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E. LESTER JONES, SUPERINTENDENT

GEODESY

FORMULÆ AND TABLES FOR THE COMPUTATION OF GEODETIC POSITIONS

SPECIAL PUBLICATION No. 8
SIXTH EDITION

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CONTENTS.

	Page.
Introductory remarks	5
Solution of triangles	6
Spherical excess	7
Number of figures in angles and lengths	7
Computation of differences of latitude, longitude, and azimuth	8
Examples of computation:	
Computation of triangles	11
Primary position	12
Secondary position	14
Inverse solution	15
Table I.—Values of log m	16
Table II.—Corrections to log $\Delta\lambda$ for difference in arc and sine	17
Table III.—Values of log sec $1/2\ (\Delta\phi)$	18
Table IV.—Conversion table	18
Constants for the reference spheroid	19
Table V.—Logarithms of factors A', B, C, D, E, and F	19
Appendix.—Historical notes and formulas	92

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FORMULÆ AND TABLES FOR THE COMPUTATION OF GEODETIC POSITIONS.

INTRODUCTORY REMARKS.

The supply being exhausted of Special Publication No. 8, "Formulæ and Tables for the Computation of Geodetic Positions" (fifth edition), the present edition is made necessary. As stated in the fifth edition, the tables now include the extension from latitude 18° to the Equator, which was published as Appendix No. 4, U. S. Coast and Geodetic Survey Report for 1901. The present tables, therefore, extend from the Equator to latitude 72°.

When the fifth edition was published a new preface was written and the historical notes and the development of formulæ as given in the fourth edition were omitted. It is frequently desirable to refer to these formulæ, and it has been thought advisable to replace them in this edition of the publication. The material in question will be found in an appendix at the end of the publication. There has also been inserted in the appendix a simple derivation of the formula for spherical excess.

One question that called for decision before printing a new edition of these tables was whether our present knowledge of the size and shape of the earth justified any change in the reference spheroid. When the change was made in 1880 from the Bessel spheroid to the Clarke spheroid of 1866, as expressed in meters, the major axis was increased by about 1 part in 8 000 and the minor axis by about 1 part in 13 000, the newly adopted spheroid being larger and flatter. In "Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy," page 77, Hayford gets values for the major and minor axes of the earth which are larger than the Clarke values of 1866 by about 1 part in 35 000 and 20 000, respectively. It is thus seen that the spheroid which most nearly fits the geoid surface in the United States is larger than the Clarke spheroid of 1866, but with a flattening lying between that of Clarke and of Bessel. The change from Clarke to Hayford is not demanded with the same force as was the change from Bessel to Clarke. Expediency weighs heavily against any change on account of the immense amount of labor involved in transforming the large number of trigonometric points already developed on the Clarke spheroid. For all questions of geograhpy and of geodesy the Clarke spheroid answers every practical requirement. However, it is desirable in dealing with the scientific problem of the figure of the earth that with each new accession of data a new spheroid fitting the geoid with the greatest possible accuracy should be derived. It may be remarked here that European countries are still using the Bessel spheroid, though in many of these countries a better fitting spheroid

could be adopted. Besides the reasons given above for no present change in this country, the Europeans have the additional argument of the existence of extensive tables based on the Bessel spheroid, such as Albrecht's, for example.

The dimensions of the adopted spheroid, the Clarke spheroid of 1866 as expressed in meters, will be found on page 19.

Recent progress in the invention and improvement of calculating machines brings up a question as to the possibility of arranging these tables for machine computing instead of preserving the previous form for logarithmic work. Where the number of factors in a product is more than two, the only mechanical device in use at present that compares in speed with the use of logarithms is the slide rule. The best forms of this instrument in present use are limited to numbers of four or five figures, while the work for which these tables are designed generally calls for seven figures. So it again appears that modern progress has not yet reached a point where a change is required.

SOLUTION OF TRIANGLES.

The triangle on the spheroid is solved by the application of the Legendre theorem. That is, one-third of the spherical excess is subtracted from each angle of the spheroidal triangle, the resulting angles being the angles of a plane triangle whose sides are approximately equal in length to the sides of the triangle on the spheroid.

The angle at each vertex of the spheroidal triangle is the angle between the two vertical planes at that vertex passed respectively through the sea-level projection of each of the other two vertices. Reduction is thus made for elevation above the *geoid* and not above the *spheroid*, for object sighted upon. Horizontal angles and directions are not reduced for local deflection of the vertical, for horizontal refraction, or for difference of direction between vertical section and geodetic (shortest) line. Nor are bases reduced for difference of elevation between geoid and spheroid. These refinements of computation, amounting generally to less than the uncertainties of errors of observation, remain to be applied at some future time as a second approximation to the primary triangulation in the United States.

For two points, A_1 and B_1 on the spheroid, the plane which contains the normal at A_1 and passes through B_1 intersects the spheroid in a plane curve, which may be called the vertical section from A_1 to B_1. The vertical section from B_1 to A_1 is determined by the plane which contains the normal at B_1 and passes through A_1. These two vertical sections do not coincide, except in particular cases, so it is not strictly accurate to say that a triangle is formed on the spheroid by the vertical sections joining three points. There are eight triangles actually formed, the sides and angles of any one differing extremely little from the corresponding sides and angles of any other, for triangles that actually enter into geodetic work—that is, for triangles whose vertices are intervisible. This ambiguity is entirely independent of that arising from extending the lines completely around the earth. The latter ambiguity does not occur in practical application to intervisible points. The fact that horizontal directions are not reduced to the direction of geodetic lines is the source of the above difficulty, but the effect on the resulting lengths is small, being well within the uncertainty due to errors of observation. The error in length due to this cause can not accumulate, since the lengths of the controlling bases do not require a corresponding correction. The effect on the azimuth is small and also well within the uncertainties arising from errors of observation.

SPHERICAL EXCESS.[a]

The spherical excess is computed by the formula:

$$\varepsilon = \frac{a_1 b_1 \sin C_1 (1 - e^2 \sin^2 \phi)^2}{2a^2(1 - e^2) \sin 1''} = a_1 b_1 \sin C_1 \times m$$

In this formula ε is the spherical excess; a_1 b_1 and C_1 are two sides and the included angle, respectively, of the corresponding triangle; e^2 is the square of the eccentricity, and a the major semiaxis of the spheroid of reference; and ϕ is the mean latitude of the three vertices of the triangle. That part of the above expression which depends only on the latitude and the dimensions of the spheroid may be designated by a single letter, m, as shown. In Table I, page 16, the logarithms of m are given with the latitude as an argument.

The above formula gives the spherical excess too small by one one-hundredth of a second for an equilateral triangle with 200-kilometer sides, or for a nonequilateral triangle of the same area. For an equilateral triangle of 100-kilometer sides, or an equivalent nonequilateral triangle, the excess as given by this formula is too small by less than one one-thousandth of a second.

In cases where a more accurate value of the spherical excess is required the formulæ given on page 51 of Special Publication No. 4 ("The Transcontinental Triangulation") may be used. These formulæ give a slightly unequal distribution of the spherical excess among the three angles of the triangle.

NUMBER OF FIGURES IN ANGLES AND LENGTHS.

According to present practice in the Coast and Geodetic Survey, directions, angles, and azimuths are computed to the hundredth of the sexagesimal second for primary triangulation and to the tenth for secondary and tertiary work. This gives from one to two uncertain figures in the corresponding values—the uncertainties due to errors of observation—and appears to be as much as can reasonably be required of the computation at the present time.

The logarithms of the lengths, expressed in meters, are given to seven decimal places for the primary lines and to six places for secondary and tertiary lines. The lengths being computed from the angles, it is best to use seven decimal places in the lengths with hundredths of seconds in the angles and six places with tenths of seconds. In reasonably well-shaped triangles this secures against the introduction of accumulated error in the last decimal place of the logarithms of the lengths due to those small accumulations in the last decimal place of the angles which arise from rounding off to the last place used. In other words, no uncertainty is introduced into the last figure of the lengths by the computing except the unavoidable accumulation due to rounding off.

An uncertainty of a unit in the fifth decimal place of the logarithm is equivalent to an uncertainty of 1 part in 43 000, while one in the sixth place corresponds to 1 part in 434 000. The base lines are scarcely more accurate than the latter ratio; so it follows at once that even for the most accurate primary triangulation the logarithms of the lengths are surely uncertain in the sixth and seventh places, and in some cases the fifth place may be uncertain by as much as a unit. Therefore it may be said that in the use of seven decimals in the logarithms for the primary lines from two to three of the

[a] See Appendix, at the end of this publication.

last figures are uncertain, and with the use of six decimals for secondary and tertiary lines the last two figures are uncertain.

In passing from the logarithm to the corresponding number the uncertainty in the logarithm is, in general, reproduced by the same amount in the corresponding figure of the number. For example, an uncertainty of one in the sixth decimal of the logarithm gives rise to an uncertainty of one in the sixth figure of the number. The counting is from the left to the right in the number, beginning with the first significant figure. This correspondence for figures in the same place in the logarithm and in the number is exact for numbers whose first figures are 434 . . . . For all numbers from 100 . . . . to 434 . . . . the uncertainty in the derived numbers is less than the uncertainty in the corresponding figure of the logarithm, being only about one-fourth as much for the former numbers. From 434 . . . . to 999 . . . . the uncertainty in the derived numbers is greater than the uncertainty in the corresponding figure of the logarithm, being about two and one-half times as great in the latter numbers. On the whole, then, the numbers should be written out to as many significant figures as there are decimal places in the logarithms from which they are derived, and the uncertainties will be about the same for corresponding figures. If this rule were followed out, it could always be said that there were two uncertain figures in the given lengths. The length of the lines varies between such wide limits, however, that the application of such a rule would give a nonuniform appearance to the results, so the practice in the Coast and Geodetic Survey is to give the lengths to two decimal places (centimeters) for the primary lines and to one decimal place for the secondary and tertiary lines.

COMPUTATION OF DIFFERENCES OF LATITUDE, LONGITUDE, AND AZIMUTH.

The problem is, given the latitude and longitude of a point A_1 and the azimuth and distance from A_1 to B_1, to determine the latitude and longitude of B_1 and the azimuth from B_1 to A_1. The distance here used is the side of a triangle, computed as explained above, and the azimuth is the angle the vertical section makes with the meridian, measured clockwise from the south up to 360°. The meridian referred to is not the directly observed meridian, but is one carried to the point in question through the triangulation and is, in general, based on many directly observed astronomic azimuths. It is customary in the Coast and Geodetic Survey to speak of this azimuth as the geodetic azimuth, meaning the azimuth of the vertical section as carried through the triangulation and having no reference to the azimuth of the geodetic (shortest) line. The formulæ used in the solution of the above problem are as follows:

(1) $$-\Delta\phi = s \cos\alpha \,.\, B + s^2 \sin^2\alpha \,.\, C + (\delta\phi)^2 D - h\, s^2 \sin^2\alpha \,.\, E - 1/2\, s^2 k E + 3/2\, s^2 \cos^2\alpha \,.\, k E + 1/2\, s^2 \cos^2\alpha \sec^2\phi\, A'^2 k \sin^2 1'';$$

(2) $$\operatorname{Sin} \Delta\lambda = \sin\frac{s}{N'} \sec\phi' \sin\alpha;$$

or $$\log \Delta\lambda = \log s + C_{\log \Delta\lambda} - C_{\log s} + \log \sin\alpha + \log A' + \log \sec\phi';$$

(3) $$-\tan 1/2\,(\Delta\alpha) = \tan 1/2\,(\Delta\lambda) \frac{\sin 1/2(\phi' + \phi)}{\cos 1/2(\phi' - \phi)};$$

or $$-\Delta\alpha = \Delta\lambda \sin 1/2\,(\phi' + \phi) \sec 1/2\,(\Delta\phi) + (\Delta\lambda)^3 F.$$

In (1) the following abbreviations are made:

$$h = s \cos \alpha \,.\, B;$$
$$-\delta\phi = s \cos \alpha \,.\, B + s^2 \sin^2 \alpha \,.\, C - h\, s^2 \sin^2 \alpha \,.\, E;$$
$$k = s^2 \sin^2 \alpha \,.\, C.$$

The symbols in the above expressions are as follows: ϕ and λ are the given latitude and longitude, respectively, of the point A_1; ϕ' and λ' represent the required latitude and longitude, respectively, of the point B_1; s is the distance from A_1 to B_1; α is the azimuth of the vertical section from A_1 to B_1, and α' is the azimuth of the vertical section from B_1 to A_1; N' is the length of the normal at the point B_1. The differences of latitude, longitude, and azimuth are represented, respectively, by $\Delta\phi$, $\Delta\lambda$, and $\Delta\alpha$, and—

$$\phi' = \phi + \Delta\phi;$$
$$\lambda' = \lambda + \Delta\lambda;$$
$$\alpha' = \alpha + \Delta\alpha + 180°;$$

A', B, C, D, E, and F are factors depending on the dimensions of the reference spheroid and the latitude. The forms of these factors are shown on page 19, and their logarithms are given with the latitude as an argument in Table V.

Equation (1) gives the difference of latitude in the form of a power series of the distance. Although terms of the sixth order appear in this expression, it can not be said to be correct up to terms of the fourth order. This formula is limited in application both by latitude and by length of line. Latitudes near 90° are excluded since the tangent of the latitude enters into some of the coefficients. For a required degree of accuracy in $\Delta\phi$—for example, that the third decimal place of the seconds shall be correct, according to usage in the Coast and Geodetic Survey—the length of line to which (1) is applicable is limited accordingly. In Appendix No. 7, Coast and Geodetic Survey Report for 1896, page 303, it is stated that (1) and (2) should not be applied to lines of greater length than 75 kilometers if the results are required to be correct to 0″.001. When this statement was made the terms of the fourth order were not included in (1), and the statement seems to have allowed considerable margin for safety.

Equation (2) gives $\Delta\lambda$ by the solution of a spherical triangle. In passing to the second form, which is more convenient for computing, corrections are given for the second term in the reduction from the logarithm of the sine to the logarithm of the arc. The form of this correction for $\Delta\lambda$ is $\frac{M}{6} \sin^2 1''(\Delta\lambda)^2$, in which M is the modulus of the common system of logarithms, and $\Delta\lambda$ is expressed in seconds; the form for s is $\frac{M}{6} s^2 A'^2 \sin^2 1''$, in which s is in meters and A' is the factor given in (2). This factor is written with the prime accent to emphasize the fact that in the use of (2) it is to be taken from the tables for the latitude ϕ' and not ϕ. In Table II the exact correction to the logarithm of $\Delta\lambda$ is placed in the middle, while just opposite on the right is the corresponding logarithm of $\Delta\lambda$ to three decimal places, and opposite on the left is the corresponding logarithm of s to three places. The correction for log $\Delta\lambda$ is always positive and that for log s is always negative. In tabulating the correction for log s an average value ($\bar{8}$.509) was taken for log A'. The correction can not be in error on this account as

much as one in the seventh place for any latitude from 0° to 72°, as long as the line does not exceed 100 kilometers in length. In forming length equations in triangulation adjustment the correction for reduction from arc to sine is taken from Table II for log s and is, of course, always negative in this case.

Formulæ (1) and (2) do not give results correct to 0''.001 in $\Delta\phi$ and $\Delta\lambda$ for lines approaching 100 kilometers in length or greater. Nevertheless the error is not more than two or three in the third decimal of the seconds for lines up to about 120 kilometers, and in general the errors due to the limitations of the formulæ are not greater for these lengths than the uncertainty arising from the use of only seven decimal places in the computations.

Formula (3) is the application of Dalby's theorem. There can be no question of the accuracy of the second decimal place of the seconds in $\Delta\alpha$, derived by the use of this formula, for any length of line for which (1) and (2) give results approximately correct to 0''.001. In passing to the second form of (3) account is taken of the second term in the expansion of tan $\frac{1}{2}\Delta\alpha$ and tan $\frac{1}{2}\Delta\lambda$, and an approximate value of the ratio of $\Delta\alpha$ to $\Delta\lambda$ is taken to derive the form of the factor F.

The formulæ (1), (2), and (3) are all arranged to give the results in seconds. An example is given on page 12 of the application to primary lines. The differences of latitude, longitude, and azimuth are computed for the two sides of a triangle, the base points of which are already known in latitude, longitude, distance, and mutual azimuths. The solution is also shown of the triangle upon which this example is based. The practice is to write the name of the new point first in the form for the computation of triangles, the known base points following in clockwise order. The two position computations from the two known extremities of the base to the as yet unknown position of the vertex of the triangle are made on two pages which face each other. The angle opposite the second name in the triangle computation is always entered on the left-hand page and is added to get the resulting azimuth from that point to the vertex. The third angle is placed on the right-hand page and always subtracted to get the resulting azimuth from the other base point. This rule of always writing the names and angles of the triangle in clockwise order and entering the angles and adding and subtracting in a specified way on the position computation forms is mechanical, but is conducive to accuracy and speed in computing. The latitude and longitude of the vertex of the triangle both appear on opposite pages, and an immediate check is furnished, while the two azimuths from the vertex back to the base points are checked if the azimuth on the right-hand page is equal to the sum of the azimuth on the left-hand page and the first angle of the triangle (called third angle in the 1911 edition of the position computation forms, which were used in the following sample computations).

In the examples given below, what is printed on the forms is indicated by roman type and italics, while the part filled in for the special computation is shown in bold-face type. No printed form is used for computing spherical excess, as it is a simple matter to add the logarithm from Table I to the three logarithms in the triangle computation, a preliminary computation of the triangle being sufficiently accurate for this purpose.

To apply these tables to the computation of positions south of the equator it is only necessary to bear in mind in using the formulæ that all south latitudes are negative. Wherever $\Delta\phi$, as computed in these formulæ, is negative, it indicates a numerical

increase in the latitude. In using the formulæ for $\Delta\alpha$ it should be noted that for the Southern Hemisphere the term $\sin \frac{1}{2}(\phi+\phi')$ is always negative, and therefore $\Delta\alpha$ and $\Delta\lambda$ always have the same sign in the Southern Hemisphere, whereas they have opposite signs in the Northern Hemisphere.

To apply these tables to the computation of positions in east longitude it is only necessary to consider that all east longitudes are negative.

In the logarithms given in the tables a minus sign over the characteristic indicates that 10 is to be subtracted from the characteristic as printed, and a double minus sign indicates that 20 is to be subtracted from the characteristic as printed.

EXAMPLES OF COMPUTATION.

Computation of triangles.

No.	Stations.	Observed angles.	Correction.	Spherical angles.	Spherical excess.	Plane angles.	Logarithms.
		° ′ ″	″	″	″	″	
	Marysville Butte to Kent						5.062 7330
1	**Lyons**	61 23 36.35	+0.43	36.78	9.17	27.61	0.056 5511
2	**Marysville Butte**	49 55 13.85	− .03	13.82	9.17	04.65	9.883 7314
3	**Kent**	68 41 37.45	− .54	36.91	9.17	27.74	9.969 2455
	Lyons to Kent						5.003 0155
	Lyons to Marysville Butte						5.088 5296

Position computation, primary triangulation.

		° ′ ″
α	**Marysville Butte** to **Kent**	137 16 41.00
$\angle$	**Kent** & **Lyons**	+ 49 55 13.82
α	2. **Marysville Butte** to 1. **Lyons**	187 11 54.82
$\Delta\alpha$		+ 6 56.03
α'	1. **Lyons** to 2. **Marysville Butte**	180 7 18 50.85
	Third angle of triangle	61 23 36.78

	° ′ ″			° ′ ″
ϕ	39 12 22.361	2. **Marysville Butte**	λ	121 49 11.540
$\Delta\phi$	+ 1 05 43.740		$\Delta\lambda$	− 10 50.533
ϕ'	40 18 06.101	1. **Lyons**	λ'	121 38 21.007

s	5.088 5296	s^2	0.17706			$-h$	3.5960
$\cos\alpha$	9.996 5633n	$\sin^2\alpha$	8.19596	$(\partial\phi)^2$	7.1918	$s^2\sin^2\alpha$	8.3730
B	8.510 9119	C	1.31615	D	2.3833	E	6.0878
h	3.596 0048n		9.68917		9.5751		8.0568
	″		″				
1st term	−3 944.6164	3d term	+0.3760			$(\Delta\lambda)^3$	8.440
2d term	+ .4888	4th term	+ .0114			F	7.871
	−3 944.1276						6.311
3d and 4th terms	+ .3874	s	5.088 5296				
		$\sin\alpha$	9.097 9799n	Arg.		$\Delta\lambda$	2.813 269n
$-\Delta\phi$	−3 943.7402	A'	8.509 1108	s	−268	$\sin\frac{1}{2}(\phi+\phi')$	9.805 835
	° ′ ″	$\sec\phi'$	0.117 6752	$\Delta\lambda$	+ 7	$\sec\frac{1}{2}(\Delta\phi)$	0.000 020
$\frac{1}{2}(\phi+\phi')$	39 45 14.23		−261	Corr.	−261		2.619 124n
			2.813 2694n				″
			″				{−416.030
		$\Delta\lambda$	−650.5330			$-\Delta\alpha$	.000

Position computation, primary triangulation.

		° ′ ″
α	Kent to Marysville Butte	316 41 36.16
$\angle$	Lyons & Marysville Butte	− 68 41 36.91
α	3. Kent to 1. Lyons	247 59 59.25
$\Delta\alpha$		+ 42 28.38
α'	1. Lyons to 3. Kent	180 68 42 27.63

	° ′ ″			° ′ ″
ϕ	39 58 01.752	3. Kent	λ	122 44 14.449
$\Delta\phi$	+ 20 04.349		$\Delta\lambda$	− 1 05 53.442
ϕ'	40 18 06.101	1. Lyons	λ'	121 38 21.007

s	5.003 0155	s^2	0.00603			$-h$	3.0874
$\cos\alpha$	9.573 5793n	$\sin^2\alpha$	9.93433	$(\partial\phi)^2$	6.1615	$s^2\sin^2\alpha$	9.9404
B	8.510 8543	C	1.32783	D	2.3856	E	6.1036
h	3.087 4491n		1.26819		8.5471		9.1314
	″		″				
1st term	−1 223.0637	3d term	+0.0353			$(\Delta\lambda)^3$	0.791
2d term	+ 18.5434	4th term	+0.1353			F	7.869
	−1 204.5203						8.660
3d and 4th terms	+ .1706	s	5.003 0155				
		$\sin\alpha$	9.967 1652n	Arg.		$\Delta\lambda$	3.596 975n
$-\Delta\phi$	−1 204.3497	A'	8.509 1108	s	−180	$\sin\frac{1}{2}(\phi+\phi')$	9.809 279
	° ′ ″	$\sec\phi'$	0.117 6752	$\Delta\lambda$	+267	$\sec\frac{1}{2}(\Delta\phi)$	0.000 002
$\frac{1}{2}(\phi+\phi')$	40 08 03.93						
			+87	Corr.	+ 87		3.406 256n
			3.596 9754n				″
			″				−2 548.33
		$\Delta\lambda$	−3 953.4423			$-\Delta\alpha$	− .05

For subordinate triangulation when the sides do not exceed, say, 25 kilometers, or about 15 miles, the term involving E in $\Delta\phi$ and the factor sec $\frac{1}{2}\Delta\phi$, as well as the term involving F in $\Delta\alpha$, may be omitted. The number of decimal places used in computing the small terms of $\Delta\phi$ may be reduced for this class of triangulation, as is shown in the example given below. Only one side of the double computation is shown in this case, though in practice the computation is always made for the two sides of the triangle in order to have complete checks.

