8.90956	7.49554	8.93962*n*
$\log \tan M$	0.82874*n*	0.94253*n*	0.80645*n*
$\log n \sin N$	7.84609	7.89603	7.94699
log sin or cos N	9.99567	9.99484	9.99510
$\log n \cos N$	6.99782*n*	7.08672*n*	7.12613*n*
$\log \tan N$	0.84827*n*	0.80931*n*	0.82086*n*
	° ′ ″	° ′ ″	° ′ ″
M	278 26 16	276 30 43	98 52 31
N	98 4 18	98 49 4	98 35 24
$M-N$	180 21 58	177 41 39	0 17 7
$\log m$	9.74303	8.44088	9.75130
$\log n$	7.85042	7.90119	7.95189
$\log \zeta$	9.85917	9.73454	9.52491
$\log \tan f$	7.66328	7.66111	7.66328
$\log \zeta \tan f$	7.52245	7.39565	7.18819
l	+0.54220	−0.00358	+0.54240
$\zeta \tan f$	+0.00333	+0.00249	+0.00154
L	+0.53887	−0.00607	+0.54086
$\log m$	9.74303	8.44088	9.75130
$\log \sin (M-N)$	7.80549*n*	8.60459	7.69714
colog L	0.26851	2.21681*n*	0.26691
$\log \sin \psi$	7.81703*n*	9.26228*n*	7.71535
	° ′ ″	° ′ ″	° ′ ″
ψ	180 22 34	−10 32 26 190 32 26	+0 17 51
$\log m/n$	1.89261	0.53969	1.79941
$\log \cos (M-N)$	9.99999*n*	9.99965*n*	9.99999
log (1)	1.89260*n*	0.53934*n*	1.79940
$\log L$	9.73149	7.78319*n*	9.73309
$\log \cos \psi$	9.99999*n*	(±)9.99261	9.99999
colog n	2.14958	2.09881	2.04811
log (2)	1.88106*n*	(∓)9.87461	1.78119
−(1)	+78.090	+3.462	−63.009
+(2)	−76.043	∓0.749	+60.421
τ	m +2.047	m +2.713 +4.211	m −2.588
T	d h m 8 10 10	d h m 8 11 20	d h m 8 12 30
$T+\tau$	d h m 8 10 12.047	d h m 8 11 22.713 8 11 24.211	d h m 8 12 27.412

Taking the four times just found, a new computation is made in each case. The times resulting from the new computation are—

	Greenwich Mean Time.					Local Mean Time.		
		d	h	m	s	h	m	s
Beginning of the eclipse	June	8	10	12	2.7	3	12	15.0
Beginning of total eclipse			11	22	42.7	4	22	55.0
Ending of total eclipse			11	24	11.4	4	24	23.7
Ending of the eclipse			12	27	24.2	5	27	36.5

The values from the last approximation of the quantities needed in computing the position angles, and the computation of these position angles, are—

	1st Contact.	2d Contact.	3d Contact.	4th Contact.
log ξ	9.76048	9.84774	9.84899	9.88286
log η	9.58718	9.66626	9.66792	9.73612
log tan C	0.17330	0.18148	0.18107	0.14674
	°	°	°	°
N	98.11	98.82	98.83	98.61
ψ	180.34	−10.62	190.54	0.27
P	278.45	88.20	289.37	98.88
C	56.14	56.64	56.61	54.50
V	222.3	31.6	232.8	44.4

The magnitude of greatest eclipse is obtained as follows:—

T	$11^h\ 20^m$	l	+0.5423	$L-\Delta$	+0.5387
log ζ	9.7345	ζ tan f	+0.0025	$2L-0.5446$	+0.5350
log tan f	7.6633	L	+0.5398	D	1.007
log ζ.tan f	7.3978	Δ	+0.0011	1/400 D	.003
				Magnitude	1.01

TABLE VI.

ELEMENTS AND CIRCUMSTANCES.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of ☌ in right ascension, June 8ᵈ 10ʰ 7ᵐ 24.2ˢ

Sun and Moon's R. A.	5ʰ 4ᵐ 39.98ˢ	Hourly motions	10.33ˢ and 152.10ˢ
Sun's declination	+22° 50′ 23.8″	Hourly motion	+ 0′ 13.6″
Moon's declination	+23 17 39.1	Hourly motion	+ 0 7.4
Sun's equa. hor. parallax	8.7	Sun's true semidiameter	15 45.3
Moon's equa. hor. parallax	58 39.4	Moon's true semidiameter	15 58.2

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time. d h m	Longitude from Greenwich. ° ′	Latitude. ° ′
Eclipse begins	June 8 7 29.0	−150 20	+16 22
Central eclipse begins	8 8 32.2	−129 58	+25 41
Central eclipse at local apparent noon	8 10 7.4	+152 10	+50 51
Central eclipse ends	8 11 42.9	+ 74 31	+25 23
Eclipse ends	8 12 46.2	+ 94 53	+16 3

TABLE VII.

BESSELIAN ELEMENTS.