Position computation, secondary triangulation.

			° ′ ″
α	Sand Point to	La Salle	8 43 54.0
$\angle$	La Salle &	Indianola	+44 46 17.3
α	2 Sand Point to 1	Indianola	53 30 11.3
$\Delta\alpha$			— 1 54.7
			180 00 00.0
α'	1 Indianola to 2	Sand Point	233 28 16.6
		Third angle of triangle	77 56 09.6

	° ′ ″			° ′ ″
ϕ	28 35 02.377	2 Sand Point	λ	96 26 59.604
$\Delta\phi$	— 2 36.805		$\Delta\lambda$	+ 3 59.900
ϕ'	28 32 25.572	1 Indianola	λ'	96 30 59.504

$\frac{1}{2}(\phi+\phi')$	° ′ ″ 28 33 44	s	3.909 175	s^2	7.818		
		$\cos\alpha$	9.774 355	$\sin^2\alpha$	9.810	h^2	4.39
		B	8.511 666	C	1.142	D	2.32
	″	h	2.195 196		8.770		6.71
1st term	+156.7458				.0589		.0005
2d and 3d terms	+ .0594						
$-\Delta\phi$	+156.8052						

s	3.909 175		
$\sin\alpha$	9.905 196		
A'	8.509 391	$\Delta\lambda$	2.38003
$\sec\phi'$	0.056 268	$\sin\frac{1}{2}(\phi+\phi')$	9.67953
	2.380 030		2.05956
	″		″
$\Delta\lambda$	+239.900	$-\Delta\alpha$	+114.7

The inverse problem.—Cases frequently occur where the distance and mutual azimuths are demanded for two points whose latitudes and longitudes only are known. It has not been found necessary to prepare special formulæ and blank forms for this computation, as it can be readily made with the help of the preceding forms. It is done by dividing $\Delta\lambda = s \sin\alpha \,.\, A' \sec\phi'$ by the first term for $\Delta\phi$, $h = s\cos\alpha \,.\, B$, whence we get—

$$\tan\alpha = \frac{\Delta\lambda B}{A' \sec\phi' h}$$

This would give the azimuth at once, provided we knew h, since $\Delta\lambda$ is given. We therefore compute the smaller terms for the difference of latitude in order to obtain h by

subtracting them from the known value of $\Delta\phi$. The only addition to the usual form is the term $\log \tan \alpha = \log (s \sin \alpha) - \log (s \cos \alpha)$. The value of s will best be taken from the term h when $\sin \alpha$ exceeds $\cos \alpha$, and from the term $\Delta\lambda$ when the reverse is the case. When the distance s is large, as in primary triangulation, it will be necessary to introduce the correction for $\Delta\lambda$ due to difference of ratio between sine and arc, using inversely the form for primary work.

The accuracy with which the length and azimuth can be derived from the given positions of the two points depends on the number of decimal places to which the seconds of the latitudes and longitudes are given, as well as on the length of the line. If the latitudes and longitudes are given to the third decimal place of the seconds, the length can be determined to within about 5 centimeters for any length of line to which the formulæ are applicable. The accuracy with which the azimuth is determined depends on the length of line, being more accurate for the longer lines.

Position computation, secondary triangulation.

INVERSE SOLUTION.

α	to					° ′ ″	
$\angle$	&					+	
α	2 **Sand Point** to 1 **Indianola**					53 30 11.5	
$\Delta\alpha$						− 1 54.7	
α'	1 **Indianola** to 2 **Sand Point** Third angle of triangle					*180 00 00.00* 233 28 16.8	
ϕ	° ′ ″ 28 35 02.377	2 **Sand Point**			λ	° ′ ″ 96 26 59.604	
$\Delta\phi$	− 2 36.805				$\Delta\lambda$	+ 3 59.900	
ϕ'	28 32 25.572	1 **Indianola**			λ'	96 30 59.504	
$\frac{1}{2}(\phi+\phi')$	° ′ ″ 28 33 44	s $\cos \alpha$ B	3.683 529 / 8.511 666	s^2 $\sin^2 \alpha$ C	7.6287 / 1.1419	h^2 D	4.39 / 2.32
1st term	″ +156.7455	h	2.195 195		8.7706		6.71
2d and 3d terms	+ .0595				.0590		.0005
$-\Delta\phi$	+156.8050						

				$s \sin \alpha =$ 3.814 371
				$s \cos \alpha =$ 3.683 529
				$\tan \alpha =$ 0.130 842
				° ′ ″ $\alpha =$ 53 30 11.5
s $\sin \alpha$	3.814 371			$\cos \alpha =$ 9.774 355
A'	8.509 391	$\Delta\lambda$	2.380 03	$s =$ 3.909 174
$\sec \phi'$	0.056 268	$\sin \frac{1}{2}(\phi+\phi')$	9.679 53	
	2.380 030		2.059 56	
$\Delta\lambda$	″ +239.900	$-\Delta\alpha$	″ +114.7	

I. *Table of log m.*

Lat.	log m.	Lat.	log m.	Lat.	log m.	Lat.	log m.
° ′		° ′		° ′		° ′	
0 00	$\bar{1}$. 40695	20 00	$\bar{1}$. 40626	40 00	$\bar{1}$. 40452	60 00	$\bar{1}$. 40253
0 30	695	20 30	623	40 30	446	60 30	249
1 00	695	21 00	619	41 00	441	61 00	244
1 30	694	21 30	616	41 30	436	61 30	240
2 00	694	22 00	612	42 00	431	62 00	235
2 30	694	22 30	608	42 30	426	62 30	231
3 00	693	23 00	605	43 00	421	63 00	227
3 30	693	23 30	601	43 30	416	63 30	223
4 00	692	24 00	597	44 00	411	64 00	219
4 30	691	24 30	594	44 30	406	64 30	215
5 00	690	25 00	590	45 00	400	65 00	210
5 30	689	25 30	586	45 30	395	65 30	207
6 00	688	26 00	582	46 00	390	66 00	203
6 30	687	26 30	578	46 30	385	66 30	199
7 00	686	27 00	573	47 00	380	67 00	195
7 30	685	27 30	569	47 30	375	67 30	192
8 00	683	28 00	565	48 00	369	68 00	188
8 30	682	28 30	560	48 30	364	68 30	185
9 00	680	29 00	556	49 00	359	69 00	181
9 30	679	29 30	552	49 30	354	69 30	178
10 00	677	30 00	548	50 00	349	70 00	174
10 30	675	30 30	544	50 30	344	70 30	171
11 00	673	31 00	539	51 00	339	71 00	168
11 30	671	31 30	534	51 30	334	71 30	164
12 00	669	32 00	530	52 00	329	72 00	$\bar{1}$. 40161
12 30	667	32 30	525	52 30	324		
13 00	665	33 00	520	53 00	319		
13 30	663	33 30	516	53 30	314		
14 00	660	34 00	511	54 00	309		
14 30	658	34 30	506	54 30	304		
15 00	655	35 00	501	55 00	299		
15 30	653	35 30	496	55 30	295		
16 00	650	36 00	491	56 00	290		
16 30	647	36 30	486	56 30	285		
17 00	644	37 00	482	57 00	280		
17 30	642	37 30	477	57 30	276		
18 00	639	38 00	472	58 00	271		
18 30	636	38 30	467	58 30	266		
19 00	632	39 00	462	59 00	262		
19 30	$\bar{1}$. 40629	39 30	$\bar{1}$. 40457	59 30	$\bar{1}$. 40257		

[The above table is computed for the Clarke spheroid of 1866 as expressed in meters.]

II.—*Table of corrections to log Δλ for difference in arc and sine.*

log s (−)	log difference.	log Δλ (+)	log s (−)	log difference.	log Δλ (+)	log s (−)	log difference.	log Δλ (+)
3.876	0.000 0001	2.385	4.871	0.000 0098	3.380	5.172	0.000 0392	3.681
4.026	02	2.535	4.882	103	3.391	5.178	402	3.687
4.114	03	2.623	4.892	108	3.401	5.183	412	3.692
4.177	04	2.686	4.904	114	3.413	5.188	422	3.697
4.225	05	2.734	4.913	119	3.422	5.194	433	3.703
4.265	06	2.774	4.922	124	3.431	5.199	443	3.708
4.298	07	2.807	4.933	130	3.442	5.204	453	3.713
4.327	08	2.836	4.942	136	3.451	5.209	464	3.718
4.353	09	2.862	4.952	142	3.461	5.214	474	3.723
4.376	10	2.885	4.959	147	3.468	5.219	486	3.728
4.396	11	2.905	4.968	153	3.477	5.224	497	3.733
4.415	12	2.924	4.978	160	3.487	5.229	508	3.738
4.433	13	2.942	4.986	166	3.495	5.233	519	3.742
4.449	14	2.958	4.993	172	3.502	5.238	530	3.747
4.464	15	2.973	5.002	179	3.511	5.242	541	3.751
4.478	16	2.987	5.010	186	3.519	5.247	553	3.756
4.491	17	3.000	5.017	192	3.526	5.252	565	3.761
4.503	18	3.012	5.025	199	3.534	5.256	577	3.765
4.526	20	3.035	5.033	206	3.542	5.260	588	3.769
4.556	23	3.065	5.040	213	3.549	5.265	600	3.774
4.575	25	3.084	5.048	221	3.557	5.269	613	3.778
4.591	27	3.100	5.055	228	3.564	5.274	625	3.783
4.614	30	3.123	5.062	236	3.571	5.278	637	3.787
4.635	33	3.144	5.068	243	3.577	5.282	650	3.791
4.654	36	3.163	5.075	251	3.584	5.286	663	3.795
4.671	39	3.180	5.082	259	3.591	5.290	674	3.799
4.687	42	3.196	5.089	267	3.598	5.294	687	3.803
4.702	45	3.211	5.095	275	3.604	5.299	702	3.808
4.716	48	3.225	5.102	284	3.611	5.303	716	3.812
4.734	52	3.243	5.108	292	3.617	5.307	729	3.816
4.750	56	3.259	5.114	300	3.623	5.311	743	3.820
4.761	59	3.270	5.121	309	3.630	5.315	757	3.824
4.775	63	3.284	5.127	318	3.636	5.319	771	3.828
4.789	67	3.298	5.133	327	3.642	5.323	785	3.832
4.801	71	3.310	5.139	336	3.648	5.327	800	3.836
4.813	75	3.322	5.145	345	3.654	5.331	814	3.840
4.827	80	3.336	5.150	354	3.659	5.335	829	3.844
4.838	84	3.347	5.156	364	3.665	5.339	845	3.848
4.850	89	3.359	5.161	373	3.670	5.343	861	3.852
4.862	94	3.371	5.167	383	3.676	5.347	877	3.856

Formula (3) page 97 may be written in its more exact form

$$\log \triangle\lambda = \log s + \log A' + \log \sin \alpha + \log \sec \phi' + c\lambda - c_s$$

in which

$$\left.\begin{aligned} c\lambda &= \log \triangle\lambda - \log \sin \triangle\lambda = \frac{M}{6}\triangle\lambda^2 \\ c_s &= \log\left(\frac{s}{N'}\right) - \log \sin\left(\frac{s}{N'}\right) = \frac{M}{6}\left(\frac{s}{N'}\right)^2 \end{aligned}\right\} \text{(B)}$$

The remaining symbols in equation (A) have already been defined. In (B) the extreme right hand side represents an infinite series of which only the first term is given; $\triangle\lambda$ and $\frac{s}{N'}$, are to be expressed in radians; M is the modulus of the common logarithms = 0.43429 . . . The central column of the table gives c_s and $c\lambda$ expressed in units of the seventh place of decimals. On the right and left are respectively the corresponding values of log $\triangle\lambda$ ($\triangle\lambda$ expressed in seconds) and of log s (s expressed in meters).

From (B)

$$\left.\begin{aligned} &\log \triangle\lambda = \log\frac{1}{\text{arc } 1''} - \frac{1}{2}\log\left(\frac{M}{6}\right) + \frac{1}{2}\log c = 5.88461 + \frac{1}{2}\log c \\ &\log s = -\frac{1}{2}\log\left(\frac{M}{6}\right) + \log N' + \frac{1}{2}\log c, \qquad \text{or} \\ &\log s = \log\frac{1}{\text{arc } 1''} - \frac{1}{2}\log\left(\frac{M}{6}\right) - \log A' + \frac{1}{2}\log c \end{aligned}\right\} \text{(C)}$$

c is the common value of $c\lambda$ and c_s. The factor $\log\frac{1}{\text{arc } 1''}$ appears because in (B) $\triangle\lambda$ was in radians, while in equation (C) it is in seconds.

In strictness N' or A' vary with the latitude, but a mean value $\log A = 8.5090$ has been taken.

Evidently $\log \triangle\lambda - \log s = 8.5090$ for a common value of c, as may be verified from the table.

III.—*Table of values of log sec ½ (Δφ).*

Δφ	log sec ½ (Δφ)	Δφ	log sec ½ (Δφ)	Δφ	log sec ½ (Δφ)	Δφ	log sec ½ (Δφ)	Δφ	log sec ½ (Δφ)
′		′		′		′		′	
10	0. 000 000	28	0. 000 004	46	0. 000 010	64	0. 000 019	82	0. 000 031
11	1	29	4	47	10	65	19	83	32
12	1	30	4	48	11	66	20	84	32
13	1	31	4	49	11	67	21	85	33
14	1	32	5	50	11	68	21	86	34
15	1	33	5	51	12	69	22	87	35
16	1	34	5	52	12	70	22	88	36
17	1	35	6	53	13	71	23	89	36
18	1	36	6	54	13	72	24	90	37
19	2	37	6	55	14	73	24	91	38
20	2	38	7	56	14	74	25	92	39
21	2	39	7	57	15	75	26	93	40
22	2	40	7	58	15	76	26	94	41
23	2	41	8	59	16	77	27	95	41
24	3	42	8	60	16	78	28	96	42
25	3	43	8	61	17	79	29	97	43
26	3	44	9	62	18	80	29	98	44
27	3	45	9	63	18	81	30	99	45

For the convenience of the computer the following conversion table is inserted:

IV.—*Conversion table.*

To convert:		To convert:	
Meters to feet.	Feet to meters.	Kilometers to statute miles.	Statute miles to kilometers.
1= 3. 280 833	1=0. 304 8006	1=0. 621 3699	1= 1. 609 347
2 6. 561 667	2 0. 609 6012	2 1. 242 7399	2 3. 218 694
3 9. 842 500	3 0. 914 4018	3 1. 864 1098	3 4. 828 042
4 13. 123 333	4 1. 219 2024	4 2. 485 4798	4 6. 437 389
5 16. 404 166	5 1. 524 0030	5 3. 106 8497	5 8. 046 736
6 19. 685 000	6 1. 828 8037	6 3. 728 2196	6 9. 656 083
7 22. 965 833	7 2. 133 6043	7 4. 349 5896	7 11. 265 430
8 26. 246 666	8 2. 438 4049	8 4. 970 9595	8 12. 874 778
9 29. 527 500	9 2. 743 2055	9 5. 592 3295	9 14. 484 125

V.—*Table of logarithms of factors A′, B, C, D, E, F, based upon the Clarke spheroid of 1866 as expressed in meters, between latitudes 0° and 72°.*

CONSTANTS.

Equatorial semi-axis=a	6 378 206. 4
Polar semi-axis=b	6 356 583. 8
$b/a=$	$\frac{293.98}{294.98}$

$$A'=\frac{(1-e^2\sin^2\phi')^{\frac{1}{2}}}{a\sin 1''}$$

$$B=\frac{(1-e^2\sin^2\phi)^{\frac{3}{2}}}{a(1-e^2)\sin 1''}$$

$$C=\frac{(1-e^2\sin^2\phi)^2\tan\phi}{2a^2(1-e^2)\sin 1''}$$

$$D=\frac{\frac{3}{2}e^2\sin\phi\cos\phi\sin 1''}{1-e^2\sin^2\phi}$$

$$E=\frac{(1+3\tan^2\phi)(1-e^2\sin^2\phi)}{6a^2}$$

$$F=\tfrac{1}{12}\sin\phi\cos^2\phi\sin^2 1''$$

$$\log a=6.804\,698\,57$$
$$\log b=6.803\,223\,78$$
$$\log e^2=\bar{7}.830\,502\,57$$
$$\log\frac{1}{a\sin 1''}=\bar{8}.509\,726\,56$$
$$\log\frac{1}{a(1-e^2)\sin 1''}=8.512\,676\,15$$
$$\log\frac{1}{2a^2(1-e^2)\sin 1''}=\bar{1}.406\,947\,6$$
$$\log(\tfrac{3}{2}e^2\sin 1'')=\bar{2}.692\,168\,7$$
$$\log\frac{1}{6a^2}=\bar{5}.612\,45$$
$$\log(\tfrac{1}{12}\sin^2 1'')=\bar{\bar{8}}.291\,96$$

LATITUDE 0°.

Lat.	log A′	log B	log C	log D	log E	log F
° ′						
00 00	$\bar{8}$. 509 7266	$\bar{8}$. 512 6761	−∞	−∞	$\bar{\bar{5}}$. 6125	−∞
1	66	61	$\bar{\bar{7}}$. 8707	$\bar{\bar{9}}$. 156	5	
2	66	61	. 1717	457	5	
3	66	61	3477	633	5	
4	66	61	4727	758	5	
05	66	61	5696	855	5	
6	66	61	6488	$\bar{\bar{9}}$. 934	5	
7	66	61	7158	$\bar{0}$. 001	5	
8	66	61	7740	059	5	
9	66	61	8249	110	5	
10	8. 509 7266	8. 512 6761	8. 8707	0. 156	5. 6125	
11	65	61	9121	197	5	
12	65	61	9499	235	5	
13	65	61	8. 9846	270	5	
14	65	61	9. 0168	302	5	
15	65	61	0468	332	5	
16	65	61	0748	360	5	
17	65	60	1011	386	5	
18	65	60	1259	411	5	
19	65	60	1494	435	5	
20	8. 509 7265	8. 512 6760	9. 1717	0. 457	5. 6125	$\bar{\bar{6}}$. 057
21	65	60	1929	478	5	
22	65	60	2131	498	5	
23	65	60	2324	518	5	
24	65	59	2509	536	5	
25	65	59	2686	554	5	
26	65	59	2857	571	5	
27	65	59	3020	587	5	
28	65	59	3178	603	5	
29	65	58	3331	618	5	
30	8. 509 7265	8. 512 6758	9. 3478	0. 633	5. 6126	
31	64	58	3620	647	6	
32	64	58	3758	661	6	
33	64	57	9. 3892	674	6	
34	64	57	9. 4022	687	6	
35	64	57	4148	700	6	
36	64	57	4270	712	6	
37	64	56	4389	724	6	
38	64	56	4505	736	6	
39	64	56	4618	747	6	
40	8. 509 7264	8. 512 6756	9. 4728	0. 758	5. 6126	6. 358
41	64	55	4835	769	6	
42	64	55	9. 4939	779	6	
43	64	55	9. 5042	789	6	
44	63	54	5141	799	7	
45	63	54	5239	809	7	
46	63	54	5335	819	7	
47	63	53	5428	828	7	
48	63	53	5519	837	7	
49	63	53	5609	846	7	
50	8. 509 7263	8. 512 6752	9. 5697	0. 855	5. 6127	
51	63	52	5783	863	7	
52	62	51	5866	872	7	
53	62	51	9. 5950	880	7	
54	62	51	9. 6031	888	8	
55	62	50	6111	896	8	
56	62	50	6189	904	8	
57	62	49	6266	912	8	
58	61	49	6341	919	8	
59	61	49	6416	927	8	
60	8. 509 7261	8. 512 6748	9. 6489	0. 934	5. 6128	6. 534

LATITUDE 1°.

Lat.	log A′	log B	log C	log D	log E	log F
° ′						
1 00	$\bar{8}$. 509 7261	$\bar{8}$. 512 6748	$\bar{\bar{9}}$. 6489	$\bar{0}$. 934	$\bar{\bar{5}}$. 6128	$\bar{\bar{6}}$. 534
1	61	48	560	941	29	
2	61	47	631	948	29	
3	61	47	701	955	29	
4	61	46	769	962	29	
05	60	46	836	969	29	
6	60	45	903	975	29	
7	60	45	9. 6968	982	29	
8	60	44	9. 7032	988	30	
9	60	44	096	0. 995	30	
10	8. 509 7260	8. 512 6743	9. 7158	1. 001	5. 6130	
11	59	43	220	007	30	
12	59	42	281	013	30	
13	59	42	341	019	30	
14	59	41	400	025	31	
15	59	41	458	031	31	
16	58	40	516	037	31	
17	58	39	572	042	31	
18	58	39	628	048	31	
19	58	38	684	053	31	
20	8. 509 7258	8. 512 6738	9. 7738	1. 059	5. 6132	6. 658
21	57	37	792	064	32	
22	57	36	846	070	32	
23	57	36	898	075	32	
24	57	35	9. 7950	080	32	
25	57	35	9. 8002	085	32	
26	56	34	053	090	33	
27	56	33	103	095	33	
28	56	33	152	100	33	
29	56	32	202	105	33	
30	8. 509 7256	8. 512 6731	9. 8250	1. 110	5. 6133	
31	55	31	298	115	34	
32	55	30	346	119	34	
33	55	29	393	124	34	
34	55	29	439	129	34	
35	54	28	485	133	34	
36	54	27	531	138	35	
37	54	26	576	142	35	
38	54	26	620	147	35	
39	53	25	664	151	35	
40	8. 509 7253	8. 512 6724	9. 8708	1. 156	5. 6136	6. 755
41	53	23	751	160	36	
42	53	23	794	164	36	
43	52	22	836	168	36	
44	52	21	878	173	36	
45	52	20	920	177	37	
46	52	20	9. 8961	181	37	
47	51	19	9. 9002	185	37	
48	51	18	042	189	37	
49	51	17	082	193	38	
50	8. 509 7251	8. 512 6716	9. 9122	1. 197	5. 6138	
51	50	16	161	201	38	
52	50	15	200	205	38	
53	50	14	239	209	39	
54	49	13	277	212	39	
55	49	12	315	216	39	
56	49	11	353	220	39	
57	49	10	390	224	40	
58	48	10	427	227	40	
59	48	09	464	231	40	
60	8. 509 7248	8. 512 6708	9. 9500	1. 2347	5. 6140	6. 834

LATITUDE 2°.