Greenwich Mean Time.	Coordinates of Center of Shadow on Fundamental Plane.		Direction of Axis of Shadow.			Radius of Penumbra and Umbra on Fundamental Plane.	
	x	y	Log sin d	Log cos d	μ	l_1	l_2
h m					° ′		
7 20	−1.55216	+0.46880	+9.58880	+9.96458	110 18.6	+0.54179	−0.00410
30	1.45946	0.46870	9.58881	9.96457	112 48.6	0.54182	0.00407
40	1.36674	0.46860	9.58882	9.96457	115 18.6	0.54185	0.00404
50	1.27403	0.46848	9.58883	9.96457	117 48.5	0.54188	0.00402
8 0	−1.18132	+0.46835	+9.58884	+9.96457	120 18.5	+0.54191	−0.00399
10	1.08860	0.46821	9.58885	9.96457	122 48.5	0.54193	0.00396
20	0.99588	0.46806	9.58887	9.96456	125 18.5	0.54196	0.00394
30	0.90316	0.46790	9.58888	9.96456	127 48.5	0.54199	0.00391
40	0.81044	0.46773	9.58889	9.96456	130 18.5	0.54201	0.00389
50	0.71772	0.46755	9.58890	9.96456	132 48.5	0.54203	0.00386
9 0	−0.62499	+0.46736	+9.58891	+9.96456	135 18.5	+0.54206	−0.00384
10	0.53227	0.46716	9.58892	9.96455	137 48.5	0.54208	0.00382
20	0.43954	0.46695	9.58893	9.96455	140 18.5	0.54210	0.00379
30	0.34682	0.46673	9.58895	9.96455	142 48.5	0.54213	0.00377
40	0.25409	0.46650	9.58896	9.96455	145 18.5	0.54215	0.00375
50	0.16137	0.46626	9.58897	9.96455	147 48.5	0.54217	0.00373
10 0	−0.06864	+0.46601	+9.58898	+9.96454	150 18.5	+0.54219	−0.00371
10	+0.02408	0.46574	9.58899	9.96454	152 48.5	0.54220	0.00369
20	0.11680	0.46547	9.58900	9.96454	155 18.5	0.54222	0.00368
30	0.20952	0.46519	9.58901	9.96454	157 48.5	0.54224	0.00366
40	0.30224	0.46489	9.58903	9.96454	160 18.5	0.54226	0.00364
50	0.39496	0.46459	9.58904	9.96453	162 48.5	0.54227	0.00362
11 0	+0.48768	+0.46428	+9.58905	+9.96453	165 18.4	+0.54229	−0.00361
10	0.58039	0.46395	9.58906	9.96453	167 48.4	0.54230	0.00359
20	0.67310	0.46362	9.58907	9.96453	170 18.4	0.54232	0.00358
30	0.76581	0.46327	9.58908	9.96453	172 48.4	0.54233	0.00357
40	0.85852	0.46292	9.58909	9.96452	175 18.4	0.54235	0.00355
50	0.95122	0.46255	9.58911	9.96452	177 48.4	0.54236	0.00354
12 0	+1.04392	+0.46217	+9.58912	+9.96452	180 18.4	+0.54237	−0.00353
10	1.13662	0.46179	9.58913	9.96452	182 48.4	0.54238	0.00352
20	1.22931	0.46139	9.58914	9.96452	185 18.4	0.54239	0.00351
30	1.32200	0.46098	9.58915	9.96451	187 48.4	0.54240	0.00350
40	1.41469	0.46056	9.58916	9.96451	190 18.4	0.54241	0.00349
50	+1.50737	+0.46014	+9.58917	+9.96451	192 48.4	+0.54242	−0.00348

Greenwich Mean Time.	Log x' for 1 Minute.	Log y' for 1 Minute.	Log μ' for 1 Minute.	Log Tangents of Angles of Cones.	
				Penumbra.	Umbra.
h m					
7 0	+7.9671	−4.8591	+1.1761	+7.66329	+7.66112
8 0	7.9672	5.1261	1.1761	7.66329	7.66112
9 0	7.9672	5.2907	1.1761	7.66328	7.66112
10 0	7.9672	5.4103	1.1761	7.66328	7.66111
11 0	7.9672	5.5041	1.1761	7.66328	7.66111
12 0	7.9671	5.5813	1.1761	7.66328	7.66111
13 0	+7.9670	−5.6472	+1.1761	+7.66328	+7.66111

TABLE VIII.

PATH OF THE TOTAL PHASE.

Greenwich Mean Time.	Northern Limit. Latitude.	Northern Limit. Longitude from Greenwich.	Central Line. Latitude.	Central Line. Longitude from Greenwich.	Southern Limit. Latitude.	Southern Limit. Longitude from Greenwich.	Duration of Total Phase on Central Line.
	° ′	° ′	° ′	° ′	° ′	° ′	m s
Limits.	+25 55	−129 47	+25 41	−129 58	+25 27	−130 9	. . . .
8h 35m	31 2.6	140 55.8	31 6.8	141 54.8	31 9.4	142 51.6	1 2.9
40	34 50.5	148 47.9	34 44.9	149 32.5	34 38.6	150 16.5	1 15.3
45	37 26.8	154 12.9	37 16.8	154 53.2	37 6.3	155 33.0	1 24.6
50	39 31.8	158 40.9	39 18.8	159 18.7	39 5.3	159 56.0	1 32.4
55	41 17.5	162 37.8	41 2.0	163 13.8	40 46.1	163 49.1	1 39.3
9 0	+42 49.2	−166 15.7	+42 31.6	−166 49.8	+42 13.7	−167 23.4	1 45.4
5	44 10.0	169 40.6	43 50.5	170 13.2	43 30.7	170 45.1	1 51.1
10	45 21.6	172 57.1	45 0.4	173 28.0	44 39.0	173 58.2	1 56.2
15	46 25.1	176 7.8	46 2.4	176 36.8	45 39.5	−177 5.1	2 0.8
20	47 21.4	−179 14.5	46 57.4	−179 41.4	46 33.1	+179 52.3	2 4.9
25	48 11.1	+177 41.5	47 45.9	+177 16.8	47 20.4	176 52.7	2 8.7
30	+48 54.6	+174 39.2	+48 28.3	+174 17.0	+48 1.7	+173 55.2	2 12.0
35	49 32.1	171 38.0	49 4.8	171 18.3	48 37.4	170 59.1	2 14.8
40	50 4.0	168 37.4	49 35.8	168 20.5	49 7.5	168 3.9	2 17.3
45	50 30.2	165 37.0	50 1.4	165 23.0	49 32.4	165 9.3	2 19.3
50	50 50.9	162 36.8	50 21.5	162 25.8	49 52.1	162 15.0	2 20.9
55	51 6.3	159 36.5	50 36.5	159 28.7	50 6.6	159 21.0	2 22.0
10 0	+51 16.2	+156 36.2	+50 46.2	+156 31.6	+50 16.1	+156 27.1	2 22.7
5	51 20.9	153 36.0	50 50.8	153 34.6	50 20.6	153 33.2	2 23.0
10	51 20.3	150 35.8	50 50.2	150 37.6	50 20.0	150 39.4	2 22.8
15	51 14.3	147 35.7	50 44.4	147 40.8	50 14.5	147 45.7	2 22.2
20	51 3.1	144 35.8	50 33.5	144 44.1	50 4.0	144 52.1	2 21.2
25	50 46.6	141 36.2	50 17.5	141 47.5	49 48.3	141 58.5	2 19.7
30	+50 24.6	+138 36.7	+49 56.1	+138 51.0	+49 27.6	+139 4.8	2 17.8
35	49 57.2	135 37.4	49 29.5	135 54.4	49 1.7	136 11.0	2 15.4
40	49 24.2	132 37.9	48 57.4	132 57.5	48 30.5	133 16.7	2 12.7
45	48 45.6	129 37.9	48 19.8	130 0.0	47 53.9	130 21.6	2 9.5
50	48 1.0	126 37.1	47 36.4	127 1.4	47 11.6	127 25.1	2 5.9
55	47 10.3	123 34.6	46 47.0	124 1.0	46 23.4	124 26.7	2 1.9
11 0	+46 13.1	+120 29.6	+45 51.2	+120 57.8	+45 28.9	+121 25.4	1 57.5
5	45 8.7	117 20.7	44 48.3	117 50.6	44 27.6	118 19.9	1 52.7
10	43 56.4	114 6.0	43 37.8	114 37.5	43 18.6	115 8.3	1 47.4
15	42 35.1	110 42.9	42 18.2	111 15.8	42 1.0	111 48.1	1 41.6
20	41 2.9	107 7.4	40 48.1	107 41.7	40 32.8	108 15.5	1 35.2
25	39 16.8	103 12.9	39 4.4	103 48.8	38 51.6	104 24.3	1 28.2
30	+37 11.7	+ 98 47.8	+37 2.2	+ 99 25.9	+36 52.4	+100 3.4	1 20.3
35	34 35.9	93 26.7	34 30.6	94 8.5	34 24.7	94 49.6	1 11.0
40	30 51.0	85 43.9	30 54.5	86 37.8	30 56.7	87 30.0	0 58.7
Limits.	+25 35	+ 74 20	+25 23	+ 74 31	+25 11	+ 74 41	. . . .