Lat.	log A′	log B	log C	log D	log E	log F
° ′						
2 00	$\bar{8}$. 509 7248	$\bar{8}$. 512 6708	$\bar{\bar{9}}$. 95002	$\bar{1}$. 2347	$\bar{\bar{5}}$. 6140	$\bar{\bar{6}}$. 834
1	47	07	5363	383	41	
2	47	06	5721	419	41	
3	47	05	6076	454	41	
4	47	04	6428	489	41	
05	46	03	6777	524	42	
6	46	02	7123	559	42	
7	46	01	7467	593	42	
8	45	6700	7808	627	43	
9	45	6699	8146	661	43	
10	8. 509 7245	8. 512 6698	$\bar{\bar{9}}$. 98482	1. 2694	5. 6143	
11	44	97	8815	727	43	
12	44	97	9145	760	44	
13	44	96	9473	793	44	
14	43	95	$\bar{\bar{9}}$. 99799	826	44	
15	43	94	$\bar{0}$. 00122	858	45	
16	43	93	0443	890	45	
17	42	91	0762	922	45	
18	42	90	1078	953	45	
19	42	89	1392	1. 2984	46	
20	8. 509 7241	8. 512 6688	0. 01703	1. 3015	5. 6146	6. 901
21	41	87	2013	046	46	
22	41	86	2320	077	47	
23	40	85	2625	107	47	
24	40	84	2928	138	47	
25	40	83	3229	168	48	
26	39	82	3528	197	48	
27	39	81	3825	227	48	
28	38	80	4119	256	49	
29	38	79	4412	285	49	
30	8. 509 7238	8. 512 6678	0. 04703	1. 3314	5. 6149	
31	37	76	4992	343	50	
32	37	75	5279	372	50	
33	37	74	5564	400	50	
34	36	73	5847	428	51	
35	36	72	6129	456	51	
36	35	71	6408	484	51	
37	35	70	6686	512	52	
38	35	68	6962	539	52	
39	34	67	7237	567	52	
40	8. 509 7234	8. 512 6666	0. 07509	1. 3594	5. 6153	6. 959
41	33	65	7780	621	53	
42	33	64	8050	648	53	
43	33	62	8317	674	54	
44	32	61	8583	701	54	
45	32	60	8848	727	54	
46	31	59	9111	753	55	
47	31	58	9372	779	55	
48	31	56	9631	805	56	
49	30	55	0. 09890	831	56	
50	8. 509 7230	8. 512 6654	0. 10146	1. 3856	5. 6156	
51	29	52	0401	882	57	
52	29	51	0655	907	57	
53	28	50	0907	932	57	
54	28	49	1158	957	58	
55	28	47	1407	1. 3982	58	
56	27	46	1655	1. 4007	59	
57	27	45	1902	031	59	
58	26	43	2147	055	59	
59	26	42	2390	080	60	
60	8. 509 7225	8. 512 6641	0. 12633	1. 4104	5. 6160	7. 010

LATITUDE 3°.

Lat.	log A′	log B diff. 1″ = −0.03	log C	log D	log E	log F
° ′						
3 00	$\bar{8}$. 509 7225	$\bar{8}$. 512 6641	$\bar{0}$. 12633	$\bar{1}$. 4104	$\bar{\bar{5}}$. 6160	$\bar{\bar{7}}$. 010
1	25	39	2874	28	61	
2	24	38	3113	52	61	
3	24	37	3352	75	61	
4	24	35	3589	1. 4199	62	
05	23	34	3825	1. 4222	62	
6	23	33	4059	46	62	
7	22	31	4293	69	63	
8	22	30	4525	1. 4292	63	
9	21	28	4756	1. 4315	64	
10	8. 509 7221	8. 512 6627	0. 4985	1. 4338	64	
11	20	26	5214	60	65	
12	20	24	5441	1. 4383	65	
13	19	23	5667	1. 4405	65	
14	19	21	5892	28	66	
15	18	20	6116	50	66	
16	18	18	6338	72	67	
17	17	17	6560	1. 4494	67	
18	17	15	6780	1. 4516	68	
19	16	14	6999	38	68	
20	8. 509 7216	8. 512 6612	0. 17217	1. 4560	5. 6168	7. 055
21	15	11	7434	1. 4581	69	
22	15	09	7650	1. 4603	69	
23	14	08	7665	24	70	
24	14	06	8079	45	70	
25	13	05	8292	66	71	
26	13	03	8504	1. 4687	71	
27	12	02	8715	1. 4708	72	
28	12	6600	8925	29	72	
29	11	6599	9133	50	72	
30	8. 509 7211	8. 512 6597	0. 19341	1. 4770	5. 6173	
31	10	96	9548	1. 4791	73	
32	10	94	9754	1. 4811	74	
33	09	92	19959	32	74	
34	09	91	20163	52	75	
35	08	89	0366	72	75	
36	08	88	0568	1. 4892	76	
37	07	86	0769	1. 4912	76	
38	07	84	0969	32	77	
39	06	83	1168	52	77	
40	8. 509 7206	8. 512 6581	0. 21367	1. 4971	5. 6178	7. 096
41	05	80	1564	1. 4991	78	
42	04	78	1761	1. 5011	79	
43	04	76	1956	30	79	
44	03	75	2151	49	80	
45	03	73	2345	68	80	
46	02	71	2538	1. 5088	81	
47	02	69	2731	1. 5107	81	
48	01	68	2922	26	81	
49	01	66	3113	45	82	
50	8. 509 7200	8. 512 6564	0. 23302	1. 5163	5. 6182	
51	7199	63	3491	1. 5182	83	
52	99	61	3680	1. 5201	84	
53	98	59	3867	19	84	
54	98	58	4053	38	85	
55	97	56	4239	56	85	
56	96	54	4424	75	86	
57	96	52	4608	1. 5293	86	
58	95	50	4792	1. 5311	87	
59	95	49	4974	29	87	
60	8. 509 7194	8. 512 6547	0. 25156	1. 5347	5. 6188	7. 133

LATITUDE 4°.

Lat.	log A′	log B diff. 1″=−0.04	log C	log D	log E	log F
° ′						
4 00	$\bar{8}$. 509 7194	$\bar{8}$. 512 6547	$\bar{0}$. 25156	$\bar{1}$. 5347	$\bar{\bar{5}}$. 6188	$\bar{\bar{7}}$. 133
1	93	45	5337	65	88	
2	93	43	5518	1. 5383	89	
3	92	42	5697	1. 5401	89	
4	92	40	5876	18	90	
05	91	38	6055	36	90	
6	91	36	6232	54	91	
7	90	34	6409	71	91	
8	89	32	6585	1. 5489	92	
9	89	31	6760	1. 5506	92	
10	8. 509 7188	8. 512 6529	0. 26935	1. 5523	5. 6193	
11	87	27	7109	40	93	
12	87	25	7282	58	94	
13	86	23	7455	75	95	
14	86	21	7627	1. 5592	95	
15	85	19	7798	1. 5609	96	
16	84	17	7968	25	96	
17	84	16	8138	42	97	
18	83	14	8308	59	97	
19	82	12	8476	76	98	
20	8. 509 7182	8. 512 6510	0. 28644	1. 5692	5. 6199	7. 168
21	81	08	8812	1. 5709	5. 6199	
22	80	06	8978	25	5. 6200	
23	80	04	9144	42	00	
24	79	02	9310	58	01	
25	78	6500	9475	74	01	
26	78	6498	9639	1. 5791	02	
27	77	96	9802	1. 5807	03	
28	76	94	0. 29965	23	03	
29	76	92	0. 30128	39	04	
30	8. 509 7175	8. 512 6490	0. 30290	1. 5855	5. 6204	
31	74	88	0451	71	05	
32	74	86	0611	1. 5887	05	
33	73	84	0771	1. 5902	06	
34	72	82	0931	18	07	
35	72	80	1090	34	07	
36	71	78	1248	50	08	
37	70	76	1406	65	08	
38	70	74	1563	81	09	
39	69	72	1719	1. 5996	10	
40	8. 509 7168	8. 512 6470	0. 31875	1. 6011	5. 6210	7. 200
41	67	68	2031	27	11	
42	67	65	2186	42	12	
43	66	63	2340	57	12	
44	66	61	2494	73	13	
45	65	59	2647	1. 6088	13	
46	64	57	2800	1. 6103	14	
47	63	55	2953	18	15	
48	63	53	3104	33	15	
49	62	51	3255	48	16	
50	8. 509 7161	8. 512 6448	0. 33406	1. 6163	5. 6216	
51	60	46	3556	77	17	
52	60	44	3706	1. 6192	18	
53	59	42	3855	1. 6207	18	
54	58	40	4004	21	19	
55	57	38	4152	36	20	
56	57	35	4300	51	20	
57	56	33	4447	65	21	
58	55	31	4594	80	22	
59	55	29	4740	1. 6294	22	
60	8. 509 7154	8. 512 6427	0. 34885	1. 6308	5. 6223	7. 229

LATITUDE 5°.

Lat.	log A′	log B diff. 1″ = −0.04	log C	log D diff. 1″ = +0.22	log E	log F
° ′						
5 00	$\bar{8}$. 509 7154	$\bar{8}$. 512 6427	$\bar{0}$. 34885	$\bar{1}$. 6308	$\bar{\bar{5}}$. 6223	$\bar{\bar{7}}$. 229
1	53	24	5030	23	24	
2	53	22	5175	37	24	
3	52	20	5320	51	25	
4	51	18	5464	65	26	
05	50	15	5607	79	26	
6	49	13	5750	1. 6393	27	
7	49	11	5892	1. 6407	28	
8	48	08	6034	21	28	
9	47	06	6176	35	29	
10	8. 509 7146	8. 512 6404	0. 36317	1. 6449	5. 6230	
11	46	6402	6457	63	30	
12	45	6399	6597	77	31	
13	44	97	6737	1. 6491	32	
14	43	95	6876	1. 6504	32	
15	43	92	7015	18	33	
16	42	90	7154	32	34	
17	41	88	7292	45	34	
18	40	85	7429	59	35	
19	39	83	7566	72	36	
20	8. 509 7139	8. 512 6381	0. 37703	1. 6586	5. 6236	7. 256
21	38	78	7839	1. 6599	37	
22	37	76	7975	1. 6612	38	
23	36	73	8111	26	38	
24	35	71	8246	39	39	
25	35	69	8380	52	40	
26	34	66	8514	65	41	
27	33	64	8648	78	41	
28	32	61	8781	1. 6692	42	
29	31	59	8914	1. 6705	43	
30	8. 509 7131	8. 512 6356	0. 39047	1. 6718	5. 6243	
31	30	54	9179	31	44	
32	29	52	9311	44	45	
33	28	49	9442	56	46	
34	27	47	9573	69	46	
35	27	44	9704	82	47	
36	26	42	9834	1. 6795	48	
37	25	39	0. 39964	1. 6808	48	
38	24	37	0. 40094	20	49	
39	23	34	0223	33	50	
40	8. 509 7122	8. 512 6332	0. 40351	1. 6846	5. 6251	7. 282
41	21	29	0480	58	51	
42	21	27	0608	71	52	
43	20	24	0735	83	53	
44	19	21	0863	1. 6896	54	
45	18	19	0990	1. 6908	54	
46	17	16	1116	21	55	
47	16	14	1242	33	56	
48	16	11	1368	45	57	
49	15	09	1493	58	57	
50	8. 509 7114	8. 512 6306	0. 41619	1. 6970	5. 6258	
51	13	03	1743	82	59	
52	12	6301	1868	1. 6994	60	
53	11	6298	1992	1. 7006	60	
54	10	96	2115	19	61	
55	09	93	2239	31	62	
56	09	90	2362	43	63	
57	08	88	2484	55	63	
58	07	85	2607	67	64	
59	06	82	2729	79	65	
60	8. 509 7105	8. 512 6280	0. 42850	1. 7090	5. 6266	7. 306

LATITUDE 6°.

Lat.	log A′ diff. 1″ = −0.02	log B diff. 1″ = −0.05	log C	log D diff. 1″ = +0.18	log E	log F
° ′						
6 00	$\bar{8}$. 509 7105	$\bar{8}$. 512 6280	$\bar{0}$. 42850	$\bar{1}$. 7090	$\bar{\bar{5}}$. 6266	$\bar{\bar{7}}$. 306
1	04	77	2972	1. 7102	67	
2	03	74	3093	14	67	
3	02	72	3213	26	68	
4	01	69	3334	38	69	
05	01	66	3454	50	70	
6	7100	64	3573	61	70	
7	7099	61	3693	73	71	
8	98	58	3812	85	72	
9	97	55	3931	1. 7196	73	
10	8. 509 7096	8. 512 6253	0. 44049	1. 7208	5. 6274	
11	95	50	4167	19	74	
12	94	47	4285	31	75	
13	93	44	4402	42	76	
14	92	42	4519	54	77	
15	91	39	4636	65	78	
16	91	36	4753	76	78	
17	90	33	4869	88	79	
18	89	31	4985	1. 7299	80	
19	88	28	5101	1. 7310	81	
20	8. 509 7087	8. 512 6225	0. 45216	1. 7322	5. 6282	7. 329
21	86	22	5331	33	83	
22	85	19	5446	44	83	
23	84	16	5560	55	84	
24	83	14	5674	66	85	
25	82	11	5788	78	86	
26	81	08	5902	1. 7389	87	
27	80	05	6015	1. 7400	88	
28	79	6202	6128	11	88	
29	78	6199	6241	22	89	
30	8. 509 7077	8. 512 6196	0. 46353	1. 7433	5. 6290	
31	76	94	6465	44	91	
32	75	91	6577	54	92	
33	74	88	6689	65	93	
34	73	85	6800	76	93	
35	72	82	6911	87	94	
36	71	79	7022	1. 7498	95	
37	70	76	7132	1. 7508	96	
38	70	73	7242	19	97	
39	69	70	7352	30	98	
40	8. 509 7068	8. 512 6167	0. 47462	1. 7541	5. 6299	7. 351
41	67	64	7571	51	5. 6299	
42	66	61	7681	62	5. 6300	
43	65	58	7789	73	01	
44	64	55	7898	83	02	
45	63	52	8006	1. 7594	03	
46	62	49	8114	1. 7604	04	
47	61	46	8222	15	05	
48	60	43	8330	25	06	
49	59	40	8437	36	06	
50	8. 509 7058	8. 512 6137	0. 48544	1. 7646	5. 6307	
51	57	34	8651	56	08	
52	56	31	8757	67	09	
53	55	28	8864	77	10	
54	53	25	8970	87	11	
55	52	22	9075	1. 7698	12	
56	51	19	9181	1. 7708	13	
57	50	16	9286	18	13	
58	49	13	9391	28	14	
59	48	10	9496	38	15	
60	8. 509 7047	8. 512 6107	0. 49600	1. 7749	5. 6316	7. 371

LATITUDE 7°.

Lat.	log A′ diff. 1″ = −0.02	log B diff. 1″ = −0.06	log C	log D diff. 1″ = +0.16	log E	log F
° ′						
7 00	$\bar{8}$. 509 7047	$\bar{8}$. 512 6107	$\bar{0}$. 49600	$\bar{1}$. 7749	$\bar{\bar{5}}$. 6316	$\bar{\bar{7}}$. 371
1	46	03	705	59	17	
2	45	6100	809	69	18	
3	44	6097	0. 49913	79	19	
4	43	94	0. 50016	89	20	
05	42	91	119	1. 7799	21	
6	41	88	222	1. 7809	22	
7	40	85	325	19	23	
8	39	82	428	29	23	
9	38	78	530	39	24	
10	8. 509 7037	8. 512 6075	0. 50632	1. 7849	5. 6325	
11	36	72	734	59	26	
12	35	69	836	68	27	
13	34	66	0. 50937	78	28	
14	33	62	0. 51039	88	29	
15	32	59	140	1. 7898	30	
16	30	56	240	1. 7908	31	
17	29	53	341	17	32	
18	28	50	441	27	33	
19	27	46	541	37	34	
20	8. 509 7026	8. 512 6043	0. 51641	1. 7946	5. 6335	7. 391
21	25	40	741	56	36	
22	24	37	840	66	37	
23	23	33	0. 51939	75	37	
24	22	30	0. 52038	85	38	
25	21	27	137	1. 7994	39	
26	20	23	236	1. 8004	40	
27	19	20	334	13	41	
28	17	17	432	23	42	
29	16	14	530	32	43	
30	8. 509 7015	8. 512 6010	0. 52628	1. 8042	5. 6344	
31	14	07	725	51	45	
32	13	04	822	61	46	
33	12	6000	0. 52919	70	47	
34	11	5997	0. 53016	79	48	
35	10	94	113	89	49	
36	09	90	209	1. 8098	50	
37	07	87	306	1. 8107	51	
38	06	83	402	17	52	
39	05	80	497	26	53	
40	8. 509 7004	8. 512 5977	0. 53593	1. 8135	5. 6354	7. 409
41	03	73	688	44	55	
42	02	70	784	53	56	
43	01	66	879	63	57	
44	7000	63	0. 53973	72	58	
45	6998	60	0. 54068	81	59	
46	97	56	162	90	60	
47	96	53	257	1. 8199	61	
48	95	49	351	1. 8208	62	
49	94	46	444	17	63	
50	8. 509 6993	8. 512 5942	0. 54538	1. 8226	5. 6364	
51	91	39	631	35	65	
52	90	35	725	44	66	
53	89	32	818	53	67	
54	88	28	0. 54911	62	68	
55	87	25	0. 55003	71	69	
56	86	21	096	80	70	
57	84	18	188	89	71	
58	83	14	280	1. 8298	72	
59	82	11	372	1. 8307	73	
60	8. 509 6981	8. 512 5907	0. 55464	1. 8315	5. 6374	7. 427

LATITUDE 8°.

Lat.	log A′ diff. 1″=−0.02	log B diff. 1″=−0.06	log C	log D diff. 1″=+0.14	log E diff. 1″=+0.02	log F
° ′						
8 00	$\bar{8}$. 509 6981	$\bar{8}$. 512 5907	$\bar{0}$. 55464	$\bar{1}$. 8315	$\bar{\bar{5}}$. 6374	$\bar{\bar{7}}$. 427
1	80	04	555	24	75	
2	79	5900	646	33	76	
3	77	5897	738	42	77	
4	76	93	829	50	78	
05	75	90	0. 55919	59	79	
6	74	86	0. 56010	68	80	
7	73	82	100	77	81	
8	71	79	191	85	82	
9	70	75	281	1. 8394	83	
10	8. 509 6969	8. 512 5872	0. 56371	1. 8403	5. 6384	
11	68	68	460	12	85	
12	67	64	550	20	86	
13	65	61	639	28	87	
14	64	57	728	37	88	
15	63	54	817	45	90	
16	62	50	906	54	91	
17	61	46	0. 56995	62	92	
18	59	43	0. 57083	71	93	
19	58	39	172	79	94	
20	8. 509 6957	8. 512 5835	0. 57260	1. 8488	5. 6395	7. 444
21	56	32	348	1. 8496	96	
22	54	28	436	1. 8505	97	
23	53	24	523	13	98	
24	52	20	611	21	99	
25	51	17	698	30	5. 6400	
26	49	13	785	38	5. 6401	
27	48	09	872	46	02	
28	47	06	0. 57959	55	03	
29	46	5802	0. 58045	63	04	
30	8. 509 6945	8. 512 5798	0. 58132	1. 8571	5. 6406	
31	43	94	218	80	07	
32	42	91	304	88	08	
33	41	87	390	1. 8596	09	
34	39	83	476	1. 8604	10	
35	38	79	562	13	11	
36	37	75	647	21	12	
37	36	72	732	29	13	
38	34	68	818	37	14	
39	33	64	903	45	15	
40	8. 509 6932	8. 512 5760	0. 58987	1. 8653	5. 6416	7. 461
41	31	56	0. 59072	61	18	
42	29	53	157	69	19	
43	28	49	241	77	20	
44	27	45	325	85	21	
45	25	41	409	1. 8693	22	
46	24	37	493	1. 8701	23	
47	23	33	577	09	24	
48	22	29	660	17	25	
49	20	26	744	25	26	
50	8. 509 6919	8. 512 5722	0. 59827	1. 8733	5. 6428	
51	18	18	910	41	29	
52	16	14	0. 59993	49	30	
53	15	10	0. 60076	57	31	
54	14	06	159	65	32	
55	12	5702	241	73	33	
56	11	5698	324	81	34	
57	10	94	406	89	35	
58	09	90	488	1. 8796	37	
59	07	86	570	1. 8804	38	
60	8. 509 6906	8. 512 5682	0. 60652	1. 8812	5. 6439	7. 476

LATITUDE 9°.

Lat.	log A′ diff. 1″=−0.02	log B diff. 1″=−0.07	log C	log D diff. 1″=+0.12	log E diff. 1″=+0.02	log F
° ′						
9 00	$\bar{8}$. 509 6906	$\bar{8}$. 512 5682	$\bar{0}$. 60652	$\bar{1}$. 8812	$\bar{\bar{5}}$. 6439	$\bar{\bar{7}}$. 476
1	05	78	733	20	40	
2	03	74	815	27	41	
3	02	70	896	35	42	
4	6901	66	0. 60977	43	44	
05	6899	62	0. 61058	51	45	
6	98	58	139	58	46	
7	97	54	220	66	47	
8	95	50	301	74	48	
9	94	46	881	81	49	
10	8. 509 6893	8. 512 5642	0. 61461	1. 8889	5. 6450	
11	91	38	542	1. 8897	52	
12	90	34	622	1. 8904	53	
13	89	30	702	12	54	
14	87	26	781	19	55	
15	86	22	861	27	56	
16	84	18	0. 61941	34	57	
17	83	14	0. 62020	42	59	
18	82	10	099	50	60	
19	80	06	178	57	61	
20	8. 509 6879	8. 512 5602	0. 62257	1. 8964	5. 6462	7. 490
21	78	5598	336	72	63	
22	76	93	415	79	65	
23	75	89	493	87	66	
24	74	85	572	1. 8994	67	
25	72	81	650	1. 9002	68	
26	71	77	728	09	69	
27	69	73	806	17	70	
28	68	69	884	24	72	
29	67	64	0. 62962	31	73	
30	8. 509 6865	8. 512 5560	0. 63039	1. 9039	5. 6474	
31	64	56	117	46	75	
32	62	52	194	53	76	
33	61	48	271	61	78	
34	60	43	349	68	79	
35	58	39	426	75	80	
36	57	35	502	82	81	
37	55	31	579	90	83	
38	54	27	656	1. 9097	84	
39	53	22	732	1. 9104	85	
40	8. 509 6851	8. 512 5518	0. 63808	1. 9111	5. 6486	7. 505
41	50	14	885	19	87	
42	48	10	0. 63961	26	89	
43	47	05	0. 64037	33	90	
44	45	5501	112	40	91	
45	44	5497	188	47	92	
46	43	92	264	54	94	
47	41	88	339	61	95	
48	40	84	415	69	96	
49	38	80	490	76	97	
50	8. 509 6837	8. 512 5475	0. 64565	1. 9183	5. 6498	
51	35	71	640	90	5. 6500	
52	34	67	715	1. 9197	01	
53	33	62	789	1. 9204	02	
54	31	58	864	11	03	
55	30	54	0. 64938	18	05	
56	28	49	0. 65013	25	06	
57	27	45	087	32	07	
58	25	40	161	39	08	
59	24	36	235	46	10	
60	8. 509 6822	8. 512 5432	0. 65309	1. 9253	5. 6511	7. 518

LATITUDE 10°.