TABLE IX.

PATH OF TOTAL PHASE IN THE UNITED STATES.

Longitude West from Greenwich.	Latitude of Points on— Northern Limit.	Central Line.	Southern Limit.	Data for Points on Central Line. First Contact. Greenwich Mean Time.	Angle East from N. Point.	Angle East from Vertex.	Second Contact. Greenwich Mean Time.	Angle East from N. Point.	Angle East from Vertex.
°	° ′	° ′	° ′	h m s	°	°	h m s	°	°
80	28 8.8	27 49.3	27 30.2	10 44 14	279	213	11 41 57	99	37
81	28 36.6	28 16.7	27 57.1	43 32	280	213	41 42	99	37
82	29 4.7	28 44.3	28 24.3	42 48	280	213	41 25	99	37
83	29 33.0	29 12.1	28 51.6	42 0	280	213	41 5	99	37
84	30 1.4	29 40.1	29 19.2	41 9	280	213	40 42	99	37
85	30 30.0	30 8.3	29 46.9	10 40 15	280	214	11 40 17	99	37
86	30 58.8	30 36.6	30 14.7	39 18	280	214	39 50	99	37
87	31 27.8	31 5.0	30 42.6	38 18	280	214	39 19	99	38
88	31 56.8	31 33.6	31 10.8	37 15	280	214	38 46	99	38
89	32 25.9	32 2.3	31 39.1	36 8	280	215	38 10	99	38
90	32 55.1	32 31.1	32 7.5	10 34 59	280	215	11 37 32	99	38
91	33 24.3	32 59.9	32 35.9	33 47	280	215	36 51	99	38
92	33 53.6	33 28.8	33 4.3	32 31	280	216	36 7	99	38
93	34 22.9	33 57.6	33 32.7	31 13	280	216	35 21	99	39
94	34 52.2	34 26.5	34 1.2	29 52	279	216	34 32	99	39
95	35 21.4	34 55.4	34 29.7	10 28 27	279	217	11 33 40	99	39
96	35 50.6	35 24.2	34 58.1	27 0	279	217	32 46	99	39
97	36 19.7	35 52.9	35 26.4	25 30	279	218	31 49	99	40
98	36 48.7	36 21.5	35 54.6	23 58	279	218	30 49	99	40
99	37 17.6	36 50.0	36 22.8	22 23	279	219	29 47	99	40
100	37 46.3	37 18.4	36 50.8	10 20 45	279	219	11 28 43	99	40
101	38 14.7	37 46.5	37 18.6	19 6	279	220	27 36	99	41
102	38 42.9	38 14.4	37 46.2	17 24	279	220	26 27	99	41
103	39 10.9	38 42.1	38 13.6	15 40	279	221	25 16	99	41
104	39 38.6	39 9.5	38 40.7	13 53	279	222	24 2	99	42
105	40 6.0	39 36.6	39 7.5	10 12 5	279	222	11 22 46	99	42
106	40 33.0	40 3.4	39 34.1	10 15	278	223	21 29	99	42
107	40 59.7	40 29.9	40 0.4	8 24	278	224	20 9	99	43
108	41 26.0	40 56.0	40 26.3	6 30	278	225	18 47	99	43
109	41 51.8	41 21.6	40 51.7	4 36	278	226	17 24	98	44
110	42 17.2	41 46.9	41 16.8	10 2 41	278	227	11 15 59	98	44
111	42 42.2	42 11.7	41 41.4	10 0 44	278	228	14 32	98	45
112	43 6.7	42 36.1	42 5.7	9 58 47	278	229	13 4	98	45
113	43 30.7	43 0.0	42 29.5	56 49	277	230	11 35	98	46
114	43 54.2	43 23.4	42 52.8	54 50	277	231	10 4	98	46
115	44 17.2	43 46.3	43 15.6	9 52 51	277	232	11 8 32	98	47
116	44 39.6	44 8.6	43 37.9	50 52	277	233	6 58	98	47
117	45 1.4	44 30.4	43 59.6	48 52	277	235	5 24	98	48
118	45 22.7	44 51.6	44 20.7	46 53	276	236	3 49	97	48
119	45 43.4	45 12.3	44 41.3	44 53	276	238	2 12	97	49
120	46 3.5	45 32.4	45 1.4	9 42 53	276	239	11 0 36	97	50
121	46 23.0	45 51.8	45 20.8	40 54	276	241	10 58 58	97	51
122	46 41.9	46 10.7	45 39.7	38 55	276	242	57 19	97	51
123	47 0.2	46 29.0	45 58.0	36 56	275	244	55 40	96	52
124	47 17.9	46 46.7	46 15.7	34 59	275	246	54 1	96	53
125	47 34.8	47 3.8	46 32.9	9 33 1	275	248	10 52 21	96	54

TABLE IX.