Lat.	log A′ diff. 1″=−0.03	log B diff. 1″=−0.08	log C	log D diff. 1″=+0.11	log E diff. 1″=+0.02	log F
° ′						
10 00	$\bar{8}$. 509 6822	$\bar{8}$. 512 5432	$\bar{0}$. 65309	$\bar{1}$. 9253	$\bar{\bar{5}}$. 6511	$\bar{\bar{7}}$. 518
1	21	27	383	60	12	
2	19	23	456	67	13	
3	18	19	530	74	15	
4	17	14	603	80	16	
05	15	10	677	87	17	
6	14	05	750	1. 9294	18	
7	12	5401	823	1. 9301	20	
8	11	5396	896	08	21	
9	09	92	0. 65968	15	22	
10	8. 509 6808	8. 512 5388	0. 66041	1. 9322	5. 6524	
11	06	83	114	28	25	
12	05	79	186	35	26	
13	03	74	259	42	27	
14	02	70	331	49	29	
15	6800	65	403	56	30	
16	6799	61	475	62	31	
17	97	56	547	69	33	
18	96	52	619	76	34	
19	94	47	691	82	35	
20	8. 509 6793	8. 512 5343	0. 66762	1. 9389	5. 6536	7. 532
21	91	38	834	1. 9396	38	
22	90	33	905	1. 9403	39	
23	88	29	0. 66976	09	40	
24	87	24	0. 67047	16	42	
25	85	20	118	23	43	
26	84	15	189	29	44	
27	82	11	260	36	46	
28	81	06	331	42	47	
29	79	5302	401	49	48	
30	8. 509 6777	8. 512 5297	0. 67472	1. 9456	5. 6549	
31	76	92	542	62	51	
32	74	88	613	69	52	
33	73	83	683	75	53	
34	71	79	753	82	55	
35	70	74	823	88	56	
36	68	69	893	1. 9495	57	
37	67	65	0. 67962	1. 9501	59	
38	65	60	0. 68032	08	60	
39	64	55	102	14	61	
40	8. 509 6762	8. 512 5251	0. 68171	1. 9521	5. 6563	7. 544
41	60	46	240	27	64	
42	59	41	310	34	65	
43	57	37	379	40	67	
44	56	32	448	47	68	
45	54	27	517	53	69	
46	53	23	586	60	71	
47	51	18	654	66	72	
48	50	13	723	72	73	
49	48	08	791	79	75	
50	8. 509 6746	8. 512 5204	0. 68860	1. 9585	5. 6576	
51	45	5199	928	91	78	
52	43	94	0. 68996	1. 9598	79	
53	42	89	0. 69064	1. 9604	80	
54	40	85	132	10	82	
55	38	80	200	17	83	
56	37	75	268	23	84	
57	35	70	336	29	86	
58	34	66	404	36	87	
59	32	61	471	42	88	
60	8. 509 6730	8. 512 5156	0. 69539	1. 9648	5. 6590	7. 556

LATITUDE 11°.

Lat.	log A′ diff. 1″ = −0.03	log B diff. 1″ = −0.08	log C	log D diff. 1″ = +0.10	log E diff. 1″ = +0.02	log F
° ′						
11 00	$\bar{8}$. 509 6730	$\bar{8}$. 512 5156	$\bar{0}$. 69539	$\bar{1}$. 9648	$\bar{\bar{5}}$. 6590	$\bar{\bar{7}}$. 556
1	29	51	606	54	91	
2	27	46	673	61	93	
3	26	41	740	67	94	
4	24	37	807	73	95	
05	22	32	874	79	97	
6	21	27	0. 69941	86	98	
7	19	22	0. 70008	92	5. 6599	
8	18	17	074	1. 9698	5. 6601	
9	16	12	141	1. 9704	02	
10	8. 509 6714	8. 512 5108	0. 70208	1. 9710	5. 6604	
11	13	5103	274	16	05	
12	11	5098	340	23	06	
13	09	93	406	29	08	
14	08	88	473	35	09	
15	06	83	539	41	11	
16	05	78	604	47	12	
17	03	73	670	53	13	
18	01	68	736	59	15	
19	6700	63	802	65	16	
20	8. 509 6698	8. 512 5058	0. 70867	1. 9771	5. 6618	7. 568
21	96	53	933	77	19	
22	95	49	0. 70998	83	20	
23	93	44	0. 71063	89	22	
24	91	39	128	1. 9795	23	
25	90	34	194	1. 9801	25	
26	88	29	259	07	26	
27	86	24	323	13	27	
28	85	19	388	19	29	
29	83	14	453	25	30	
30	8. 509 6681	8. 512 5009	0. 71518	1. 9831	5. 6632	
31	80	04	582	37	33	
32	78	4999	647	43	35	
33	76	94	711	49	36	
34	75	89	775	55	37	
35	73	83	840	61	39	
36	71	78	904	67	40	
37	70	73	0. 71968	73	42	
38	68	68	0. 72032	79	43	
39	66	63	095	85	45	
40	8. 509 6665	8. 512 4958	0. 72159	1. 9890	5. 6646	7. 580
41	63	53	223	1. 9896	47	
42	61	48	286	1. 9902	49	
43	59	43	350	08	50	
44	58	38	413	14	52	
45	56	33	477	20	53	
46	54	28	540	25	55	
47	53	22	603	31	56	
48	51	17	666	37	58	
49	49	12	729	43	59	
50	8. 509 6647	8. 512 4907	0. 72792	1. 9949	5. 6661	
51	46	4902	855	54	62	
52	44	4897	918	60	64	
53	43	92	0. 72980	66	65	
54	41	86	0. 73043	72	66	
55	39	81	106	77	68	
56	37	76	168	83	69	
57	35	71	230	89	71	
58	34	66	293	94	72	
59	32	60	355	1. 9900	74	
60	8. 509 6630	8. 512 4855	0. 73417	2. 0006	5. 6675	7. 591

LATITUDE 12°.

Lat.	log A′ diff. 1″=−0.03	log B diff. 1″=−0.09	log C	log D diff. 1″=+0.09	log E diff. 1″=+0.04	log F
° ′						
12 00	$\bar{8}$. 509 6630	$\bar{8}$. 512 4855	$\bar{0}$. 73417	$\bar{2}$. 0006	$\bar{\bar{5}}$. 6675	$\bar{\bar{7}}$. 591
1	29	50	479	11	77	
2	27	45	541	17	78	
3	25	39	603	23	80	
4	23	34	664	28	81	
05	21	29	726	34	83	
6	20	24	788	40	84	
7	18	18	849	45	86	
8	16	13	911	51	87	
9	14	08	0. 73972	57	89	
10	8. 509 6613	8. 512 4803	0. 74033	2. 0062	5. 6690	
11	11	4797	094	67	92	
12	09	92	156	73	93	
13	07	87	217	79	95	
14	06	81	278	84	96	
15	04	76	339	90	98	
16	02	71	399	2. 0096	5. 6699	
17	6600	65	460	2. 0101	5. 6701	
18	6599	60	521	07	02	
19	97	55	581	12	04	
20	8. 509 6595	8. 512 4749	0. 74642	2. 0118	5. 6705	7. 601
21	93	44	702	23	07	
22	91	39	763	29	08	
23	90	33	823	34	10	
24	88	28	883	40	11	
25	86	23	0. 74943	45	13	
26	84	17	0. 75003	50	14	
27	82	12	063	56	16	
28	81	06	123	61	17	
29	79	4701	183	67	19	
30	8. 509 6577	8. 512 4696	0. 75243	2. 0172	5. 6720	
31	75	90	302	77	22	
32	73	85	362	83	24	
33	72	79	422	88	25	
34	70	74	481	94	27	
35	68	68	540	2. 0199	28	
36	66	63	600	2. 0205	30	
37	64	57	659	10	31	
38	62	52	718	15	33	
39	61	46	777	21	34	
40	8. 509 6559	8. 512 4641	0. 75836	2. 0226	5. 6736	7. 611
41	57	35	895	32	37	
42	55	30	0. 75954	37	39	
43	53	24	0. 76013	42	41	
44	51	19	072	47	42	
45	50	13	130	53	44	
46	48	08	189	58	45	
47	46	4602	247	63	47	
48	44	4597	306	69	48	
49	42	91	364	74	50	
50	8. 509 6540	8. 512 4586	0. 76422	2. 0279	5. 6751	
51	39	80	481	84	53	
52	37	75	539	90	55	
53	35	69	597	2. 0295	56	
54	33	63	655	2. 0300	58	
55	31	58	713	05	59	
56	29	52	771	10	61	
57	27	47	828	16	62	
58	25	41	886	21	64	
59	24	35	0. 76944	26	66	
60	8. 509 6522	8. 512 4530	0. 77001	2. 0331	5. 6767	7. 621

LATITUDE 13°.

Lat.	log A′ diff. 1″=−0.03	log B diff. 1″=−0.10	log C diff. 1″=+0.93	log D diff. 1″=+0.08	log E diff. 1″=+0.03	log F
° ′						
13 00	$\bar{8}$. 509 6522	$\bar{8}$. 512 4530	$\bar{0}$. 77001	$\bar{2}$. 0331	$\bar{\bar{5}}$. 6767	$\bar{\bar{7}}$. 621
1	20	24	059	36	69	
2	18	19	116	42	70	
3	16	13	174	47	72	
4	14	07	231	52	74	
05	12	4502	288	57	75	
6	10	4496	346	62	77	
7	09	90	403	67	78	
8	07	85	460	73	80	
9	05	79	517	78	82	
10	8. 509 6503	8. 512 4473	0. 77574	2. 0383	5. 6783	
11	6501	67	630	88	85	
12	6499	62	687	93	86	
13	97	56	744	2. 0398	88	
14	95	50	801	2. 0403	90	
15	93	45	857	08	91	
16	91	39	914	13	93	
17	90	33	0. 77970	18	94	
18	88	27	0. 78027	23	96	
19	86	22	083	28	98	
20	8. 509 6484	8. 512 4416	0. 78139	2. 0433	5. 6799	7. 631
21	82	10	195	38	5. 6801	
22	80	4404	251	44	03	
23	78	4399	307	49	04	
24	76	93	363	54	06	
25	74	87	419	59	07	
26	72	81	475	64	09	
27	70	76	531	69	11	
28	68	70	587	74	12	
29	66	64	642	78	14	
30	8. 509 6464	8. 512 4358	0. 78698	2. 0483	5. 6816	
31	63	52	754	88	17	
32	61	46	809	93	19	
33	59	41	865	2. 0498	20	
34	57	35	920	2. 0503	22	
35	55	29	0. 78975	08	24	
36	53	23	0. 79030	13	25	
37	51	17	086	18	27	
38	49	11	141	23	29	
39	47	4305	196	28	30	
40	8. 509 6445	8. 512 4299	0. 79251	2. 0533	5. 6832	7. 640
41	43	94	306	38	34	
42	41	88	360	42	35	
43	39	82	415	47	37	
44	37	76	470	52	39	
45	35	70	525	57	40	
46	33	64	579	62	42	
47	31	58	634	67	44	
48	29	52	688	72	45	
49	27	46	743	76	47	
50	8. 509 6425	8. 512 4240	0. 79797	2. 0581	5. 6849	
51	23	34	851	86	50	
52	21	28	905	91	52	
53	19	22	0. 79960	2. 0596	54	
54	17	16	0. 80014	2. 0601	55	
55	15	10	068	05	57	
56	13	4204	122	10	59	
57	11	4198	176	15	60	
58	09	92	230	20	62	
59	07	86	284	24	64	
60	8. 509 6405	8. 512 4180	0. 80337	2. 0629	5. 6865	7. 649

LATITUDE 14°.

Lat.	log A′ diff. 1″=−0.03	log B diff. 1″=−0.10	log C diff. 1″=+0.87	log D diff. 1″=+0.08	log E diff. 1″=+0.03	log F
° ′						
14 00	$\bar{8}$. 509 6405	$\bar{8}$. 512 4180	$\bar{0}$. 80337	$\bar{2}$. 0629	$\bar{\bar{5}}$. 6865	$\bar{\bar{7}}$. 649
1	03	74	391	34	67	
2	6401	68	445	39	69	
3	6399	62	498	43	71	
4	97	56	552	48	72	
05	95	50	605	53	74	
6	93	44	659	58	76	
7	91	38	712	62	77	
8	89	32	765	67	79	
9	87	26	819	72	81	
10	8. 509 6385	8. 512 4120	0. 80872	2. 0676	5. 6882	
11	83	14	925	81	84	
12	81	08	0. 80978	86	86	
13	79	4101	0. 81031	90	88	
14	77	4095	084	2. 0695	89	
15	75	89	137	2. 0700	91	
16	73	83	190	04	93	
17	71	77	243	09	94	
18	69	71	295	14	96	
19	67	65	348	18	98	
20	8. 509 6365	8. 512 4059	0. 81401	2. 0723	5. 6900	7. 658
21	63	52	453	28	01	
22	61	46	506	32	03	
23	58	40	558	36	05	
24	56	34	611	41	06	
25	54	28	663	46	08	
26	52	21	715	51	10	
27	50	15	767	55	12	
28	48	09	820	60	13	
29	46	4003	872	64	15	
30	8. 509 6344	8. 512 3997	0. 81924	2. 0769	5. 6917	
31	42	90	0. 81976	73	19	
32	40	84	0. 82028	78	20	
33	38	78	080	83	22	
34	36	72	131	87	24	
35	34	65	183	92	26	
36	32	59	235	2. 0796	27	
37	29	53	287	2. 0801	29	
38	27	47	338	05	31	
39	25	40	390	10	33	
40	8. 509 6323	8. 512 3934	0. 82441	2. 0814	5. 6934	7. 667
41	21	28	493	19	36	
42	19	22	544	23	38	
43	17	15	596	28	40	
44	15	09	647	32	41	
45	13	3903	698	37	43	
46	11	3896	749	41	45	
47	08	90	800	46	47	
48	06	84	852	50	48	
49	04	77	903	54	50	
50	8. 509 6302	8. 512 3871	0. 82954	2. 0859	5. 6952	
51	6300	65	0. 83005	63	54	
52	6298	58	055	68	55	
53	96	52	106	72	57	
54	94	45	157	77	59	
55	92	39	208	81	61	
56	89	33	258	85	63	
57	87	26	309	90	64	
58	85	20	360	94	66	
59	83	13	410	2. 0899	68	
60	8. 509 6281	8. 512 3807	0. 83461	2. 0903	5. 6970	7. 675

LATITUDE 15°.

Lat.	log A′ diff. 1″=−0.04	log B diff. 1″=−0.11	log C diff. 1″=+0.82	log D diff. 1″=+0.07	log E diff. 1″=+0.03	log F
° ′						
15 00	$\bar{8}$. 509 6281	$\bar{8}$. 512 3807	$\bar{0}$. 83461	$\bar{2}$. 0903	$\bar{\bar{5}}$. 6970	$\bar{\bar{7}}$. 675
1	79	3801	511	07	72	
2	77	3794	561	12	73	
3	74	88	612	16	75	
4	72	81	662	21	77	
05	70	75	712	25	79	
6	68	68	762	29	80	
7	66	62	813	34	82	
8	64	56	863	38	84	
9	62	49	913	42	86	
10	8. 509 6259	8. 512 3743	0. 83963	2. 0947	5. 6988	
11	57	36	0. 84012	51	89	
12	55	30	062	55	91	
13	53	23	112	59	93	
14	51	17	162	64	95	
15	49	10	212	68	97	
16	46	3704	261	72	5. 6999	
17	44	3697	311	77	5. 7000	
18	42	91	361	81	02	
19	40	84	410	85	04	
20	8. 509 6238	8. 512 3677	0. 84460	2. 0990	5. 7006	7. 683
21	35	71	509	94	08	
22	33	64	558	2. 0998	09	
23	31	58	608	2. 1002	11	
24	29	51	657	07	13	
25	27	45	706	11	15	
26	24	38	755	15	17	
27	22	31	804	19	19	
28	20	25	854	23	20	
29	18	18	903	28	22	
30	8. 509 6216	8. 512 3612	0. 84952	2. 1032	5. 7024	
31	14	3605	0. 85001	36	26	
32	11	3598	049	40	28	
33	09	92	098	44	30	
34	07	85	147	49	31	
35	05	79	196	53	33	
36	02	72	245	57	35	
37	6200	65	293	61	37	
38	6198	59	342	65	39	
39	96	52	390	69	41	
40	8. 509 6194	8. 512 3545	0. 85439	2. 1074	5. 7042	7. 691
41	91	39	487	78	44	
42	89	32	536	82	46	
43	87	25	584	86	48	
44	85	19	633	90	50	
45	82	12	681	94	52	
46	80	3505	729	2. 1099	54	
47	78	3498	777	2. 1103	55	
48	76	92	825	07	57	
49	73	85	874	11	59	
50	8. 509 6171	8. 512 3478	0. 85922	2. 1115	5. 7061	
51	69	71	0. 85970	19	63	
52	67	65	0. 86018	23	65	
53	64	58	066	27	67	
54	62	51	113	31	69	
55	60	44	161	35	70	
56	58	38	209	39	72	
57	55	31	257	44	74	
58	53	24	304	48	76	
59	51	17	352	52	78	
60	8. 509 6149	8. 512 3411	0. 86400	2. 1156	5. 7080	7. 698

LATITUDE 16°.

Lat.	log A′ diff. 1″=−0.04	log B diff. 1″=−0.12	log C diff. 1″=+0.77	log D diff. 1″=+0.06	log E diff. 1″=+0.03	log F
° ′						
16 00	$\bar{8}$. 509 6149	8. 512 3411	$\bar{0}$. 86400	$\bar{2}$. 1156	$\bar{\bar{5}}$. 7080	$\bar{\bar{7}}$. 698
1	46	3404	447	60	82	
2	44	3397	495	64	84	
3	42	90	542	68	85	
4	40	83	590	72	87	
05	37	76	637	76	89	
6	35	70	684	80	91	
7	33	63	732	84	93	
8	30	56	779	88	95	
9	28	49	826	92	97	
10	8. 509 6126	8. 512 3342	0. 86873	2. 1196	5. 7099	
11	24	35	921	2. 1200	5. 7101	
12	21	28	0. 86968	04	03	
13	19	22	0. 87015	08	04	
14	17	15	062	12	06	
15	14	08	109	16	08	
16	12	3301	156	20	10	
17	10	3294	202	24	12	
18	08	87	249	28	14	
19	05	80	296	32	16	
20	8. 509 6103	8. 512 3273	0. 87343	2. 1236	5. 7118	7. 705
21	6101	66	389	40	20	
22	6098	59	436	44	22	
23	96	52	483	47	24	
24	94	45	529	51	25	
25	91	39	576	55	27	
26	89	32	622	59	29	
27	87	25	669	63	31	
28	84	18	715	67	33	
29	82	11	761	71	35	
30	8. 509 6080	8. 512 3204	0. 87808	2. 1275	5. 7137	
31	77	3197	854	79	39	
32	75	90	900	83	41	
33	73	83	947	87	43	
34	70	76	0. 87993	90	45	
35	68	69	0. 88039	94	47	
36	66	62	085	2. 1298	49	
37	63	55	131	2. 1302	51	
38	61	48	177	06	52	
39	59	41	223	10	54	
40	8. 509 6056	8. 512 3133	0. 88269	2. 1314	5. 7156	7. 712
41	54	26	315	17	58	
42	52	19	360	21	60	
43	49	12	406	25	62	
44	47	3105	452	29	64	
45	45	3098	498	33	66	
46	42	91	543	37	68	
47	40	84	589	40	70	
48	37	77	634	44	72	
49	35	70	680	48	74	
50	8. 509 6033	8. 512 3063	0. 88726	2. 1352	5. 7176	
51	30	56	771	56	78	
52	28	48	816	59	80	
53	26	41	862	63	82	
54	23	34	907	67	84	
55	21	27	952	71	86	
56	18	20	0. 88998	74	88	
57	16	13	0. 89043	78	90	
58	14	3006	088	82	92	
59	11	2998	133	86	94	
60	8. 509 6009	8. 512 2991	0. 89178	2. 1390	5. 7196	7. 719

LATITUDE 17°.