PATH OF TOTAL PHASE IN THE UNITED STATES.

Longitude West from Greenwich.	Data for Points on Central Line. Third Contact. Greenwich Mean Time.	Third Contact. Angle East from N. Point.	Third Contact. Angle East from Vertex.	Fourth Contact. Greenwich Mean Time.	Fourth Contact. Angle East from N. Point.	Fourth Contact. Angle East from Vertex.	Duration.	Sun's Altitude at Mid-Totality.	Shortest Distance to Edge of Path.
°	h m s	°	°	h m s	°	°	s	°	Miles.
80	11 42 46	279	217	. . . . . .	. .	. .	49.0	5.6	19.6
81	42 32	279	217	. . . . . .	. .	. .	50.4	6.6	20.0
82	42 16	279	217	. . . . . .	. .	. .	51.8	7.7	20.4
83	41 58	279	217	. . . . . .	. .	. .	53.3	8.7	20.8
84	41 37	279	217	. . . . . .	. .	. .	54.7	9.8	21.2
85	11 41 14	279	217	12 35 44	99	42	56.3	10.8	21.7
86	40 47	279	218	35 41	99	42	57.8	11.9	22.1
87	40 18	279	218	35 35	99	42	59.3	13.0	22.5
88	39 47	279	218	35 27	99	42	60.8	14.0	22.9
89	39 13	279	218	35 17	99	42	62.5	15.1	23.3
90	11 38 36	279	218	12 35 4	99	42	64.2	16.2	23.7
91	37 57	279	218	34 50	99	42	65.8	17.3	24.1
92	37 15	279	218	34 33	99	42	67.4	18.4	24.5
93	36 30	279	219	34 13	99	42	69.1	19.4	24.9
94	35 42	279	219	33 52	99	42	70.8	20.5	25.3
95	11 34 52	279	219	12 33 28	99	43	72.4	21.6	25.7
96	34 0	279	219	33 2	99	43	74.0	22.7	26.1
97	33 5	279	220	32 34	99	43	75.7	23.8	26.4
98	32 7	279	220	32 3	99	43	77.6	24.8	26.8
99	31 7	279	220	31 30	99	43	79.5	25.9	27.1
100	11 30 4	279	221	12 30 56	99	43	81.2	27.0	27.4
101	28 59	279	221	30 19	99	43	83.0	28.1	27.8
102	27 52	279	221	29 40	99	44	84.8	29.1	28.1
103	26 42	279	222	28 58	99	44	86.6	30.2	28.4
104	25 31	279	222	28 15	99	44	88.4	31.2	28.7
105	11 24 17	279	222	12 27 30	99	44	90.2	32.3	29.0
106	23 1	279	223	26 42	99	44	92.0	33.3	29.3
107	21 43	279	223	25 58	99	45	93.8	34.4	29.6
108	20 23	279	223	25 2	99	45	95.8	35.4	29.8
109	19 2	278	224	24 10	99	45	97.6	36.4	30.1
110	11 17 38	278	224	12 23 15	98	45	99.4	37.4	30.3
111	16 14	278	225	22 19	98	45	101.2	38.4	30.6
112	14 47	278	225	21 22	98	46	103.0	39.4	30.8
113	13 19	278	226	20 23	98	46	104.6	40.4	31.0
114	11 50	278	226	19 22	98	46	106.3	41.3	31.2
115	11 10 20	278	227	12 18 20	98	46	108.0	42.2	31.4
116	8 48	278	227	17 17	98	47	109.7	43.2	31.6
117	7 15	278	228	16 12	98	47	111.2	44.1	31.8
118	5 42	277	228	15 6	98	47	112.9	45.0	32.0
119	4 7	277	229	13 59	98	48	114.5	45.8	32.2
120	11 2 32	277	230	12 12 51	98	48	116.0	46.7	32.4
121	11 0 55	277	230	11 42	98	48	117.5	47.6	32.5
122	10 59 18	277	231	10 32	97	48	119.0	48.4	32.7
123	57 41	276	232	9 21	97	49	120.5	49.2	32.8
124	56 3	276	233	8 8	97	49	121.9	50.0	32.9
125	10 54 24	276	234	12 6 55	97	50	123.1	50.8	33.0

TABLE X.

REDUCTIONS FOR POINTS IN THE PATH OF THE TOTAL PHASE, BUT NOT ON THE CENTRAL LINE, TO BE APPLIED TO CENTRAL LINE DATA TO OBTAIN TIMES OF CONTACTS.

For points north of the central line the reductions are negative.
For points south of the central line the reductions are positive.

(*a*) To obtain Greenwich Mean Time of First Contact.

Long. \ Diff. of Lat.	0′	2′	4′	6′	8′	10′	12′	14′	16′	18′	20′	22′	24′	26′	28′
°	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
80	0	2	5	7	9	12	14	16	19	21	23	26	28	30	33
85	0	3	5	8	10	13	15	18	20	23	26	28	31	33	36
90	0	3	5	8	11	14	16	19	22	25	27	30	33	36	38
95	0	3	6	9	12	14	17	20	23	26	29	32	35	37	40
100	0	3	6	9	12	15	18	21	24	27	30	33	36	38	41
105	0	3	6	9	12	15	18	21	24	27	30	33	36	38	41
110	0	3	6	8	11	14	17	20	23	25	28	31	34	37	39
115	0	3	5	8	10	13	15	18	21	23	26	28	31	34	36
120	0	2	4	7	9	11	13	15	18	20	22	24	26	29	31
125	0	2	3	5	7	8	10	12	14	15	17	19	20	22	24

(*b*) To obtain Greenwich Mean Time of Second Contact at points north of Central Line, or of Third Contact at points south of Central Line.