Lat.	log A′ diff. 1″ = −0.04	log B diff. 1″ = −0.12	log C diff. 1″ = +0.73	log D diff. 1″ = +0.06	log E diff. 1″ = +0.03	log F
° ′						
17 00	$\bar{8}$. 509 6009	$\bar{8}$. 512 2991	$\bar{0}$. 89178	$\bar{2}$. 1390	$\bar{\bar{5}}$. 7196	$\bar{\bar{7}}$. 719
1	06	84	223	93	97	
2	04	77	268	2. 1397	99	
3	6002	70	313	2. 1401	5. 7201	
4	5999	62	358	04	03	
05	97	55	403	08	05	
6	94	48	448	12	07	
7	92	41	493	16	09	
8	90	34	538	19	11	
9	87	26	583	23	13	
10	8. 500 5985	8. 512 2919	0. 89627	2. 1427	5. 7215	
11	82	12	672	30	17	
12	80	2905	717	34	19	
13	78	2897	761	38	21	
14	75	90	806	42	23	
15	73	83	850	45	25	
16	70	76	895	49	27	
17	68	68	939	53	29	
18	65	61	0. 89984	56	31	
19	63	54	0. 90028	60	33	
20	8. 509 5961	8. 512 2846	0. 90072	2. 1464	5. 7235	7. 726
21	58	39	117	67	37	
22	56	32	161	71	39	
23	53	24	205	75	41	
24	51	17	249	78	43	
25	48	10	294	82	45	
26	46	2802	338	85	47	
27	44	2795	382	89	49	
28	41	88	426	93	51	
29	39	80	470	2. 1496	53	
30	8. 509 5936	8. 512 2773	0. 90514	2. 1500	5. 7255	
31	34	66	558	04	57	
32	31	58	602	07	59	
33	29	51	646	11	61	
34	26	44	689	14	64	
35	24	36	733	18	66	
36	21	29	777	22	68	
37	19	21	821	25	70	
38	16	14	864	29	72	
39	14	2707	908	32	74	
40	8. 509 5912	8. 512 2699	0. 90952	2. 1536	5. 7276	7. 732
41	09	92	0. 90995	39	78	
42	07	84	0. 91039	43	80	
43	04	77	082	47	82	
44	5902	69	126	50	84	
45	5899	62	169	54	86	
46	97	55	212	57	88	
47	94	47	256	61	90	
48	92	40	299	64	92	
49	89	32	342	68	94	
50	8. 509 5887	8. 512 2625	0. 91386	2. 1571	5. 7296	
51	84	17	429	75	5. 7298	
52	82	10	472	78	5. 7300	
53	79	2602	515	82	02	
54	77	2595	558	85	04	
55	74	87	601	89	06	
56	72	80	644	92	08	
57	69	72	687	96	11	
58	67	65	730	2. 1599	13	
59	64	57	773	2. 1603	15	
60	8. 509 5862	8. 512 2550	0. 91816	2. 1606	5. 7317	7. 738

LATITUDE 18°

Lat.	log A′ diff. 1″ = − 0·04	log B diff. 1″ = − 0·13	log C diff. 1″ = + 0·70	log D diff. 1″ = + 0·06	log E diff. 1″ = + 0·03	log F diff. 10′ = + 3·0
° ′						
18 00	$\bar{8}$·509 5862	$\bar{8}$·512 2550	$\bar{0}$·91816	$\bar{2}$·1606	$\bar{\bar{5}}$·7317	$\bar{\bar{7}}$·738
1	59	42	859	10	19	
2	57	35	902	13	21	
3	54	27	945	17	23	
4	52	19	0·91987	20	25	
05	49	12	0·92030	24	27	
6	46	8·512 2504	073	27	29	
7	44	8·512 2497	115	31	31	
8	41	89	158	34	33	
9	39	81	201	38	35	
10	8·509 5836	8·512 2474	0·92243	2·1641	5·7337	
11	34	66	286	44	39	
12	31	59	328	48	41	
13	29	51	371	51	44	
14	26	43	413	55	46	
15	24	36	456	58	48	
16	21	28	498	62	50	
17	19	20	540	65	52	
18	16	13	582	68	54	
19	13	8·512 2405	625	72	56	
20	8·509 5811	8·512 2397	0·92667	2·1675	5·7358	7·744
21	08	90	709	79	60	
22	06	82	751	82	62	
23	03	74	793	85	64	
24	8·509 5801	67	836	89	67	
25	8·509 5798	59	878	92	69	
26	96	51	920	95	71	
27	93	44	0·92962	2·1699	73	
28	90	36	0·93004	2·1702	75	
29	88	28	046	06	77	
30	8·509 5785	8·512 2320	0·93088	2·1709	5·7379	
31	83	13	129	12	81	
32	80	8·512 2305	171	16	83	
33	78	8·512 2297	213	19	85	
34	75	90	255	22	88	
35	72	82	296	26	90	
36	70	74	338	29	92	
37	67	66	380	32	94	
38	65	58	421	36	96	
39	62	51	463	39	5·7398	
40	8·509 5759	8·512 2243	0·93505	2·1742	5·7400	7·750
41	57	35	546	46	02	
42	54	27	588	49	05	
43	52	19	629	52	07	
44	49	12	671	56	09	
45	46	8·512 2204	712	59	11	
46	44	8·512 2196	753	62	13	
47	41	88	795	65	15	
48	39	80	836	69	17	
49	36	72	877	72	19	
50	8·509 5733	8·512 2165	0·93919	2·1775	5·7422	
51	31	57	0·93960	79	24	
52	28	49	0·94001	82	26	
53	25	41	042	85	28	
54	23	33	083	88	30	
55	20	25	125	92	32	
56	18	17	166	95	34	
57	15	10	207	2·1798	37	
58	12	8·512 2102	248	2·1801	39	
59	10	8·512 2094	289	05	41	
60	8·509 5707	8·512 2086	0·94330	2·1808	5·7443	7·756

LATITUDE 19°

Lat.	log A′ diff. 1″ = −0·04	log B diff. 1″ = −0·13	log C diff. 1″ = +0·67	log D diff 1″ = +0·05	log E diff. 1″ = +0·04	log F diff. 10′ = +2·7
° ′						
19 00	$\bar{8}$·509 5707	$\bar{8}$·512 2086	$\bar{0}$·94330	$\bar{2}$·1808	$\bar{\bar{5}}$·7443	$\bar{\bar{7}}$·756
1	04	78	370	11	45	
2	8·509 5702	70	411	14	47	
3	8·509 5699	62	452	18	49	
4	96	54	493	21	52	
05	94	46	534	24	54	
6	91	38	575	27	56	
7	89	30	615	30	58	
8	86	22	656	34	60	
9	83	14	697	37	62	
10	8·509 5681	8·512 2006	0·94737	2·1840	5·7464	
11	78	8·512 1999	778	43	67	
12	75	91	819	46	69	
13	73	83	859	50	71	
14	70	75	900	53	73	
15	67	67	940	56	75	
16	65	59	0·94981	59	78	
17	62	51	0·95021	62	80	
18	59	43	061	66	82	
19	57	35	102	69	84	
20	8·509 5654	8·512 1927	0·95142	2·1872	5·7486	7·761
21	52	19	182	75	88	
22	49	11	223	78	91	
23	46	8·512 1903	263	81	93	
24	43	8·512 1895	303	84	95	
25	41	87	344	88	97	
26	38	79	384	91	5·7499	
27	35	71	424	94	5·7501	
28	33	63	464	2·1897	04	
29	30	55	504	2·1900	06	
30	8·509 5627	8·512 1847	0·95544	2·1903	5·7508	
31	25	38	584	07	10	
32	22	30	624	10	12	
33	19	22	664	13	15	
34	16	14	704	16	17	
35	14	8·512 1806	744	19	19	
36	11	8·512 1798	784	22	21	
37	08	90	824	25	23	
38	06	82	863	28	26	
39	03	74	903	31	28	
40	8·509 5600	8·512 1766	0·95943	2·1934	5·7530	7·767
41	8·509 5598	57	0·95983	38	32	
42	95	49	0·96022	41	34	
43	92	41	062	44	37	
44	89	33	102	47	39	
45	87	25	142	50	41	
46	84	17	181	53	43	
47	81	08	221	56	46	
48	78	8·512 1700	260	59	48	
49	76	8·512 1692	300	62	50	
50	8·509 5573	8·512 1684	0·96339	2·1965	5·7552	
51	70	75	379	68	54	
52	68	67	418	71	57	
53	65	59	457	74	59	
54	62	51	497	77	61	
55	59	43	536	80	63	
56	57	34	575	83	65	
57	54	26	615	86	68	
58	51	18	654	89	70	
59	48	10	693	92	72	
60	8·509 5546	8·512 1602	0·96733	2·1996	5·7574	7·772

LATITUDE 20°

Lat.	log A diff. 1″ = − 0·05	log B diff. 1″ = − 0·14	log C diff. 1″ = + 0·64	log D diff. 1″ = + 0·05	log E diff. 1″ = + 0·04	log F diff. 10′ = + 2·5
° ′						
20 00	$\bar{8}$·509 5546	$\bar{8}$·512 1602	$\bar{0}$·96733	$\bar{2}$·1996	$\bar{\bar{5}}$·7574	$\bar{\bar{7}}$·772
1	43	8·512 1593	772	2·1999	77	
2	40	85	811	2·2002	79	
3	37	77	850	05	81	
4	35	68	889	08	83	
05	32	60	928	11	86	
6	29	52	0·96967	14	88	
7	26	44	0·97006	17	90	
8	24	35	045	20	92	
9	21	27	084	23	94	
10	8·509 5518	8·512 1519	0·97123	2·2026	5·7597	
11	15	10	162	28	5·7599	
12	12	8·512 1502	201	31	5·7601	
13	10	8·512 1494	240	34	03	
14	07	85	279	37	06	
15	04	77	318	40	08	
16	8·509 5501	69	356	43	10	
17	8·509 5499	60	395	46	12	
18	96	52	434	49	15	
19	93	44	472	52	17	
20	8·509 5490	8·512 1435	0·97511	2·2055	5·7619	7·777
21	87	27	550	58	21	
22	85	18	588	61	24	
23	82	10	627	64	26	
24	79	8·512 1402	666	67	28	
25	76	8·512 1393	704	70	30	
26	73	85	743	73	33	
27	71	76	781	76	35	
28	68	68	819	79	37	
29	65	60	858	81	40	
30	8·509 5462	8·512 1351	0·97896	2·2084	5·7642	
31	59	43	935	87	44	
32	57	34	0·97973	90	46	
33	54	26	0·98011	93	49	
34	51	17	050	96	51	
35	48	09	088	2·2099	53	
36	45	8·512 1301	126	2·2102	55	
37	42	8·512 1292	164	05	58	
38	40	84	203	08	60	
39	37	75	241	10	62	
40	8·509 5434	8·512 1267	0·98279	2·2113	5·7664	7·782
41	31	58	317	16	67	
42	28	50	355	19	69	
43	25	41	393	22	71	
44	23	33	431	25	74	
45	20	24	469	28	76	
46	17	16	507	31	78	
47	14	8·512 1207	545	33	81	
48	11	8·512 1199	583	36	83	
49	08	90	621	39	85	
50	8·509 5406	8·512 1182	0·98659	2·2142	5·7688	
51	03	73	697	45	90	
52	8·509 5400	64	735	48	92	
53	8·509 5397	56	773	50	94	
54	94	47	811	53	97	
55	91	39	848	56	5·7699	
56	88	30	886	59	5·7701	
57	86	21	924	62	04	
58	83	13	962	65	06	
59	80	8·512 1104	0·98999	67	08	
60	8·509 5377	8·512 1096	0·99037	2·2170	5·7711	7·787

LATITUDE 21°

Lat.	log A′ diff. 1″ = −0·05	log B diff. 1″ = −0·15	log C diff. 1″ = +0·62	log D diff. 1″ = +0·04	log E diff. 1″ = +0·04	log F diff. 10′ = +2·2
° ′						
21 00	$\bar{8}$·509 5377	$\bar{8}$·512 1096	$\bar{0}$·99037	$\bar{2}$·2170	$\bar{5}$·7711	$\bar{7}$·787
1	74	87	075	73	13	
2	71	79	112	76	15	
3	68	70	150	79	18	
4	66	62	187	81	20	
05	63	53	225	84	22	
6	60	45	262	87	24	
7	57	36	300	90	27	
8	54	27	337	93	29	
9	51	19	375	95	31	
10	8·509 5348	8·512 1010	0·99412	2·2198	5·7734	
11	46	8·512 1002	450	2·2201	36	
12	43	8·512 0993	487	04	38	
13	40	84	524	07	41	
14	37	76	562	09	43	
15	34	67	599	12	45	
16	31	58	636	15	48	
17	28	50	673	18	50	
18	25	41	711	20	52	
19	22	32	748	23	55	
20	8·509 5320	8·512 0924	0·99785	2·2226	5·7757	7·791
21	17	15	822	29	59	
22	14	8·512 0906	859	31	62	
23	11	8·512 0897	896	34	64	
24	08	89	933	37	66	
25	05	80	0·99971	40	69	
26	8·509 5302	71	1·00008	42	71	
27	8·509 5299	62	045	45	73	
28	96	54	082	48	76	
29	93	45	119	50	78	
30	8·509 5290	8·512 0836	1·00156	2·2253	5·7780	
31	88	27	192	56	83	
32	85	19	229	59	85	
33	82	10	266	61	87	
34	79	8·512 0801	303	64	90	
35	76	8·512 0792	340	67	92	
36	73	84	377	69	94	
37	70	75	413	72	97	
38	67	66	450	75	5·7799	
39	64	57	487	78	5·7802	
40	8·509 5261	8·512 0748	1·00524	2·2280	5·7804	7·796
41	58	39	560	83	06	
42	55	31	597	86	09	
43	52	22	634	88	11	
44	49	13	670	91	13	
45	46	8·512 0704	707	94	16	
46	44	8·512 0695	743	96	18	
47	41	86	780	2·2299	20	
48	38	78	816	2·2301	23	
49	35	69	853	04	25	
50	8·509 5232	8·512 0660	1·00890	2·2307	5·7828	
51	29	51	926	09	30	
52	26	42	962	12	32	
53	23	33	1·00999	15	35	
54	20	24	1·01035	17	37	
55	17	15	072	20	40	
56	14	8·512 0606	108	23	42	
57	11	8·512 0598	144	25	44	
58	08	89	181	28	47	
59	05	80	217	31	49	
60	8·509 5202	8·512 0571	1·01253	2·2333	5·7851	7·800

LATITUDE 22°

Lat.	log A′ diff. 1″ = −0·05	log B diff. 1″ = −0·15	log C diff. 1″ = +0·59	log D diff. 1″ = +0·04	log E diff. 1″ = +0·04	log F diff. 10′ = +2·0
° ′						
22 00	$\bar{8}$·509 5202	$\bar{8}$·512 0571	$\bar{1}$·01253	$\bar{2}$·2333	$\bar{\bar{5}}$·7851	$\bar{\bar{7}}$·800
1	8·509 5199	62	289	36	54	
2	96	53	326	38	56	
3	93	44	362	41	59	
4	90	35	398	44	61	
05	87	26	434	46	63	
6	84	17	470	49	66	
7	81	8·512 0508	506	51	68	
8	78	8·512 0499	542	54	71	
9	75	90	578	57	73	
10	8·509 5172	8·512 0481	1·01615	2·2359	5·7875	
11	69	72	651	62	78	
12	66	63	687	64	80	
13	63	54	723	67	83	
14	60	45	759	70	85	
15	57	36	794	72	87	
16	54	27	830	75	90	
17	51	18	866	77	92	
18	48	09	902	80	95	
19	45	8·512 0400	938	83	97	
20	8·509 5142	8·512 0391	1·01974	2·2385	5·7899	7·804
21	39	82	1·02010	88	5·7902	
22	36	73	045	90	04	
23	33	64	081	93	07	
24	30	55	117	95	09	
25	27	46	153	2·2398	11	
26	24	37	188	2·2400	14	
27	21	28	224	03	16	
28	18	19	260	06	19	
29	15	10	295	08	21	
30	8·509 5112	8·512 0301	1·02331	2·2411	5·7924	
31	09	8·512 0292	367	13	26	
32	06	83	402	16	28	
33	03	73	438	18	31	
34	8·509 5100	64	473	21	33	
35	8·509 5097	55	509	23	36	
36	94	46	544	26	38	
37	91	37	580	28	41	
38	88	28	615	31	43	
39	85	19	651	33	45	
40	8·509 5082	8·512 0210	1·02686	2·2436	5·7948	7·808
41	79	8·512 0200	721	38	50	
42	76	8·512 0191	757	41	53	
43	72	82	792	43	55	
44	69	73	828	46	58	
45	66	64	863	48	60	
46	63	55	898	51	62	
47	60	46	933	53	65	
48	57	36	1·02969	56	67	
49	54	27	1·03004	58	70	
50	8·509 5051	8·512 0118	1·03039	2·2461	5·7972	
51	48	09	074	63	75	
52	45	8·512 0100	109	66	77	
53	42	8·512 0090	145	68	80	
54	39	81	180	70	82	
55	36	72	215	73	84	
56	33	63	250	75	87	
57	30	54	285	78	89	
58	27	44	320	80	92	
59	23	35	355	83	94	
60	8·509 5020	8·512 0026	1·03390	2·2485	5·7997	7·812

LATITUDE 23°

Lat.	log A′ diff. 1″ = −0·05	log B diff. 1″ = −0·16	log C diff. 1″ = +0·57	log D diff. 1″ = +0·04	log E diff. 1″ = +0·04	log F diff. 10′ = +1·8
° ′						
23 00	$\bar{8}$·509 5020	$\bar{8}$·512 0026	1·03390	$\bar{2}$·2485	$\bar{\bar{5}}$·7997	$\bar{\bar{7}}$·812
1	17	17	425	88	5·7999	
2	14	8·512 0008	460	90	5·8002	
3	11	8·511 9998	495	93	04	
4	08	89	530	95	07	
05	05	80	565	2·2497	09	
6	8·509 5002	71	600	2·2500	12	
7	8·509 4999	61	634	02	14	
8	96	52	669	05	16	
9	93	43	704	07	19	
10	8·509 4990	8·511 9934	1·03739	2·2510	5·8021	
11	87	24	774	12	24	
12	83	15	809	14	26	
13	80	8·511 9906	843	17	29	
14	77	8·511 9896	878	19	31	
15	74	87	913	22	34	
16	71	78	947	24	36	
17	68	68	1·03982	26	39	
18	65	59	1·04017	29	41	
19	62	50	052	31	44	
20	8·509 4959	8·511 9840	1·04086	2·2534	5·8046	7·816
21	55	31	121	36	49	
22	52	22	155	38	51	
23	49	12	190	41	54	
24	46	8·511 9803	224	43	56	
25	43	8·511 9794	259	45	59	
26	40	84	293	48	61	
27	37	75	328	50	64	
28	34	66	362	53	66	
29	31	56	397	55	69	
30	8·509 4927	8·511 9747	1·04431	2·2557	5·8071	
31	24	37	466	60	74	
32	21	28	500	62	76	
33	18	19	534	64	79	
34	15	09	569	67	81	
35	12	8·511 9700	603	69	84	
36	09	8·511 9690	637	71	86	
37	05	81	672	74	89	
38	8·509 4902	71	706	76	91	
39	8·509 4899	62	740	78	93	
40	8·509 4896	8·511 9653	1·04775	2·2581	5·8096	7·819
41	93	43	809	83	5·8099	
42	90	34	843	85	5·8101	
43	87	24	877	88	04	
44	83	15	911	90	06	
45	80	8·511 9605	945	92	09	
46	77	8·511 9596	1·04980	95	11	
47	74	86	1·05014	97	14	
48	71	77	048	2·2599	16	
49	68	67	082	2·2601	19	
50	8·509 4865	8·511 9558	1·05116	2·2604	5·8121	
51	61	48	150	06	24	
52	58	39	184	09	26	
53	55	29	218	11	29	
54	52	20	252	13	31	
55	49	10	286	16	34	
56	45	8·511 9501	320	18	36	
57	42	8·511 9491	354	20	39	
58	39	82	388	23	41	
59	36	72	422	25	44	
60	8·509 4833	8·511 9463	1·05456	2·2627	5·8146	7·823

LATITUDE 24°

Lat.	log A′ diff. 1″ = −0·05	log B diff. 1″ = −0·16	log C diff. 1″ = +0·56	log D diff. 1″ = +0·04	log E diff. 1″ = +0·04	log F diff. 10′ = +1·6
° ′						
24 00	$\bar{8}$·509 4833	$\bar{8}$·511 9463	$\bar{1}$·05456	$\bar{2}$·2627	$\bar{\bar{5}}$·8146	$\bar{\bar{7}}$·823
1	30	53	490	29	49	
2	26	44	523	31	51	
3	23	34	557	34	54	
4	20	24	591	36	57	
05	17	15	625	38	59	
6	14	8·511 9405	658	41	62	
7	10	8·511 9396	692	43	64	
8	07	86	726	45	67	
9	04	77	760	47	69	
10	8·509 4801	8·511 9367	1·05794	2·2650	5·8172	
11	8·509 4798	58	827	52	74	
12	94	48	861	54	77	
13	91	38	894	56	79	
14	88	29	928	59	82	
15	85	19	962	61	85	
16	82	09	1·05995	63	87	
17	78	8·511 9300	1·06029	65	90	
18	75	8·511 9290	062	68	92	
19	72	81	096	70	95	
20	8·509 4769	8·511 9271	1·06130	2·2672	5·8197	7·826
21	66	61	163	74	5·8200	
22	62	52	197	77	02	
23	59	42	230	79	05	
24	56	32	263	81	07	
25	53	23	297	83	10	
26	50	13	330	85	13	
27	46	8·511 9203	364	88	15	
28	43	8·511 9194	397	90	18	
29	40	84	431	92	20	
30	8·509 4737	8·511 9174	1·06464	2·2694	5·8223	
31	33	65	497	96	25	
32	30	55	530	2·2699	28	
33	27	45	564	2·2701	31	
34	24	35	597	03	33	
35	20	26	630	05	36	
36	17	16	664	07	38	
37	14	8·511 9106	697	10	41	
38	11	8·511 9096	730	12	43	
39	07	87	763	14	46	
40	8·509 4704	8·511 9077	1·06797	2·2716	5·8249	7·829
41	8·509 4701	67	830	18	51	
42	8·509 4698	58	863	20	54	
43	94	48	896	23	56	
44	91	38	929	25	59	
45	88	28	962	27	61	
46	85	18	1·06995	29	64	
47	81	8·511 9009	1·07028	31	67	
48	78	8·511 8999	061	33	69	
49	75	89	095	36	72	
50	8·509 4672	8·511 8979	1·07128	2·2738	5·8274	
51	68	70	161	40	77	
52	65	60	194	42	80	
53	62	50	226	44	82	
54	59	40	259	46	85	
55	55	30	292	49	87	
56	52	21	325	51	90	
57	49	11	358	53	92	
58	45	8·511 8901	391	55	95	
59	42	8·511 8891	424	57	5·8298	
60	8·509 4639	8·511 8881	1·07457	2·2759	5·8300	7·832

LATITUDE 25°

Lat.	log A diff. 1″ = −0·06	log B diff. 1″ = −0·16	log C diff. 1″ = +0·54	log D diff. 1″ = +0·03	log E diff. 1″ = +0·04	log F diff. 10′ = +1·5
° ′						
25 00	$\bar{8}$·509 4639	$\bar{8}$·511 8881	$\bar{1}$·07457	$\bar{2}$·2759	$\bar{\bar{5}}$·8300	$\bar{\bar{7}}$·832
1	36	71	490	61	03	
2	32	62	523	63	05	
3	29	52	555	66	08	
4	26	42	588	68	11	
05	23	32	621	70	13	
6	19	22	654	72	16	
7	16	12	687	74	18	
8	13	8·511 8802	719	76	21	
9	09	8·511 8793	752	78	24	
10	8·509 4606	8·511 8783	1·07785	2·2780	5·8326	
11	03	73	817	82	29	
12	8·509 4600	63	850	85	32	
13	8·509 4596	53	883	87	34	
14	93	43	915	89	37	
15	90	33	948	91	39	
16	86	23	1·07981	93	42	
17	83	13	1·08013	95	45	
18	80	8·511 8704	046	97	47	
19	76	8·511 8694	078	2·2799	50	
20	8·509 4573	8·511 8684	1·08111	2·2801	5·8352	7·835
21	70	74	143	03	55	
22	66	64	176	05	59	
23	63	54	208	07	60	
24	60	44	241	10	63	
25	56	34	273	12	66	
26	53	24	306	14	68	
27	50	14	338	16	71	
28	46	8·511 8604	370	18	73	
29	43	8·511 8594	403	20	76	
30	8·509 4540	8·511 8584	1·08435	2·2822	5·8379	
31	37	74	468	24	81	
32	33	64	500	26	84	
33	30	54	532	28	87	
34	26	44	565	30	89	
35	23	34	597	32	92	
36	20	24	629	34	94	
37	17	14	662	36	5·8397	
38	13	8·511 8504	694	38	5·8400	
39	10	8·511 8494	726	40	02	
40	8·509 4507	8·511 8484	1·08758	2·2842	5·8405	7·838
41	03	74	791	44	08	
42	8·509 4500	64	823	46	10	
43	8·509 4496	54	855	48	13	
44	93	44	887	50	16	
45	90	34	919	52	18	
46	86	24	951	54	21	
47	83	14	1·08984	56	24	
48	80	8·511 8404	1·09016	58	26	
49	76	8·511 8393	048	60	29	
50	8·509 4473	8·511 8383	1·09080	2·2862	5·8431	
51	70	73	112	64	34	
52	66	63	144	66	37	
53	63	53	176	68	39	
54	60	43	208	70	42	
55	56	33	240	72	45	
56	53	23	272	74	47	
57	50	13	304	76	50	
58	46	8·511 8303	336	78	53	
59	43	8·511 8293	368	80	55	
60	8·509 4439	8·511 8283	1·09400	2·2882	5·8458	7·841