Long. \ Diff. of Lat.	0′	2′	4′	6′	8′	10′	12′	14′	16′	18′	20′	22′	24′	26′	28′
°	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
80	0	2	4	5	6	7	7	7	6	3	..	..	..	..	..
85	0	2	4	6	7	8	9	9	9	8	5	..	..	..	..
90	0	2	5	7	8	10	11	12	12	12	11	8	..	..	..
95	0	3	5	7	9	11	12	13	14	14	14	13	10	..	..
100	0	3	5	8	10	12	13	15	16	17	17	16	15	12	..
105	0	3	6	8	10	12	14	16	17	18	18	18	17	15	11
110	0	3	6	8	11	13	14	16	17	18	18	18	18	16	12
115	0	3	6	8	10	12	14	16	17	18	18	18	17	15	12
120	0	3	5	8	10	12	13	14	15	16	16	15	14	12	8
125	0	3	5	7	9	10	11	12	13	13	13	12	10	7	2

(*c*) To obtain Greenwich Mean Time of Second Contact at points south of Central Line, or of Third Contact at points north of Central Line.

Long. \ Diff. of Lat.	0′	2′	4′	6′	8′	10′	12′	14′	16′	18′	20′	22′	24′	26′	28′
°	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
80	0	2	5	7	10	14	18	22	27	34	..	..	..	..	..
85	0	2	5	8	11	15	19	23	28	34	41	..	..	..	..
90	0	3	5	9	12	16	20	24	28	34	40	48	..	..	..
95	0	3	6	9	13	16	21	25	30	35	40	47	55	..	..
100	0	3	6	10	13	17	22	26	31	36	42	48	55	64	..
105	0	3	7	10	14	18	22	27	32	37	43	49	56	64	75
110	0	3	7	10	14	18	23	27	32	38	44	50	57	65	74
115	0	3	7	10	14	18	23	28	32	38	44	50	57	65	74
120	0	3	6	10	14	18	22	27	32	37	43	50	56	65	74
125	0	3	6	9	13	17	21	26	30	36	42	48	55	63	73

TABLE X.

REDUCTIONS FOR POINTS IN THE PATH OF THE TOTAL PHASE, BUT NOT ON THE CENTRAL LINE, TO BE APPLIED TO CENTRAL LINE DATA TO OBTAIN TIMES OF CONTACTS.

For points north of the central line the reductions are negative.
For points south of the central line the reductions are positive.

(*d*) To obtain Greenwich Mean Time of Fourth Contact.

Long. \ Diff. of Lat.	0′	2′	4′	6′	8′	10′	12′	14′	16′	18′	20′	22′	24′	26′	28′
°	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
80	0	2	4	5	7	9	11	13	14	16	18	20	22	23	25
85	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28
90	0	2	4	7	9	11	13	16	18	20	22	24	27	29	31
95	0	2	5	7	10	12	15	17	20	22	24	27	29	32	34
100	0	3	5	8	11	13	16	19	21	24	27	29	32	35	37
105	0	3	6	9	11	14	17	20	23	26	29	31	34	37	40
110	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42
115	0	3	6	9	12	16	19	22	25	28	31	34	37	41	44
120	0	3	6	9	13	16	19	22	25	28	32	35	38	41	44
125	0	3	6	9	13	16	19	22	25	28	31	35	38	41	44

TABLE XI.

REDUCTIONS FOR POINTS IN THE PATH OF THE TOTAL PHASE, BUT NOT ON THE CENTRAL LINE, TO BE APPLIED TO CENTRAL LINE DATA TO OBTAIN POSITION ANGLES AT SECOND AND THIRD CONTACTS.*

For points north of the central line the reductions are negative for second contact and positive for third contact.

For points south of the central line the reductions are positive for second contact and negative for third contact.

Long. \ Diff. of Lat.	0′	2′	4′	6′	8′	10′	12′	14′	16′	18′	20′	22′	24′	26′	28′
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
80	0	6	12	18	24	31	38	46	56	69	..	..	..	..	..
85	0	5	11	16	22	28	34	41	48	57	68	..	..	..	..
90	0	5	10	15	20	25	30	36	42	49	57	68	..	..	..
95	0	4	9	13	18	23	28	33	38	44	51	58	68	..	..
100	0	4	8	12	17	21	26	30	35	40	46	52	60	70	..
105	0	4	8	12	16	20	24	29	33	38	43	49	55	63	73
110	0	4	8	11	15	19	23	28	32	37	41	47	53	59	68
115	0	4	7	11	15	19	23	27	31	36	40	46	51	58	65
120	0	4	7	11	15	19	23	27	31	36	40	45	51	57	65
125	0	4	7	11	15	19	23	27	31	36	40	45	51	57	65

*NOTE.—The reductions for first and fourth contacts never exceed one degree.

The Duration of the Total Phase for points not on the central line is given by the formula—

$$D=T\sqrt{1-\frac{b^2}{a^2}}$$

where

T=duration at nearest point of central line;
b=distance in miles from central line;
a=one-half the width of path through given point (last column, Table IX).

USE OF TABLES X AND XI.

The vertical argument is the longitude of the given place, the horizontal argument the distance of the given place north or south of that point of the central line of which the longitude is the same as that of the given place.

Example.—Find the times and position angles of the contacts for Jackson, Miss., whose position is—

Longitude 90° 11′.1=90°.185 west of Greenwich.
Latitude +32° 20′.0=16′.4 south of central line.

	1st Contact.	2d Contact.	3d Contact.	4th Contact.
	h m s	h m s	h m s	h m s
Table IX (Central Line Data) .	10 34 46	11 37 24	11 38 29	12 35 1
Table X	+ 23	+ 29	+ 12	+ 18
Greenwich Mean Time . . .	10 35 9	11 37 53	11 38 41	12 35 19
	°	°	°	°
Table IX (Central Line Data) .	280	99	279	99
Table XI, and Note . . .	0	+43	−43	0
Angle from North Point . .	280	142	236	99
	°	°	°	°
Table IX (Central Line Data) .	215	38	218	42
Table XI, and Note . . .	0	+43	−43	0
Angle from Vertex . . .	215	81	175	42

TABLE XII.

LOCAL CIRCUMSTANCES.