LATITUDE 26°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·17	log C diff. 1″ = +0·52	log D diff. 1″ = +0·03	log E diff. 1″ = +0·04	log F diff. 10′ = +1·3
° ′						
26 00	$\bar{8}$·509 4439	$\bar{8}$·511 8283	$\bar{1}$·09400	$\bar{2}$·2882	$\bar{\bar{5}}$·8458	$\bar{\bar{7}}$·841
1	36	72	432	84	61	
2	33	62	464	86	63	
3	29	52	496	88	66	
4	26	42	527	90	69	
05	22	32	559	92	71	
6	19	22	591	94	74	
7	16	12	623	96	77	
8	12	8·511 8201	655	2·2898	79	
9	09	8·511 8191	687	2·2900	82	
10	8·509 4406	8·511 8181	1·09718	2·2902	5·8485	
11	8·509 4402	71	750	04	88	
12	8·509 4399	61	782	06	90	
13	95	51	814	08	93	
14	92	40	845	10	96	
15	88	30	877	12	5·8498	
16	85	20	909	14	5·8501	
17	82	10	940	16	04	
18	78	8·511 8100	1·09972	18	06	
19	75	8·511 8089	1·10004	20	09	
20	8·509 4372	8·511 8079	1·10036	2·2922	5·8512	7·844
21	68	69	067	23	14	
22	65	59	099	25	17	
23	61	48	130	27	20	
24	58	38	162	29	22	
25	54	28	194	31	25	
26	51	18	225	33	28	
27	48	8·511 8008	257	35	30	
28	44	8·511 7997	288	37	33	
29	41	87	320	39	36	
30	8·509 4337	8·511 7977	1·10351	2·2941	5·8539	
31	34	67	383	43	41	
32	31	56	414	45	44	
33	27	46	446	47	47	
34	24	36	477	48	49	
35	20	25	509	50	52	
36	17	15	540	52	55	
37	13	8·511 7905	571	54	57	
38	10	8·511 7895	603	56	60	
39	07	84	634	58	63	
40	8·509 4303	8·511 7874	1·10666	2·2960	5·8566	7·846
41	8·509 4300	64	697	62	68	
42	8·509 4296	53	728	63	71	
43	93	43	760	65	74	
44	89	33	791	67	76	
45	86	22	822	69	79	
46	83	12	854	71	82	
47	79	8·511 7802	885	73	85	
48	76	8·511 7791	916	75	87	
49	72	81	947	77	90	
50	8·509 4269	8·511 7771	1·10979	2·2978	5·8593	
51	65	60	1·11010	80	95	
52	62	50	041	82	5·8598	
53	58	40	072	84	5·8601	
54	55	29	103	86	04	
55	52	19	134	88	06	
56	48	8·511 7709	166	89	09	
57	45	8·511 7698	197	91	12	
58	41	88	228	93	14	
59	38	77	259	95	17	
60	8·509 4234	8·511 7667	1·11290	2·2997	5·8620	7·849

LATITUDE 27°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·18	log C diff. 1″ = +0·51	log D diff. 1″ = +0·03	log E diff. 1″ = +0·05	log F diff. 10′ = +1·1
° ′						
27 00	$\bar{8}$·509 4234	$\bar{8}$·511 7667	1·11290	$\bar{2}$·2997	$\bar{5}$·8620	$\bar{7}$·849
1	31	57	321	2·2909	23	
2	27	46	352	2·3001	25	
3	24	36	383	03	28	
4	20	25	414	04	31	
05	17	15	445	06	34	
6	13	8·511 7605	476	08	36	
7	10	8·511 7594	507	10	39	
8	06	84	538	12	42	
9	03	73	569	14	44	
10	8·509 4200	8·511 7563	1·11600	2·3015	5·8647	
11	8·509 4196	53	631	17	50	
12	93	42	662	19	53	
13	89	32	693	21	55	
14	86	21	724	23	58	
15	82	11	755	24	61	
16	79	8·511 7500	786	26	64	
17	75	8·511 7490	817	28	66	
18	72	79	848	30	69	
19	68	69	878	32	72	
20	8·509 4165	8·511 7458	1·11909	2·3033	5·8675	7·851
21	61	48	940	35	77	
22	58	37	1·11971	37	80	
23	54	27	1·12002	39	83	
24	51	16	032	41	86	
25	47	8·511 7406	063	42	88	
26	44	8·511 7395	094	44	91	
27	40	85	125	46	94	
28	37	74	156	48	97	
29	33	64	186	50	5·8699	
30	8·509 4130	8·511 7353	1·12217	2·3051	5·8702	
31	26	43	248	53	05	
32	23	32	278	55	08	
33	19	22	309	57	10	
34	16	11	340	58	13	
35	12	8·511 7301	370	60	16	
36	08	8·511 7290	401	62	19	
37	05	80	432	64	22	
38	8·509 4101	69	462	65	24	
39	8·509 4098	58	493	67	27	
40	8·509 4094	8·511 7248	1·12523	2·3069	5·8730	7·853
41	91	37	554	70	33	
42	87	27	584	72	35	
43	84	16	615	74	38	
44	80	8·511 7206	646	76	41	
45	77	8·511 7195	676	78	44	
46	73	84	707	79	46	
47	70	74	737	81	49	
48	66	63	768	83	52	
49	63	53	798	85	55	
50	8·509 4059	8·511 7142	1·12829	2·3086	5·8757	
51	56	31	859	88	60	
52	52	21	889	90	63	
53	49	10	920	91	66	
54	45	8·511 7100	950	93	69	
55	41	8·511 7089	1·12981	95	72	
56	38	78	1·13011	97	74	
57	34	68	041	2·3099	77	
58	31	57	072	2·3100	80	
59	27	46	102	02	83	
60	8·509 4024	8·511 7036	1·13132	2·3104	5·8785	7·855

LATITUDE 28°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·18	log C diff. 1″ = +0·50	log D diff. 1″ = +0·03	log E diff. 1″ = +0·05	log F diff. 10′ = +1·0
° ′						
28 00	$\bar{8}$·509 4024	$\bar{8}$·511 7036	$\bar{1}$·13132	$\bar{2}$·3104	$\bar{\bar{5}}$·8785	$\bar{\bar{7}}$·855
1	20	25	163	05	88	
2	17	14	193	07	91	
3	13	8·511 7004	223	09	94	
4	10	8·511 6993	254	10	97	
05	06	82	284	12	5·8799	
6	8·509 4002	72	314	14	5·8802	
7	8·509 3999	61	345	16	05	
8	95	50	375	17	08	
9	92	40	405	19	11	
10	8·509 3988	8·511 6929	1·13435	2.3121	5·8813	
11	85	18	465	22	16	
12	81	8·511 6908	496	24	19	
13	78	8·511 6897	526	26	22	
14	74	86	556	27	25	
15	70	75	586	29	27	
16	67	65	616	31	30	
17	63	54	646	32	33	
18	60	43	677	34	36	
19	56	33	707	36	39	
20	8·509 3952	8·511 6822	1·13737	2·3137	5·8841	7·857
21	49	11	767	39	44	
22	45	8·511 6800	797	41	47	
23	42	8·511 6790	827	42	50	
24	38	79	857	44	53	
25	35	68	887	46	55	
26	31	57	917	47	58	
27	27	47	947	49	61	
28	24	36	1·13977	51	64	
29	20	25	1·14007	52	67	
30	8·509 3917	8·511 6714	1·14037	2·3154	5·8870	
31	13	8·511 6704	067	56	72	
32	09	8·511 6693	097	57	75	
33	06	82	127	59	78	
34	8·509 3902	71	157	61	81	
35	8·509 3899	61	187	62	84	
36	95	50	217	64	87	
37	92	39	247	65	89	
38	88	28	277	67	92	
39	84	17	307	69	95	
40	8·509 3881	8·511 6607	1·14337	2·3170	5·8898	7·859
41	77	8·511 6596	366	72	5·8901	
42	73	85	396	74	04	
43	70	74	426	75	06	
44	66	63	456	77	09	
45	63	52	486	78	12	
46	59	42	516	80	15	
47	55	31	545	82	18	
48	52	20	575	83	21	
49	48	8·511 6509	605	85	23	
50	8·509 3845	8·511 6498	1·14635	2·3187	5·8926	
51	41	87	664	88	29	
52	37	76	694	90	32	
53	34	66	724	91	35	
54	30	55	754	93	38	
55	26	44	783	95	40	
56	23	33	813	96	43	
57	19	22	843	98	46	
58	16	11	872	2·3199	49	
59	12	8·511 6400	902	2·3201	52	
60	8·509 3808	8·511 6389	1·14932	2·3203	5·8955	7·861

LATITUDE 29°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·18	log C diff. 1″ = +0·49	log D diff. 1″ = +0·03	log E diff. 1″ = +0·05	log F diff. 10′ = +0·8
° ′						
29 00	8·509 3808	$\bar{8}$·511 6389	$\bar{1}$·14932	$\bar{2}$·3203	$\bar{\bar{5}}$·8955	$\bar{\bar{7}}$·861
1	05	78	961	04	58	
2	8·509 3801	68	1·14991	06	60	
3	8·509 3797	57	1·15021	07	63	
4	94	46	050	09	66	
05	90	35	080	10	69	
6	86	24	109	12	72	
7	83	13	139	14	75	
8	79	8·511 6302	168	15	78	
9	76	8·511 6291	198	17	80	
10	8·509 3772	8·511 6280	1·15228	2·3218	5·8983	
11	68	69	257	20	86	
12	65	58	287	21	89	
13	61	47	316	23	92	
14	57	36	346	25	95	
15	54	26	375	26	5·8998	
16	50	15	405	28	5·9000	
17	46	8·511 6204	434	29	03	
18	43	8·511 6193	464	31	06	
19	39	82	493	32	09	
20	8·509 3735	8·511 6171	1·15522	2·3234	5·9012	7·863
21	32	60	552	35	15	
22	28	49	581	37	18	
23	24	38	611	38	21	
24	21	27	640	40	23	
25	17	16	670	42	26	
26	13	8·511 6105	699	43	29	
27	10	8·511 6094	728	45	32	
28	06	83	758	46	35	
29	8·509 3702	72	787	48	38	
30	8·509 3699	8·511 6061	1·15816	2·3249	5·9041	
31	95	50	846	51	43	
32	91	39	875	52	46	
33	88	28	904	54	49	
34	84	17	934	55	52	
35	80	8·511 6006	963	57	55	
36	77	8·511 5995	1·15992	58	58	
37	73	84	1·16021	60	61	
38	69	73	051	61	64	
39	66	61	080	63	67	
40	8·509 3662	8·511 5950	1·16109	2·3264	5·9069	7·864
41	58	39	138	66	72	
42	55	28	167	67	75	
43	51	17	197	69	78	
44	47	8·511 5906	226	70	81	
45	44	8·511 5895	255	72	84	
46	40	84	284	73	87	
47	36	73	313	75	90	
48	33	62	343	76	93	
49	29	51	372	78	96	
50	8·509 3625	8·511 5840	1·16401	2·3279	5·9098	
51	21	29	430	81	5·9101	
52	18	18	459	82	04	
53	14	8·511 5806	488	84	07	
54	10	8·511 5795	517	85	10	
55	07	84	546	87	13	
56	8·509 3603	73	575	88	16	
57	8·509 3599	62	604	90	19	
58	96	51	633	91	22	
59	92	40	663	93	25	
60	8·509 3588	8·511 5729	1·16692	2·3294	5·9127	7·866

LATITUDE 30°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·19	log C diff. 1″ = +0·48	log D diff. 1″ = +0·02	log E diff. 1″ = +0·05	log F diff. 10′ = +0·7
° ′						
30 00	$\bar{8}$·509 3588	$\bar{8}$·511 5729	$\bar{1}$·16692	$\bar{2}$·3294	$\bar{\bar{5}}$·9127	$\bar{\bar{7}}$·866
1	84	18	721	96	30	
2	81	8·511 5706	750	97	33	
3	77	8·511 5695	778	2·3298	36	
4	73	84	807	2·3300	39	
05	69	73	836	01	42	
6	66	62	865	03	45	
7	62	51	894	04	48	
8	58	40	923	06	51	
9	55	28	952	07	54	
10	8·509 3551	8·511 5617	1·16981	2·3309	5·9157	
11	47	8·511 5606	1·17010	10	59	
12	43	8·511 5595	039	12	62	
13	40	84	068	13	65	
14	36	73	097	14	68	
15	32	61	126	16	71	
16	29	50	155	17	74	
17	25	39	184	18	77	
18	21	28	212	20	80	
19	17	17	241	22	83	
20	8·509 3514	8·511 5505	1·17270	2·3323	5·9186	7·867
21	10	8·511 5494	299	24	89	
22	06	83	328	26	92	
23	8·509 3502	72	357	27	95	
24	8·509 3499	61	385	29	5·9198	
25	95	49	414	30	5·9200	
26	91	38	443	32	03	
27	88	27	472	33	06	
28	84	16	500	34	09	
29	80	8·511 5404	529	36	12	
30	8·509 3476	8·511 5393	1·17558	2·3337	5·9215	
31	72	82	587	39	18	
32	69	71	615	40	21	
33	65	59	644	41	24	
34	61	48	673	43	27	
35	57	37	701	44	30	
36	54	26	730	46	33	
37	50	14	759	47	36	
38	46	8·511 5303	788	48	39	
39	42	8·511 5292	816	50	42	
40	8·509 3439	8·511 5281	1·17845	2·3351	5·9245	7·869
41	35	69	874	53	48	
42	31	58	902	54	51	
43	27	47	931	55	53	
44	24	35	959	57	56	
45	20	24	1·17988	58	59	
46	16	13	1·18017	59	62	
47	12	8·511 5202	045	61	65	
48	09	8·511 5190	074	62	68	
49	05	79	102	64	71	
50	8·509 3401	8·511 5168	1·18131	2·3365	5·9274	
51	8·509 3397	56	160	66	77	
52	94	45	188	68	80	
53	90	34	217	69	83	
54	86	22	245	70	86	
55	82	11	274	72	89	
56	78	8·511 5100	302	73	92	
57	75	8·511 5088	331	74	95	
58	71	77	359	76	5·9298	
59	67	66	388	77	5·9301	
60	8·509 3363	8·511 5054	1·18416	2·3379	5·9304	7·870

LATITUDE 31°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·19	log C diff. 1″ = +0·47	log D diff. 1″ = +0·02	log E diff. 1″ = +0·05	log F diff. 10′ = +0·5
° ′						
31 00	$\bar{8}$·509 3363	$\bar{8}$·511 5054	$\bar{1}$·18416	$\bar{2}$·3379	$\bar{\bar{5}}$·9304	$\bar{\bar{7}}$·870
1	60	43	445	80	07	
2	56	32	473	81	10	
3	52	20	501	83	13	
4	48	8·511 5009	530	84	16	
05	44	8·511 4998	558	85	19	
6	41	86	587	87	22	
7	37	75	615	88	25	
8	33	64	643	89	28	
9	29	52	672	91	31	
10	8·509 3325	8·511 4941	1·18700	2·3392	5·9334	
11	22	29	729	93	37	
12	18	18	757	95	39	
13	14	8·511 4907	785	96	42	
14	10	8·511 4895	813	97	45	
15	06	84	842	2·3399	48	
16	8·509 3303	72	870	2·3400	51	
17	8·509 3299	61	898	01	54	
18	95	50	927	03	57	
19	91	38	955	04	60	
20	8·509 3287	8·511 4827	1·18983	2·3405	5·9363	7·871
21	84	15	1·19012	06	66	
22	80	8·511 4804	040	08	69	
23	76	8·511 4793	068	09	72	
24	72	81	096	10	75	
25	68	70	125	12	78	
26	65	58	153	13	81	
27	61	47	181	14	84	
28	57	35	209	16	87	
29	53	24	238	17	90	
30	8·509 3249	8·511 4713	1·19266	2·3418	5·9393	
31	46	8·511 4701	294	20	96	
32	42	8·511 4690	322	21	5·9399	
33	38	78	351	22	5·9402	
34	34	67	379	23	05	
35	30	55	407	25	08	
36	26	44	435	26	11	
37	23	32	463	27	14	
38	19	21	491	29	17	
39	15	8·511 4609	520	30	20	
40	8·509 3211	8·511 4598	1·19548	2·3431	5·9423	7·872
41	07	86	576	32	26	
42	03	75	604	34	29	
43	8·509 3200	63	632	35	32	
44	8·509 3196	52	660	36	35	
45	92	40	688	37	38	
46	88	29	716	39	41	
47	84	17	744	40	44	
48	81	8·511 4506	772	41	47	
49	77	8·511 4494	800	43	50	
50	8·509 3173	8·511 4483	1·19828	2·3444	5·9453	
51	69	71	856	45	56	
52	65	60	884	46	59	
53	61	48	912	48	62	
54	57	37	940	49	65	
55	54	25	968	50	68	
56	50	14	1·19996	51	72	
57	46	8·511 4402	1·20024	53	75	
58	42	8·511 4391	052	54	78	
59	38	79	080	55	81	
60	8·509 3134	8·511 4368	1·20108	2·3456	5·9484	7·873

LATITUDE 32°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·19	log C diff. 1″ = +0·46	log D diff. 1″ = +0·02	log E diff. 1″ = +0·05	log F diff. 10′ = +0·3
° ′						
32 00	$\bar{8}$·509 3134	$\bar{8}$·511 4368	$\bar{1}$·20108	$\bar{2}$·3456	$\bar{\bar{5}}$·9484	$\bar{\bar{7}}$·872
1	31	56	136	57	87	
2	27	44	164	59	90	
3	23	33	192	60	93	
4	19	21	220	61	96	
05	15	8·511 4310	248	62	5·9499	
6	11	8·511 4298	276	64	5·9502	
7	07	87	304	65	05	
8	04	75	332	66	08	
9	8·509 3100	63	360	67	11	
10	8·509 3096	8·511 4252	1·20387	2·3469	5·9514	
11	92	40	415	70	17	
12	88	29	443	71	20	
13	84	17	471	72	23	
14	80	8·511 4205	499	73	26	
15	76	8·511 4194	527	75	29	
16	73	82	555	76	32	
17	69	71	582	77	35	
18	65	59	610	78	38	
19	61	47	638	79	41	
20	8·509 3057	8·511 4136	1·20666	2·3481	5·9544	7·874
21	53	24	694	82	47	
22	49	13	722	83	50	
23	46	8·511 4101	749	84	53	
24	42	8·511 4089	777	85	56	
25	38	78	805	87	60	
26	34	66	833	88	63	
27	30	54	860	89	66	
28	26	43	888	90	69	
29	22	31	916	91	72	
30	8·509 3018	8·511 4020	1·20944	2·3493	5·9575	
31	15	8·511 4008	971	94	78	
32	11	8·511 3996	1·20999	95	81	
33	07	85	1·21027	96	84	
34	8·509 3003	73	054	97	87	
35	8·509 2999	61	082	2·3499	90	
36	95	50	110	2·3500	93	
37	91	38	137	01	96	
38	87	26	165	02	5·9599	
39	83	15	193	03	5·9602	
40	8·509 2980	8·511 3903	1·21220	2·3504	5·9605	7·875
41	76	8·511 3891	248	06	08	
42	72	79	276	07	11	
43	68	68	303	08	15	
44	64	56	331	09	18	
45	60	44	358	10	21	
46	56	33	386	11	24	
47	52	21	414	13	27	
48	48	8·511 3809	441	14	30	
49	44	8·511 3798	469	15	33	
50	8·509 2940	8·511 3786	1·21496	2·3516	5·9636	
51	37	74	524	17	39	
52	33	63	551	18	42	
53	29	51	579	19	45	
54	25	39	607	21	48	
55	21	27	634	22	51	
56	17	16	662	23	54	
57	13	8·511 3704	689	24	58	
58	09	8·511 3692	717	25	61	
59	05	80	744	26	64	
60	8·509 2901	8·511 3669	1·21772	2·3527	5·9667	7·875

LATITUDE 33°

Lat.	log A diff. 1″ = −0·07	log B diff. 1″ = −0·20	log C diff. 1″ = +0·45	log D diff. 1″ = +0·02	log E diff. 1″ = +0·05	log F diff. 10′ = +0·2
° ′						
33 00	$\bar{8}$·509 2901	$\bar{8}$·511 3669	$\bar{1}$·21772	$\bar{2}$·3527	$\bar{\bar{5}}$·9667	$\bar{\bar{7}}$·875
1	8·509 2897	57	799	29	70	
2	94	45	827	30	73	
3	90	33	854	31	76	
4	86	22	882	32	79	
05	82	8·511 3610	909	33	82	
6	78	8·511 3598	937	34	85	
7	74	86	964	35	88	
8	70	75	1·21992	36	92	
9	66	63	1·22019	38	95	
10	8·509 2862	8·511 3551	1·22047	2·3539	5·9698	
11	58	39	074	40	5·9701	
12	54	28	101	41	04	
13	51	16	129	42	07	
14	47	8·511 3504	156	43	10	
15	43	8·511 3492	184	44	13	
16	39	80	211	45	16	
17	35	69	238	46	19	
18	31	57	266	48	22	
19	27	45	293	49	26	
20	8·509 2823	8·511 3433	1·22321	2·3550	5·9729	7·876
21	19	21	348	51	32	
22	15	8·511 3410	375	52	35	
23	11	8·511 3398	403	53	38	
24	07	86	430	54	41	
25	8·509 2803	74	457	55	44	
26	8·509 2799	62	485	56	47	
27	95	51	512	57	50	
28	91	39	539	58	53	
29	88	27	567	60	57	
30	8·509 2784	8·511 3315	1·22594	2·3561	5·9760	
31	80	8·511 3303	621	62	63	
32	76	8·511 3291	648	63	66	
33	72	80	676	64	69	
34	68	68	703	65	72	
35	64	56	730	66	75	
36	60	44	757	67	78	
37	56	32	785	68	81	
38	52	20	812	69	85	
39	48	8·511 3209	839	70	88	
40	8·509 2744	8·511 3197	1·22866	2·3571	5·9791	7·876
41	40	85	893	72	94	
42	36	73	921	73	5·9797	
43	32	61	948	75	5·9800	
44	28	49	1·22975	76	03	
45	24	37	1·23002	77	06	
46	20	25	029	78	10	
47	16	13	057	79	13	
48	12	8·511 3102	084	80	16	
49	08	8·511 3090	111	81	19	
50	8·509 2704	8·511 3078	1·23138	2·3582	5·9822	
51	8·509 2701	66	165	83	25	
52	8·509 2697	54	192	84	28	
53	93	42	220	85	31	
54	89	30	247	86	35	
55	85	18	274	87	38	
56	81	8·511 3006	301	88	41	
57	77	8·511 2995	328	89	44	
58	73	83	355	90	47	
59	69	71	382	91	50	
60	8·509 2665	8·511 2959	1·23409	2·3592	5·9853	7·877

LATITUDE 34°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·20	log C diff. 1″ = +0·45	log D diff. 1″ = +0·02	log E diff. 1″ = +0·05	log F diff. 10′ = +0·0
° ′						
34 00	$\bar{8}$·509 2665	$\bar{8}$·511 2959	$\bar{1}$·23409	$\bar{2}$·3592	$\bar{5}$·9853	$\bar{7}$·877
1	61	47	437	93	57	
2	57	35	464	94	60	
3	53	23	491	95	63	
4	49	8·511 2911	518	96	66	
05	45	8·511 2899	545	97	69	
6	41	87	572	98	72	
7	37	75	599	2·3599	75	
8	33	63	626	2·3600	79	
9	29	51	653	01	82	
10	8·509 2625	8·511 2840	1·23680	2·3602	5·9885	
11	21	28	707	03	88	
12	17	16	734	04	91	
13	13	8·511 2804	761	05	94	
14	09	8·511 2792	788	06	5·9897	
15	05	80	815	07	5·9901	
16	8·509 2601	68	842	08	04	
17	8·509 2597	56	869	09	07	
18	93	44	896	10	10	
19	89	32	923	11	13	
20	8·509 2585	8·511 2720	1·23950	2·3612	5·9916	7·877
21	81	8·511 2708	1·23977	13	19	
22	77	8·511 2696	1·24004	14	23	
23	73	84	031	15	26	
24	69	72	058	16	29	
25	65	60	085	17	32	
26	61	48	112	18	35	
27	57	36	139	19	38	
28	53	24	165	20	42	
29	49	12	192	21	45	
30	8·509 2545	8·511 2600	1·24219	2·3622	5·9948	
31	41	8·511 2588	246	23	51	
32	37	76	273	24	54	
33	33	64	300	25	57	
34	29	52	327	26	61	
35	25	40	354	27	64	
36	21	28	381	28	67	
37	17	16	408	29	70	
38	13	8·511 2504	434	30	73	
39	09	8·511 2492	461	31	76	
40	8·509 2505	8·511 2480	1·24488	2·3632	5·9980	7·877
41	8·509 2501	68	515	33	83	
42	8·509 2497	56	542	34	86	
43	93	44	569	35	89	
44	89	32	595	36	92	
45	85	20	622	37	96	
46	81	8·511 2408	649	38	5·9999	
47	77	8·511 2396	676	39	6·0002	
48	73	84	703	40	05	
49	69	72	729	41	08	
50	8·509 2465	8·511 2360	1·24756	2·3642	6·0011	
51	61	48	783	43	15	
52	57	35	810	43	18	
53	53	23	837	44	21	
54	49	8·511 2311	863	45	24	
55	45	8·511 2299	890	46	27	
56	41	87	917	47	31	
57	37	75	944	48	34	
58	33	63	970	49	37	
59	29	51	1·24997	50	40	
60	8·509 2425	8·511 2239	1·25024	2·3651	6·0043	7·877

LATITUDE 35°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·20	log C diff. 1″ = +0·44	log D diff. 1″ = +0·01	log E diff. 1″ = +0·05	log F diff. 10′ = +0·0
° ′						
35 00	$\bar{8}$·509 2425	$\bar{8}$·511 2239	$\bar{1}$·25024	$\bar{2}$·3651	$\bar{\bar{6}}$·0043	$\bar{\bar{7}}$·877
1	21	27	050	52	47	
2	17	15	077	53	50	
3	13	8·511 2203	104	54	53	
4	09	8·511 2191	131	55	56	
05	05	78	157	56	59	
6	8·509 2401	66	184	56	63	
7	8·509 2396	54	211	57	66	
8	92	42	237	58	69	
9	88	30	264	59	72	
10	8·509 2384	8·511 2118	1·25291	2·3660	6·0075	
11	80	8·511 2106	317	61	79	
12	76	8·511 2094	344	62	82	
13	72	82	371	63	85	
14	68	70	397	64	88	
15	64	57	424	65	91	
16	60	45	451	66	95	
17	56	33	477	66	6·0098	
18	52	21	504	67	6·0101	
19	48	8·511 2009	531	68	04	
20	8·509 2344	8·511 1997	1·25557	2·3669	6·0107	7·877
21	40	85	584	70	11	
22	36	72	610	71	14	
23	32	60	637	72	17	
24	28	48	664	73	20	
25	24	36	690	74	23	
26	20	24	717	75	27	
27	16	12	743	75	30	
28	12	8·511 1900	770	76	33	
29	08	8·511 1887	796	77	36	
30	8·509 2304	8·511 1875	1·25823	2·3678	6·0140	
31	8·509 2300	63	850	79	43	
32	8·509 2296	51	876	80	46	
33	92	39	903	81	49	
34	87	27	929	82	52	
35	83	15	956	82	56	
36	79	8·511 1802	1·25982	83	59	
37	75	8·511 1790	1·26009	84	62	
38	71	78	035	85	65	
39	67	66	062	86	69	
40	8·509 2263	8·511 1754	1·26088	2·3687	6·0172	7·877
41	59	41	115	88	75	
42	55	29	141	88	78	
43	51	17	168	89	81	
44	47	8·511 1705	194	90	85	
45	43	8·511 1693	221	91	88	
46	39	80	247	92	91	
47	35	68	274	93	94	
48	31	56	300	94	6·0198	
49	27	44	327	94	6·0201	
50	8·509 2222	8·511 1632	1·26353	2·3695	6·0204	
51	18	20	380	96	07	
52	14	8·511 1607	406	97	11	
53	10	8·511 1595	432	98	14	
54	06	83	459	99	17	
55	8·509 2202	71	485	2·3699	20	
56	8·509 2198	58	512	2·3700	24	
57	94	46	538	01	27	
58	90	34	565	02	30	
59	86	22	591	03	33	
60	8·509 2182	8·511 1510	1·26617	2·3704	6·0237	7·877

LATITUDE 36°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·20	log C diff. 1″ = +0·44	log D diff. 1″ = +0·01	log E diff. 1″ = +0·05	log F diff. 10′ = −0·2
° ′						
36 00	$\bar{8}$·509 2182	$\bar{8}$·511 1510	$\bar{1}$·26617	$\bar{2}$·3704	$\bar{\bar{6}}$·0237	$\bar{\bar{7}}$·877
1	78	8·511 1497	644	04	40	
2	74	85	670	05	43	
3	70	73	697	06	46	
4	65	61	723	07	50	
05	61	48	749	08	53	
6	57	36	776	09	56	
7	53	24	802	09	59	
8	49	8·511 1412	828	10	63	
9	45	8·511 1399	855	11	66	
10	8·509 2141	8·511 1387	1·26881	2·3712	6·0269	
11	37	75	908	13	72	
12	33	63	934	13	76	
13	29	50	960	14	79	
14	25	38	1·26987	15	82	
15	21	26	1·27013	16	85	
16	16	14	039	17	89	
17	12	8·511 1301	066	17	92	
18	08	8·511 1289	092	18	95	
19	04	77	118	19	6·0299	
20	8·509 2100	8·511 1265	1·27145	2·3720	6·0302	7·877
21	8·509 2096	52	171	21	05	
22	92	40	197	21	08	
23	88	28	223	22	12	
24	84	15	250	23	15	
25	80	8·511 1203	276	24	18	
26	75	8·511 1191	302	25	21	
27	71	79	329	25	25	
28	67	66	355	26	28	
29	63	54	381	27	31	
30	8·509 2059	8·511 1142	1·27407	2·3728	6·0334	
31	55	29	434	29	38	
32	51	17	460	29	41	
33	47	8·511 1105	486	30	44	
34	43	8·511 1092	512	31	48	
35	39	80	539	32	51	
36	35	68	565	32	54	
37	30	56	591	33	57	
38	26	43	617	34	61	
39	22	31	644	35	64	
40	8·509 2018	8·511 1019	1·27670	2·3735	6·0367	7·877
41	14	8·511 1006	696	36	71	
42	10	8·511 0994	722	37	74	
43	06	82	748	38	77	
44	8·509 2002	69	775	39	80	
45	8·509 1998	57	801	39	84	
46	93	45	827	40	87	
47	89	32	853	41	90	
48	85	20	879	42	94	
49	81	8·511 0908	905	42	6·0397	
50	8·509 1977	8·511 0895	1·27932	2·3743	6·0400	
51	73	83	958	44	03	
52	69	71	1·27984	45	07	
53	65	58	1·28010	45	10	
54	61	46	036	46	13	
55	56	34	062	47	17	
56	52	21	088	48	20	
57	48	8·511 0809	114	48	23	
58	44	8·511 0797	141	49	27	
59	40	84	167	50	30	
60	8·509 1936	8·511 0772	1·28193	2·3750	6·0433	7·876

LATITUDE 37°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·43	log D diff. 1″ = +0·01	log E diff. 1″ = +0·06	log F diff. 10′ = −0·3
° ′						
37 00	$\bar{8}$·509 1936	$\bar{8}$·511 0772	$\bar{1}$·28193	$\bar{2}$·3750	$\bar{\bar{6}}$·0433	$\bar{\bar{7}}$·876
1	32	60	219	51	37	
2	28	47	245	52	40	
3	23	35	271	53	43	
4	19	22	297	53	46	
05	15	8·511 0710	324	54	50	
6	11	8·511 0698	350	55	53	
7	07	85	376	56	56	
8	8·509 1903	73	402	56	60	
9	8·509 1899	61	428	57	63	
10	8·509 1895	8·511 0648	1·28454	2·3758	6·0466	
11	90	36	480	59	70	
12	86	23	506	59	73	
13	82	8·511 0611	532	60	76	
14	78	8·511 0599	558	61	80	
15	74	86	584	61	83	
16	70	74	610	62	86	
17	66	61	636	63	89	
18	62	49	662	63	93	
19	57	37	688	64	96	
20	8·509 1853	8·511 0524	1·28715	2·3765	6·0499	7·876
21	49	12	741	66	6·0503	
22	45	8·511 0500	767	66	06	
23	41	8·511 0487	793	67	09	
24	37	75	819	68	13	
25	33	62	845	68	16	
26	28	50	871	69	19	
27	24	37	897	70	23	
28	20	25	923	70	26	
29	16	13	949	71	29	
30	8·509 1812	8·511 0400	1·28975	2·3772	6·0533	
31	08	8·511 0388	1·29001	72	36	
32	04	75	027	73	39	
33	8·509 1800	63	053	74	43	
34	8·509 1795	51	079	74	46	
35	91	38	104	75	49	
36	87	26	130	76	53	
37	83	13	156	76	56	
38	79	8·511 0301	182	77	59	
39	75	8·511 0288	208	78	63	
40	8·509 1771	8·511 0276	1·29234	2·3779	6·0566	7·875
41	66	64	260	79	69	
42	62	51	286	80	73	
43	58	39	312	81	76	
44	54	26	338	81	79	
45	50	14	364	82	83	
46	46	8·511 0201	390	82	86	
47	41	8·511 0189	416	83	89	
48	37	76	442	84	93	
49	33	64	468	84	6·0596	
50	8·509 1729	8·511 0151	1·29494	2·3785	6·0600	
51	25	39	520	86	03	
52	21	26	546	86	06	
53	16	14	571	87	10	
54	12	8·511 0102	597	88	13	
55	08	8·511 0089	623	88	16	
56	04	77	649	89	20	
57	8·509 1700	64	675	90	23	
58	8·509 1696	52	701	90	26	
59	92	39	727	91	30	
60	8·509 1687	8·511 0027	1·29753	2·3792	6·0633	7·874

LATITUDE 38°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·43	log D diff. 1″ = +0·01	log E diff. 1″ = +0·06	log F diff. 10′ = −0·4
° ′						
38 00	$\bar{8}$·509 1687	$\bar{8}$·511 0027	$\bar{1}$·29753	$\bar{2}$·3792	$\bar{\bar{6}}$·0633	$\bar{\bar{7}}$·874
1	83	14	778	92	36	
2	79	8·511 0002	804	93	40	
3	75	8·510 9989	830	93	43	
4	71	77	856	94	47	
05	67	64	882	95	50	
6	62	52	908	95	53	
7	58	39	934	96	57	
8	54	27	959	97	60	
9	50	14	1·29985	97	63	
10	8·509 1646	8·510 9902	1·30011	2·3798	6·0667	
11	42	8·510 9889	037	2·3799	70	
12	37	77	063	2·3800	73	
13	33	64	089	00	77	
14	29	52	114	01	80	
15	25	39	140	01	84	
16	21	27	166	02	87	
17	17	14	192	02	90	
18	12	8·510 9802	218	03	94	
19	08	8·510 9789	243	03	6·0697	
20	8·509 1604	8·510 9777	1·30269	2·3804	6·0701	7·874
21	8·509 1600	64	295	05	04	
22	8·509 1596	52	321	05	07	
23	92	39	347	06	11	
24	87	27	372	06	14	
25	83	14	398	07	17	
26	79	8·510 9701	424	08	21	
27	75	8·510 9689	450	08	24	
28	71	77	476	09	28	
29	66	64	501	09	31	
30	8·509 1562	8·510 9652	1·30527	2·3810	6·0734	
31	58	39	553	11	38	
32	54	27	579	11	41	
33	50	14	604	12	44	
34	46	8·510 9601	630	12	48	
35	41	8·510 9589	656	13	51	
36	37	76	682	14	55	
37	33	64	707	14	58	
38	29	51	733	15	61	
39	25	39	759	15	65	
40	8·509 1521	8·510 9526	1·30785	2·3816	6·0768	7·873
41	16	14	810	16	72	
42	12	8·510 9501	836	17	75	
43	08	8·510 9488	862	18	78	
44	04	76	887	18	82	
45	8·509 1500	63	913	19	85	
46	8·509 1495	51	939	19	89	
47	91	38	965	20	92	
48	87	26	1·30990	20	95	
49	83	13	1·31016	21	6·0799	
50	8·509 1479	8·510 9401	1·31042	2·3822	6·0802	
51	75	8·510 9388	067	22	06	
52	70	76	093	23	09	
53	66	63	119	23	13	
54	62	50	144	24	16	
55	58	38	170	24	19	
56	53	25	196	25	23	
57	49	13	221	25	26	
58	45	8·510 9300	247	26	30	
59	41	8·510 9287	273	27	33	
60	8·509 1437	8·510 9275	1·31299	2·3827	6·0836	7·872

LATITUDE 39°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·43	log D diff. 1″ = +0·01	log E diff. 1″ = +0·06	log F diff. 10′ = −0·5
° ′						
39 00	$\bar{8}$·509 1437	$\bar{8}$·510 9275	$\bar{1}$·31299	$\bar{2}$·3827	$\bar{\bar{6}}$·0836	$\bar{\bar{7}}$·872
1	33	62	324	28	40	
2	28	50	350	28	43	
3	24	37	375	29	47	
4	20	25	401	29	50	
05	16	8·510 9212	427	30	53	
6	12	8·510 9199	452	30	57	
7	07	87	478	31	60	
8	8·509 1403	74	504	31	64	
9	8·509 1399	62	529	32	67	
10	8·509 1395	8·510 9149	1·31555	2·3832	6·0871	
11	91	36	581	33	74	
12	86	24	606	33	77	
13	82	8·510 9111	632	34	81	
14	78	8·510 9098	658	35	84	
15	74	86	683	35	88	
16	70	73	709	36	91	
17	65	61	734	36	95	
18	61	48	760	37	6·0898	
19	57	36	786	37	6·0902	
20	8·509 1353	8·510 9023	1·31811	2·3838	6·0905	7·871
21	49	8·510 9010	837	38	08	
22	44	8·510 8998	862	39	12	
23	40	85	888	39	15	
24	36	73	913	40	19	
25	32	60	939	40	22	
26	28	47	965	41	26	
27	23	35	1·31990	41	29	
28	19	22	1·32016	42	32	
29	15	8·510 8909	041	42	36	
30	8·509 1311	8·510 8897	1·32067	2·3843	6·0939	
31	07	84	092	43	43	
32	8·509 1302	72	118	44	46	
33	8·509 1298	59	144	44	50	
34	94	46	169	45	53	
35	90	34	195	45	57	
36	86	21	220	46	60	
37	81	8·510 8808	246	46	63	
38	77	8·510 8796	271	47	67	
39	73	83	297	47	70	
40	8·509 1269	8·510 8771	1·32323	2·3848	6·0974	7·870
41	64	58	348	48	77	
42	60	45	374	49	81	
43	56	33	399	49	84	
44	52	20	425	50	88	
45	48	8·510 8707	450	50	91	
46	43	8·510 8695	476	51	95	
47	39	82	501	51	6·0998	
48	35	69	527	52	6·1002	
49	31	57	552	52	05	
50	8·509 1227	8·510 8644	1·32578	2·3852	6·1008	
51	22	31	603	53	12	
52	18	19	629	53	15	
53	14	8·510 8606	654	54	19	
54	10	8·510 8593	680	54	22	
55	06	81	705	55	26	
56	8·509 1201	68	731	55	29	
57	8·509 1197	55	756	56	33	
58	93	43	782	56	36	
59	89	30	807	57	40	
60	8·509 1184	8·510 8517	1·32833	2·3857	6·1043	7·869

LATITUDE 40°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·42	log D diff. 1″ = +0·01	log E diff. 1″ = +0·06	log F diff. 10′ = −0·7
° ′						
40 00	$\bar{8}$·509 1184	$\bar{8}$·510 8517	$\bar{1}$·32833	$\bar{2}$·3857	$\bar{\bar{6}}$·1043	$\bar{\bar{7}}$·869
1	80	8·510 8505	858	58	47	
2	76	8·510 8492	884	58	50	
3	72	79	909	58	54	
4	67	67	935	59	57	
05	63	54	960	59	61	
6	59	41	1·32986	60	64	
7	55	29	1·33011	60	67	
8	50	16	037	60	71	
9	46	8·510 8403	062	61	74	
10	8·509 1142	8·510 8391	1·33088	2·3861	6·1078	
11	38	78	113	62	81	
12	34	65	139	62	85	
13	29	53	164	63	88	
14	25	40	189	63	92	
15	21	27	215	64	95	
16	17	15	240	64	6·1099	
17	12	8·510 8302	266	65	6·1102	
18	08	8·510 8289	291	65	06	
19	04	77	317	65	09	
20	8·509 1100	8·510 8264	1·33342	2·3866	6·1113	7·867
21	8·509 1096	51	368	66	16	
22	91	38	393	67	20	
23	87	26	418	67	23	
24	83	13	444	68	27	
25	79	8·510 8200	469	68	30	
26	74	8·510 8188	495	68	34	
27	70	75	520	69	37	
28	66	62	546	69	41	
29	62	50	571	70	44	
30	8·509 1057	8·510 8137	1·33596	2·3870	6·1148	
31	53	24	622	70	51	
32	49	8·510 8111	647	71	55	
33	45	8·510 8099	673	71	58	
34	41	86	698	72	62	
35	36	73	723	72	65	
36	32	61	749	72	69	
37	28	48	774	73	72	
38	24	35	800	73	76	
39	19	23	825	74	79	
40	8·509 1015	8·510 8010	1·33850	2·3874	6·1183	7·866
41	11	8·510 7997	876	74	86	
42	07	84	901	75	90	
43	8·509 1002	72	926	75	93	
44	8·509 0998	59	952	76	6·1197	
45	94	46	1·33977	76	6·1200	
46	90	33	1·34003	76	04	
47	85	21	028	77	07	
48	81	8·510 7908	053	77	11	
49	77	8·510 7895	079	77	15	
50	8·509 0973	8·510 7883	1·34104	2·3878	6·1218	
51	68	70	129	78	22	
52	64	57	155	79	25	
53	60	44	180	79	29	
54	56	32	206	79	32	
55	52	19	231	80	36	
56	47	8·510 7806	256	80	39	
57	43	8·510 7793	282	80	43	
58	39	81	307	81	46	
59	34	68	332	81	50	
60	8·509 0930	8·510 7755	1·34358	2·3882	6·1253	7·864

LATITUDE 41°

Lat.	log A diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·42	log D diff. 1″ = +0·01	log E diff. 1″ = +0·06	log F diff. 10′ = −0·8
° ′						
41 00	$\bar{8}$·509 0930	$\bar{8}$·510 7755	$\bar{1}$·34358	$\bar{2}$·3882	$\bar{\bar{6}}$·1253	$\bar{\bar{7}}$·864
1	26	42	383	82	57	
2	22	30	408	82	60	
3	18	17	434	83	64	
4	13	8·510 7704	459	83	67	
05	09	8·510 7691	484	83	71	
6	05	79	510	84	75	
7	8·509 0900	66	535	84	78	
8	8·509 0896	53	560	84	82	
9	92	40	586	85	85	
10	8·509 0888	8·510 7628	1·34611	2·3885	6·1289	
11	83	15	636	85	92	
12	79	8·510 7602	662	86	96	
13	75	8·510 7590	687	86	6·1299	
14	71	77	712	87	6·1303	
15	67	64	738	87	06	
16	62	51	763	87	10	
17	58	39	788	88	14	
18	54	26	814	88	17	
19	49	13	839	88	21	
20	8·509 0845	8·510 7500	1·34864	2·3889	6·1324	7·863
21	41	8·510 7488	890	89	28	
22	37	75	915	89	31	
23	32	62	940	90	35	
24	28	49	965	90	38	
25	24	36	1·34991	90	42	
26	20	24	1·35016	91	46	
27	15	8·510 7411	041	91	49	
28	11	8·510 7398	066	91	53	
29	07	85	092	91	56	
30	8·509 0803	8·510 7373	1·35117	2·3892	6·1360	
31	8·509 0798	60	142	92	63	
32	94	47	168	92	67	
33	90	34	193	93	70	
34	86	22	218	93	74	
35	81	8·510 7309	243	93	78	
36	77	8·510 7296	269	94	81	
37	73	83	294	94	85	
38	69	70	319	94	88	
39	64	58	345	95	92	
40	8·509 0760	8·510 7245	1·35370	2·3895	6·1395	7·861
41	56	32	395	95	6·1399	
42	52	19	420	96	6·1403	
43	47	8·510 7207	446	96	06	
44	43	8·510 7194	471	96	10	
45	39	81	496	97	13	
46	35	68	522	97	17	
47	30	55	547	97	20	
48	26	43	572	97	24	
49	22	30	597	98	28	
50	8·509 0718	8·510 7117	1·35623	2·3898	6·1431	
51	13	8·510 7104	648	98	35	
52	09	8·510 7091	673	98	38	
53	05	79	698	99	42	
54	8·509 0700	66	723	99	46	
55	8·509 0696	53	749	2·3899	49	
56	92	40	774	2·3900	53	
57	88	27	799	00	56	
58	83	15	824	00	60	
59	79	8·510 7002	850	00	63	
60	8·509 0675	8·510 6989	1·35875	2·3901	6·1467	7·860