Place.	Beginning.			Middle.		Ending.		
	Greenwich Mean Time.	Angle from North Point.	Angle from Vertex.	Greenwich Mean Time.	Magnitude.	Greenwich Mean Time.	Angle from North Point.	Angle from Vertex.
	h m	°	°	h m		h m	°	°
Albany, N. Y.	10 30	256	206	11 23	0.64	12 14	118	74
Allegheny, Pa.	10 30	263	208	11 27	0.74	12 20	113	66
Amherst, Mass. . . .	10 30	256	205	11 24	0.64	12 13	119	75
Ann Arbor, Mich. . .	10 26	263	210	11 25	0.74	12 20	113	66
Appleton, Wis. . . .	10 21	263	212	11 22	0.75	12 18	113	66
Atlanta, Ga.	10 36	274	212	11 36	0.92	12 32	103	49
Augusta, Me.	10 29	252	204	11 20	0.58	12 8	122	80
Austin, Tex.	10 34	288	220	11 40	0.87	12 39	92	30
Baton Rouge, La. . .	10 37	283	216	11 40	0.95	12 38	96	37
Berkeley, Cal. . . .	9 49	290	240	11 10	0.79	12 22	86	27
Bismarck, N. Dak. . .	10 7	266	219	11 14	0.81	12 16	109	62
Boise City, Idaho . .	9 51	278	233	11 8	0.99	12 18	97	45
Buffalo, N. Y. . . .	10 28	259	207	11 24	0.69	12 16	116	71
Cambridge, Mass . .	10 31	255	205	11 23	0.63	12 12	119	76
Carson City, Nev. . .	9 52	286	237	11 11	0.85	12 22	90	32
Charleston, W. Va. . .	10 32	266	210	11 30	0.80	12 24	110	60
Charlottesville, Va. . .	10 33	265	208	11 30	0.77	12 23	111	62
Cheyenne, Wyo. . . .	10 10	276	222	11 21	0.97	12 25	101	48
Cincinnati, Ohio . . .	10 29	267	211	11 30	0.81	12 24	110	60
Cleveland, Ohio . . .	10 28	262	209	11 26	0.74	12 20	113	66
Columbia, Mo.	10 25	272	215	11 29	0.89	12 28	105	53
Columbia, S. C. . . .	10 37	272	211	11 36	0.88	12 30	105	52
Columbus, Ohio . . .	10 29	265	210	11 28	0.78	12 23	111	62
Denver, Colo.	10 12	278	222	11 24 [1]	1.01 [1]	12 27	99	44
Des Moines, Iowa . .	10 20	269	215	11 25	0.85	12 24	107	57
Dover, Del.	10 33	262	207	11 28	0.72	12 20	114	67
Evanston, Ill.	10 24	265	212	11 25	0.78	12 22	111	63
Flagstaff, Ariz. . . .	10 11	289	227	11 26	0.83	12 32	89	29
Geneva, N. Y.	10 28	258	207	11 24	0.67	12 15	117	72
Greencastle, Ind. . . .	10 28	268	212	11 29	0.82	12 25	109	59
Hanover, N. H. . . .	10 29	254	205	11 22	0.61	12 11	120	77
Harrisburg, Pa. . . .	10 31	261	207	11 27	0.72	12 19	114	68
Helena, Mont.	9 54	272	229	11 8	0.92	12 15	103	55
Honolulu, Hawaii . .	9 1	331	61	9 45	0.09	10 30	23	203
Iowa City, Iowa . . .	10 22	268	214	11 25	0.83	12 23	108	59
Ithaca, N. Y.	10 29	258	206	11 24	0.67	12 16	117	72
Jackson, Miss.	10 35	280	215	11 38 [2]	1.00 [2]	12 35	98	42
Juneau, Alaska . . .	9 15	258	254	10 29	0.77	11 40	108	79
Kansas City, Mo. . . .	10 23	273	216	11 28	0.91	12 28	104	51
Little Rock, Ark. . .	10 30	278	216	11 35	0.99	12 33	100	45
Louisville, Ky. . . .	10 30	269	212	11 31	0.84	12 26	108	57
Madison, Wis.	10 22	265	212	11 24	0.78	12 20	111	63
Minneapolis, Minn. . .	10 16	265	214	11 20	0.78	12 18	111	64
Montgomery, Ala. . .	10 37	277	213	11 38	0.97	12 34	101	45
Mount Hamilton, Cal. .	9 51	290	238	11 12	0.78	12 23	86	26

[1] Duration of totality $1^m.5$. [2] Duration of totality $0^m.8$.

TABLE XII.

LOCAL CIRCUMSTANCES.

Place.	Beginning.			Middle.		Ending.		
	Greenwich Mean Time.	Angle from North Point.	Angle from Vertex.	Greenwich Mean Time.	Magnitude.	Greenwich Mean Time.	Angle from North Point.	Angle from Vertex.
	h m	°	°	h m		h m	°	°
Mount Wilson, Cal.	10 3	294	233	11 21	0.74	12 29	84	21
Nashville, Tenn.	10 32	273	212	11 34	0.90	12 30	105	52
New Haven, Conn.	10 31	258	206	11 25	0.66	12 15	117	73
New Orleans, La.	10 38	283	216	11 41	0.95	12 38	96	37
New York, N. Y.	10 32	259	206	11 26	0.68	12 16	116	71
Nome, Alaska	8 49	246	265	9 55	0.63	11 2	111	111
Oklahoma City, Okla.	10 26	280	218	11 33	0.99	12 33	98	42
Omaha, Nebr.	10 19	271	216	11 25	0.88	12 25	106	55
Orono, Me.	10 29	251	203	11 19	0.56	12 7	123	82
Oxford, Miss.	10 33	277	214	11 36	0.96	12 33	101	46
Panama, Panama	11 8	308	226	....	...	....	...	...
Philadelphia, Pa.	10 32	261	207	11 27	0.71	12 18	115	68
Phoenix, Ariz.	10 13	292	228	11 28	0.79	12 33	87	25
Pierre, S. Dak.	10 11	269	219	11 18	0.86	12 20	107	58
Portland, Oreg.	9 38	277	243	10 58	0.99	12 11	96	46
Poughkeepsie, N. Y.	10 31	258	206	11 25	0.66	12 15	117	70
Raleigh, N. C.	10 36	268	209	11 33	0.82	12 26	109	58
Richmond, Va.	10 34	265	208	11 31	0.77	12 23	111	62
Sacramento, Cal.	9 50	288	239	11 10	0.82	12 22	88	30
Salt Lake City, Utah	10 1	280	228	11 17	0.97	12 24	96	42
San Juan, P. R.	10 52	284	213	....	...	....	...	...
Santa Fe, N. Mex.	10 17	285	223	11 29	0.91	12 33	94	35
Seattle, Wash.	9 37	273	243	10 56	0.98	12 8	99	52
Springfield, Ill.	10 26	269	213	11 28	0.85	12 25	108	57
St. Louis, Mo.	10 27	271	214	11 30	0.88	12 27	106	54
Syracuse, N. Y.	10 28	258	206	11 23	0.66	12 14	118	73
Tallahassee, Fla.	10 40	279	213	11 40	0.99	12 35	99	43
Topeka, Kans.	10 22	274	216	11 28	0.93	12 28	103	50
Tuscaloosa, Ala.	10 35	277	214	11 37	0.97	12 34	101	46
Ukiah, Cal.	9 46	288	242	11 7	0.82	12 20	87	30
Urbana, Ill.	10 26	268	212	11 28	0.83	12 25	108	58
Washington, D. C.	10 33	263	208	11 29	0.74	12 21	113	65
Williams Bay, Wis.	10 23	265	212	11 24	0.78	12 21	111	63

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B.

CHART I

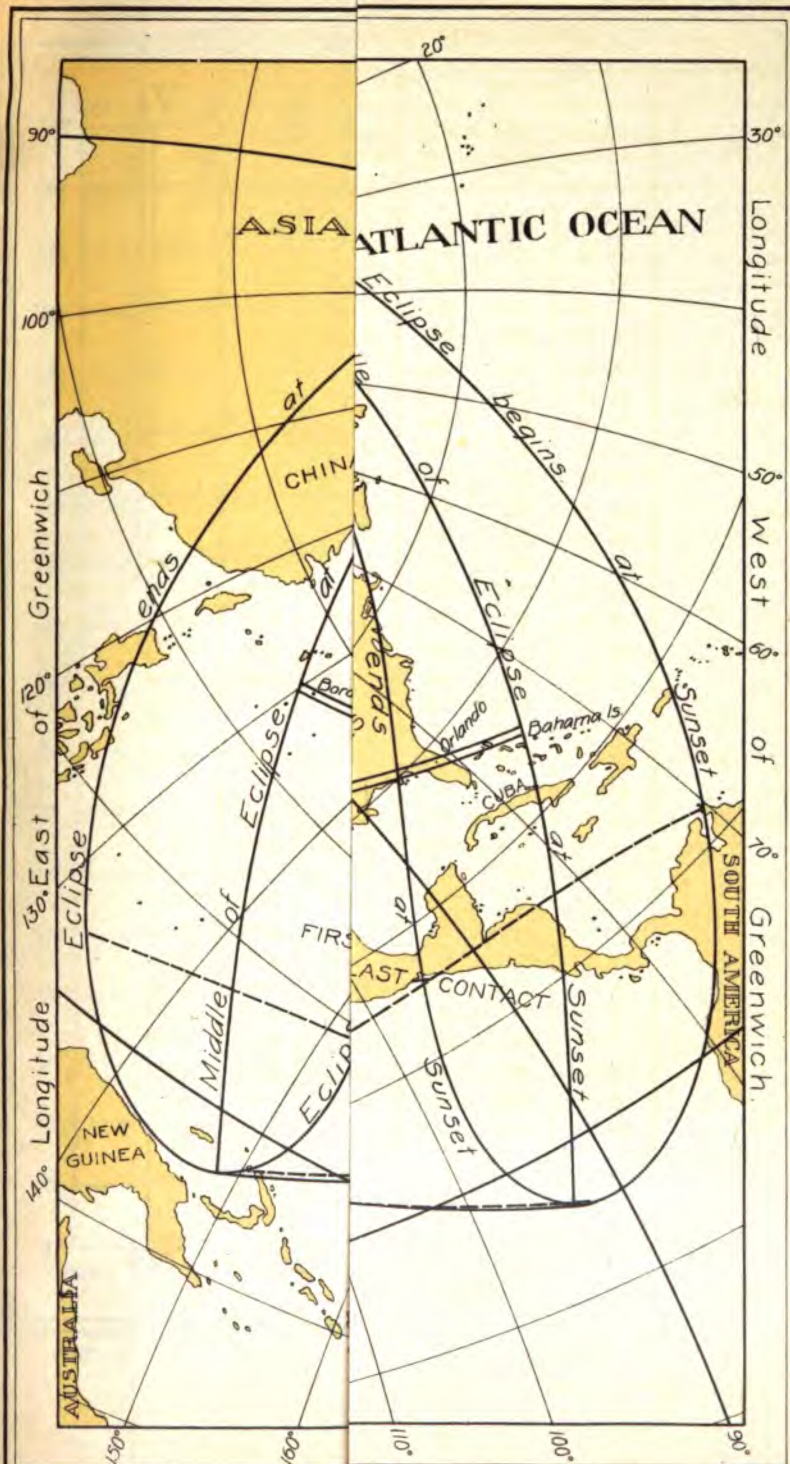

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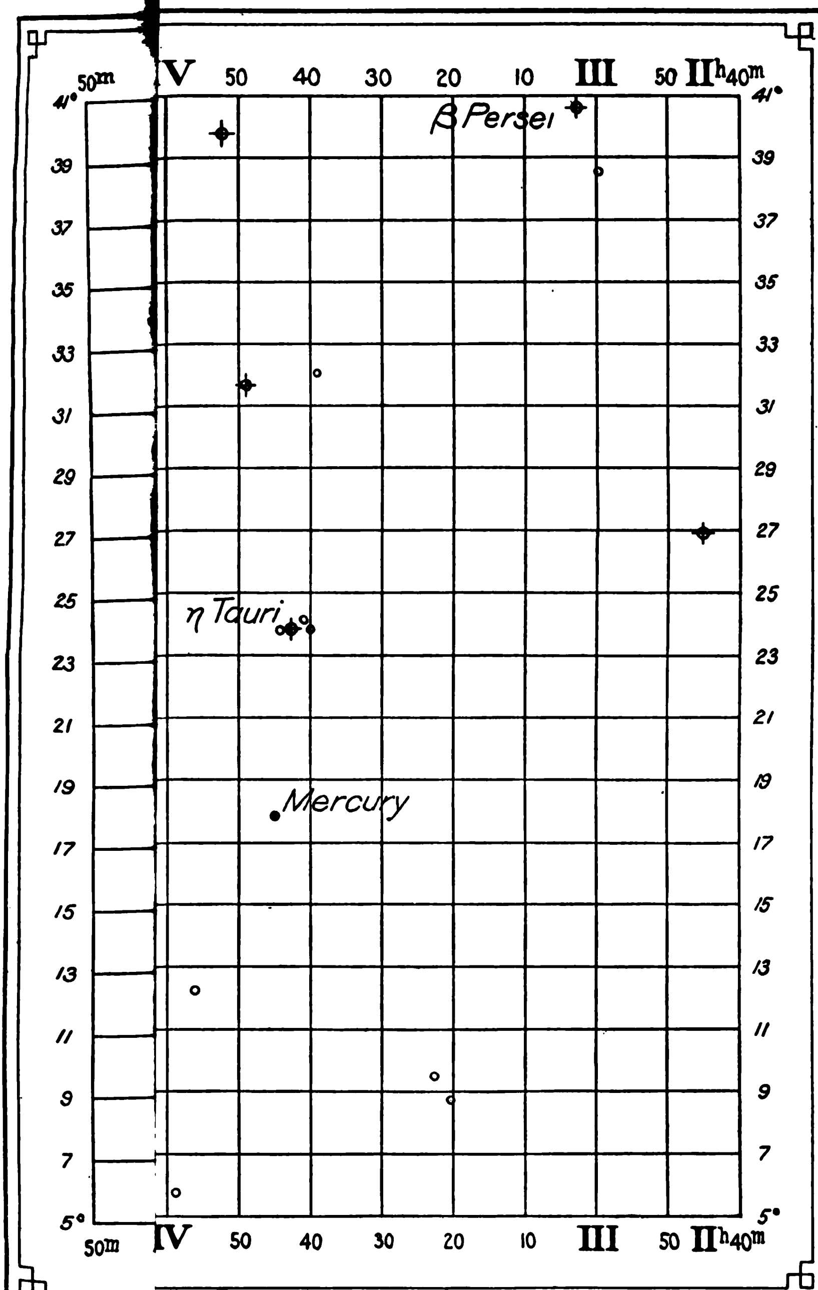
CHART II.



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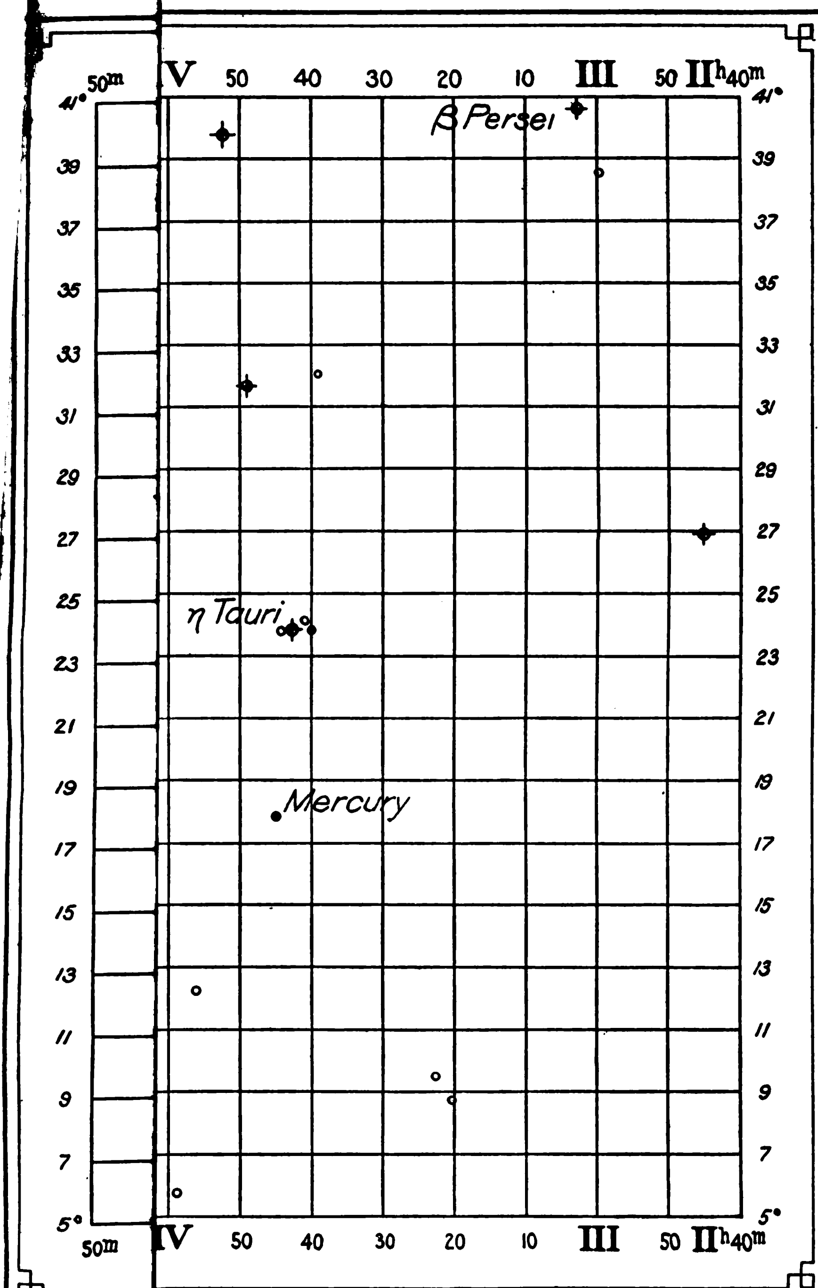

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