LATITUDE 42°

Lat.	log A′ diff. 1″ = − 0·07	log B diff. 1″ = − 0·21	log C diff. 1″ = + 0·42	log D diff. 1″ = + 0·00	log E diff. 1″ = + 0·06	log F diff. 10′ = − 0·9
° ′						
42 00	$\bar{8}$·509 0675	$\bar{8}$·510 6989	$\bar{1}$·35875	$\bar{2}$·3901	$\bar{\bar{6}}$·1467	$\bar{\bar{7}}$·860
1	71	76	900	01	71	
2	66	64	925	01	74	
3	62	51	951	01	78	
4	58	38	1·35976	02	81	
05	54	25	1·36001	02	85	
6	49	12	026	02	89	
7	45	8·510 6900	052	03	92	
8	41	8·510 6887	077	03	96	
9	36	74	102	03	6·1499	
10	8·509 0632	8·510 6861	1·36127	2·3903	6·1503	
11	28	48	152	04	07	
12	24	36	178	04	10	
13	19	23	203	04	14	
14	15	8·510 6810	228	04	17	
15	11	8·510 6797	253	05	21	
16	07	84	278	05	25	
17	8·509 0602	72	304	05	28	
18	8·509 0598	59	329	05	32	
19	94	46	354	06	35	
20	8·509 0590	8·510 6733	1·36379	2·3906	6·1539	7·858
21	85	20	404	06	43	
22	81	8·510 6707	430	06	46	
23	77	8·510 6695	455	07	50	
24	72	82	480	07	54	
25	68	69	505	07	57	
26	64	56	530	07	61	
27	60	43	556	08	64	
28	55	31	581	08	68	
29	51	18	606	08	72	
30	8·509 0547	8·510 6605	1·36631	2·3908	6·1575	
31	43	8.510 6592	656	08	79	
32	38	79	682	09	83	
33	34	66	707	09	86	
34	30	54	732	09	90	
35	25	41	757	09	93	
36	21	28	782	10	6·1597	
37	17	15	808	10	6·1601	
38	13	8·510 6502	833	10	04	
39	08	8·510 6490	858	10	08	
40	8·509 0504	8·510 6477	1·36883	2·3910	6·1612	7·856
41	8·509 0500	64	908	11	15	
42	8·509 0496	51	934	11	19	
43	91	38	959	11	22	
44	87	25	1·36984	11	26	
45	83	13	1·37009	12	30	
46	78	8·510 6400	034	12	33	
47	74	8·510 6387	059	12	37	
48	70	74	085	12	41	
49	66	61	110	12	44	
50	8·509 0461	8·510 6348	1·37135	2·3913	6·1648	
51	57	36	160	13	52	
52	53	23	185	13	55	
53	48	8·510 6310	210	13	59	
54	44	8·510 6297	235	13	63	
55	40	84	261	14	66	
56	36	71	286	14	70	
57	31	59	311	14	73	
58	27	46	336	14	77	
59	23	33	361	14	81	
60	8·509 0419	8·510 6220	1·37386	2·3914	6·1684	7·854

LATITUDE 43°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·42	log D diff. 1″ = +0·00	log E diff. 1″ = +0·06	log F diff. 10′ = −1·0
° ′						
43 00	$\bar{8}$·509 0419	$\bar{8}$·510 6220	$\bar{1}$·37386	$\bar{2}$·3914	$\bar{\bar{6}}$·1684	$\bar{\bar{7}}$·854
1	14	8·510 6207	412	15	88	
2	10	8·510 6195	437	15	92	
3	06	82	462	15	95	
4	8·509 0401	69	487	15	6·1699	
05	8·509 0397	56	512	15	6·1703	
6	93	43	537	16	06	
7	89	30	563	16	10	
8	84	17	588	16	14	
9	80	8·510 6105	613	16	17	
10	8·509 0376	8·510 6092	1·37638	2·3916	6·1721	
11	71	79	663	16	25	
12	67	66	688	17	28	
13	63	53	713	17	32	
14	59	40	739	17	36	
15	54	28	764	17	39	
16	50	15	789	17	43	
17	46	8·510 6002	814	17	47	
18	41	8·510 5989	839	18	50	
19	37	76	864	18	54	
20	8·509 0333	8·510 5963	1·37889	2·3918	6·1758	7·852
21	29	50	915	18	61	
22	24	38	940	18	65	
23	20	25	965	18	69	
24	16	8·510 5912	1·37990	18	72	
25	12	8·510 5899	1·38015	19	76	
26	07	86	040	19	80	
27	8·509 0303	73	065	19	83	
28	8·509 0299	60	091	19	87	
29	94	48	116	19	91	
30	8·509 0290	8·510 5835	1·38141	2·3919	6·1795	
31	86	22	166	20	6·1798	
32	82	8·510 5809	191	20	6·1802	
33	77	8·510 5796	216	20	06	
34	73	83	241	20	09	
35	69	71	266	20	13	
36	64	58	292	20	17	
37	60	45	317	20	20	
38	56	32	342	20	24	
39	52	19	367	21	28	
40	8·509 0247	8·510 5706	1·38392	2·3921	6·1831	7·850
41	43	8·510 5693	417	21	35	
42	39	81	442	21	39	
43	34	68	467	21	42	
44	30	55	492	21	46	
45	26	42	518	21	50	
46	22	29	543	21	53	
47	17	16	568	22	57	
48	13	8·510 5603	593	22	61	
49	09	8·510 5591	618	22	65	
50	8·509 0204	8·510 5578	1·38643	2·3922	6·1868	
51	8·509 0200	65	668	22	72	
52	8·509 0196	52	693	22	76	
53	92	39	719	22	79	
54	87	26	744	22	83	
55	83	13	769	22	87	
56	79	8·510 5501	794	23	91	
57	74	8·510 5488	819	23	94	
58	70	75	844	23	6·1898	
59	66	62	869	23	6·1902	
60	8·509 0162	8·510 5449	1·38894	2·3923	6·1905	7·848

LATITUDE 44°.

Lat.	log A diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·42	log D diff. 1″ = +0·00	log E diff. 1″ = +0·06	log F diff. 10′ = −1·2
° ′						
44 00	$\bar{8}$·509 0162	$\bar{8}$·510 5449	$\bar{1}$·38894	$\bar{2}$·3923	$\bar{\bar{6}}$·1905	$\bar{\bar{7}}$·848
1	57	36	919	23	09	
2	53	23	945	23	13	
3	49	8·510 5411	970	23	17	
4	44	8·510 5398	1·38995	23	20	
05	40	85	1·39020	23	24	
6	36	72	045	24	28	
7	31	59	070	24	31	
8	27	46	095	24	35	
9	23	33	120	24	39	
10	8·509 0119	8·510 5320	1·39145	2·3924	6·1943	
11	14	8·510 5307	171	24	46	
12	10	8·510 5295	196	24	50	
13	06	82	221	24	54	
14	8·509 0102	69	246	24	58	
15	8·509 0097	56	271	24	61	
16	93	43	296	24	65	
17	89	30	321	24	69	
18	84	18	346	24	72	
19	80	8·510 5205	371	25	76	
20	8·509 0076	8·510 5192	1·39396	2·3925	6·1980	7·845
21	72	79	422	25	84	
22	67	66	447	25	87	
23	63	53	472	25	91	
24	59	40	497	25	95	
25	54	28	522	25	6·1999	
26	50	15	547	25	6·2002	
27	46	8·510 5102	572	25	06	
28	42	8·510 5089	597	25	10	
29	37	76	623	25	14	
30	8·509 0033	8·510 5063	1·39648	2·3925	6·2017	
31	29	50	673	25	21	
32	24	37	698	25	25	
33	20	25	723	25	29	
34	16	8·510 5012	748	25	32	
35	11	8·510 4999	773	25	36	
36	07	86	798	26	40	
37	8·509 0003	73	823	26	44	
38	8·508 9999	60	848	26	47	
39	94	47	873	26	51	
40	8·508 9990	8·510 4935	1·39898	2·3926	6·2055	7·843
41	86	22	924	26	59	
42	81	8·510 4909	949	26	62	
43	77	8·510 4896	974	26	66	
44	73	83	1·39999	26	70	
45	69	70	1·40024	26	74	
46	64	57	049	26	77	
47	60	44	074	26	81	
48	56	32	099	26	85	
49	51	19	124	26	89	
50	8·508 9947	8·510 4806	1·40149	2·3926	6·2092	
51	43	8·510 4793	174	26	6·2096	
52	39	80	200	26	6·2100	
53	34	67	225	26	04	
54	30	54	250	26	08	
55	26	41	275	26	11	
56	21	29	300	26	15	
57	17	16	325	26	19	
58	13	8·510 4703	350	26	23	
59	09	8·510 4690	375	26	27	
60	8·508 9904	8·510 4677	1·40400	2·3926	6·2130	7·840

LATITUDE 45°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·42	log D diff. 1″ = ±0·00	log E diff. 1″ = +0·06	log F diff. 10′ = −1·3
° ′						
45 00	$\bar{8}$·508 9904	$\bar{8}$·510 4677	$\bar{1}$·40400	$\bar{2}$·3926	$\bar{\bar{6}}$·2130	$\bar{\bar{7}}$·840
1	8·508 9900	64	425	26	34	
2	8·508 9896	51	450	26	38	
3	91	39	475	26	42	
4	87	26	501	26	46	
05	83	13	526	26	49	
6	78	8·510 4600	551	26	53	
7	74	8·510 4587	576	26	57	
8	70	74	601	26	61	
9	66	61	626	26	64	
10	8·508 9861	8·510 4548	1·40651	2·3926	6·2168	
11	57	36	676	26	72	
12	53	23	701	26	76	
13	48	8·510 4510	727	26	80	
14	44	8·510 4497	752	26	83	
15	40	84	777	26	87	
16	36	71	802	26	91	
17	31	59	827	26	95	
18	27	46	852	26	6·2199	
19	23	33	877	26	6·2202	
20	8·508 9818	8·510 4420	1·40902	2·3926	6·2206	7·838
21	14	8·510 4407	927	26	10	
22	10	8·510 4394	952	26	14	
23	06	81	1·40978	26	18	
24	8·508 9801	68	1·41003	26	21	
25	8·508 9797	56	028	26	25	
26	93	43	053	26	29	
27	88	30	078	26	33	
28	84	17	103	26	37	
29	80	8·510 4304	128	26	40	
30	8·508 9776	8·510 4291	1·41153	2·3926	6·2244	
31	71	78	178	26	48	
32	67	65	203	26	52	
33	63	52	229	26	56	
34	58	40	254	26	60	
35	54	27	279	26	63	
36	50	14	304	25	67	
37	46	8·510 4201	329	25	71	
38	41	8·510 4188	354	25	75	
39	37	75	379	25	79	
40	8·508 9733	8·510 4162	1·41404	2·3925	6·2283	7·835
41	28	49	429	25	86	
42	24	37	454	25	90	
43	20	24	479	25	94	
44	16	8·510 4111	505	25	6·2298	
45	11	8·510 4098	530	25	6·2302	
46	07	85	555	25	06	
47	8·508 9703	72	580	25	09	
48	8·508 9698	60	605	25	13	
49	94	47	630	25	17	
50	8·508 9689	8·510 4034	1·41655	2·3925	6·2321	
51	85	21	680	25	25	
52	81	8·510 4008	705	25	29	
53	77	8·510 3995	731	25	32	
54	72	82	756	24	36	
55	68	69	781	24	40	
56	64	57	806	24	44	
57	60	44	831	24	48	
58	55	31	856	24	52	
59	51	18	881	24	55	
60	8·508 9647	8·510 3905	1·41906	2·3924	6·2359	7·832

LATITUDE 46°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·42	log D diff. 1″ = −0·00	log E diff. 1″ = +0·06	log F diff. 10′ = −1·4
° ′						
46 00	$\bar{8}$·508 9647	$\bar{8}$·510 3905	$\bar{1}$·41906	$\bar{2}$·3924	$\bar{\bar{6}}$·2359	$\bar{\bar{7}}$·832
1	43	8·510 3892	931	24	63	
2	38	79	957	24	67	
3	34	67	1·41982	24	71	
4	30	54	1·42007	24	75	
05	25	41	032	24	79	
6	21	28	057	23	82	
7	17	15	082	23	86	
8	13	8·510 3802	107	23	90	
9	08	8·510 3789	132	23	94	
10	8·508 9604	8·510 3776	1·42157	2·3923	6·2398	
11	8·508 9600	64	183	23	6·2402	
12	8·508 9595	51	208	23	06	
13	91	38	233	23	09	
14	87	25	258	23	13	
15	83	8·510 3712	283	23	17	
16	78	8·510 3699	308	23	21	
17	74	86	333	22	25	
18	70	74	358	22	29	
19	65	61	384	22	33	
20	8·508 9561	8·510 3648	1·42409	2·3922	6·2436	7·830
21	57	35	434	22	40	
22	53	22	459	22	44	
23	48	8·510 3609	484	22	48	
24	44	8·510 3596	509	22	52	
25	40	84	534	22	56	
26	35	71	559	21	60	
27	31	58	584	21	64	
28	27	45	610	21	67	
29	23	32	635	21	71	
30	8·508 9518	8·510 3519	1·42660	2·3921	6·2475	
31	14	8·510 3506	685	21	79	
32	10	8·510 3494	710	21	83	
33	05	81	735	21	87	
34	8·508 9501	68	760	20	91	
35	8·508 9497	55	786	20	95	
36	93	42	811	20	6·2499	
37	88	29	836	20	6·2502	
38	84	17	861	20	06	
39	80	8·510 3404	886	20	10	
40	8·508 9475	8·510 3391	1·42911	2·3920	6·2514	7·827
41	71	78	936	19	18	
42	67	65	961	19	22	
43	63	52	1·42987	19	26	
44	58	39	1·43012	19	30	
45	54	27	037	19	34	
46	50	14	062	19	38	
47	45	8·510 3301	087	19	41	
48	41	8·510 3288	112	18	45	
49	37	75	137	18	49	
50	8·508 9433	8·510 3262	1·43163	2·3918	6·2553	
51	28	49	188	18	57	
52	24	37	213	18	61	
53	20	24	238	18	65	
54	16	8·510 3211	263	18	69	
55	11	8·510 3198	288	17	73	
56	07	85	314	17	77	
57	8·508 9403	72	339	17	81	
58	8·508 9398	60	364	17	84	
59	94	47	389	17	88	
60	8·508 9390	8·510 3134	1·43414	2·3917	6·2592	7·824

LATITUDE 47°

Lat.	log A′ diff. 1″ = − 0·07	log B diff. 1″ = − 0·21	log C diff. 1″ = + 0·42	log D diff. 1″ = − 0·00	log E diff. 1″ = + 0·07	log F diff. 10′ = − 1·6
° ′						
47 00	$\bar{8}$·508 9390	$\bar{8}$·510 3134	$\bar{1}$·43414	$\bar{2}$·3917	$\bar{\bar{6}}$·2592	$\bar{\bar{7}}$·824
1	86	21	439	16	6·2596	
2	81	8·510 3108	465	16	6·2600	
3	77	8·510 3095	490	16	04	
4	73	82	515	16	08	
05	68	70	540	16	12	
6	64	57	565	16	16	
7	60	44	590	15	20	
8	56	31	615	15	24	
9	51	18	641	15	28	
10	8·508 9347	8·510 3005	1·43666	2·3915	6·2632	
11	43	8·510 2993	691	15	35	
12	38	80	716	14	39	
13	34	67	741	14	43	
14	30	54	766	14	47	
15	26	41	792	14	51	
16	21	28	817	14	55	
17	17	16	842	13	59	
18	13	8·510 2903	867	13	63	
19	09	8·510 2890	892	13	67	
20	8·508 9304	8·510 2877	1·43917	2·3913	6·2671	7·821
21	8·508 9300	64	943	13	75	
22	8·508 9296	51	968	12	79	
23	91	39	1·43993	12	83	
24	87	26	1·44018	12	87	
25	83	13	043	12	91	
26	79	8·510 2800	069	12	95	
27	74	8·510 2787	094	11	6·2699	
28	70	74	119	11	6·2702	
29	66	62	144	11	06	
30	8·508 9261	8·510 2749	1·44169	2·3911	6·2710	
31	57	36	195	11	14	
32	53	23	220	10	18	
33	49	8·510 2710	245	10	22	
34	44	8·510 2698	270	10	26	
35	40	85	295	10	30	
36	36	72	321	10	34	
37	32	59	346	09	38	
38	27	46	371	09	42	
39	23	33	396	09	46	
40	8·508 9219	8·510 2621	1·44421	2·3909	6·2750	7·817
41	14	8·510 2608	447	08	54	
42	10	8·510 2595	472	08	58	
43	06	82	497	08	62	
44	8·508 9202	69	522	08	66	
45	8·508 9197	57	547	07	70	
46	93	44	573	07	74	
47	89	31	598	07	78	
48	84	18	623	07	82	
49	80	8·510 2505	648	07	86	
50	8·508 9176	8·510 2493	1·44673	2·3906	6·2790	
51	72	80	699	06	94	
52	67	67	724	06	6·2798	
53	63	54	749	06	6·2802	
54	59	41	774	05	06	
55	55	28	800	05	10	
56	50	16	825	05	14	
57	46	8·510 2403	850	05	18	
58	42	8·510 2390	875	04	22	
59	38	77	900	04	26	
60	8·508 9133	8·510 2364	1·44926	2·3904	6·2830	7·814

LATITUDE 48°

Lat.	log A diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·42	log D diff. 1″ = −0·00	log E diff. 1″ = +0·07	log F diff. 10′ = −1·7
° ′						
48 00	$\bar{8}$·508 9133	$\bar{8}$·510 2364	$\bar{1}$·44926	$\bar{2}$·3904	$\bar{\bar{6}}$·2830	$\bar{\bar{7}}$·814
1	29	52	951	04	34	
2	25	39	1·44976	03	38	
3	20	26	1·45001	03	42	
4	16	13	027	03	46	
05	12	8·510 2300	052	02	50	
6	08	8·510 2288	077	02	54	
7	8·508 9103	75	102	02	58	
8	8·508 9099	62	128	02	62	
9	95	49	153	01	66	
10	8·508 9091	8·510 2236	1·45178	2·3901	6·2870	
11	86	24	203	01	74	
12	82	8·510 2211	229	01	78	
13	78	8·510 2198	254	00	82	
14	74	85	279	00	86	
15	69	72	304	2·3900	90	
16	65	60	330	2·3899	94	
17	61	47	355	99	6·2898	
18	57	34	380	99	6·2902	
19	52	21	406	99	06	
20	8·508 9048	8·510 2108	1·45431	2·3898	6·2910	7·811
21	44	8·510 2096	456	98	14	
22	39	83	481	98	18	
23	35	70	507	97	22	
24	31	57	532	97	26	
25	27	45	557	97	30	
26	22	32	582	97	34	
27	18	19	608	96	38	
28	14	8·510 2006	633	96	42	
29	10	8·510 1993	658	96	46	
30	8·508 9005	8·510 1981	1·45683	2·3895	6·2950	
31	8·508 9001	68	709	95	54	
32	8·508 8997	55	734	95	58	
33	93	42	759	95	62	
34	88	30	785	94	66	
35	84	17	810	94	70	
36	80	8·510 1904	835	94	74	
37	76	8·510 1891	861	93	78	
38	71	78	886	93	82	
39	67	66	911	93	86	
40	8·508 8963	8·510 1853	1·45937	2·3892	6·2990	7·807
41	59	40	962	92	94	
42	54	27	1·45987	92	6·2998	
43	50	15	1·46012	91	6·3002	
44	46	8·510 1802	038	91	06	
45	41	8·510 1789	063	91	10	
46	37	76	088	90	15	
47	33	64	114	90	19	
48	29	51	139	90	23	
49	24	38	164	89	27	
50	8·508 8920	8·510 1725	1·46190	2·3889	6·3031	
51	16	13	215	89	35	
52	12	8·510 1700	240	88	39	
53	08	8·510 1687	266	88	43	
54	8·508 8903	74	291	88	47	
55	8·508 8899	62	316	87	51	
56	95	49	342	87	55	
57	90	36	367	87	59	
58	86	23	392	86	63	
59	82	8·510 1610	418	86	67	
60	8·508 8878	8·510 1598	1·46443	2·3886	6·3071	7·804

LATITUDE 49°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·42	log D diff. 1″ = −0·01	log E diff. 1″ = +0·07	log F diff. 10′ = −1·9
° ′						
49 00	$\bar{8}$·508 8878	$\bar{8}$·510 1598	$\bar{1}$·46443	$\bar{2}$·3886	$\bar{\bar{6}}$·3071	$\bar{\bar{7}}$·804
1	73	85	468	85	75	
2	69	72	494	85	79	
3	65	59	519	85	84	
4	61	47	544	84	88	
05	57	34	570	84	92	
6	52	21	595	84	6·3096	
7	48	8·510 1508	621	83	6·3100	
8	44	8·510 1496	646	83	04	
9	39	83	671	83	08	
10	8·508 8835	8·510 1470	1·46696	2·3882	6·3112	
11	31	58	722	82	16	
12	27	45	747	81	20	
13	23	32	773	81	24	
14	18	19	798	81	28	
15	14	8·510 1407	824	80	32	
16	10	8·510 1394	849	80	37	
17	06	81	874	80	41	
18	8·508 8801	68	899	79	45	
19	8·508 8797	56	925	79	49	
20	8·508 8793	8·510 1343	1·46950	2·3878	6·3153	7·800
21	89	30	1·46976	78	57	
22	84	17	1·47001	78	61	
23	80	8·510 1305	026	77	65	
24	76	8·510 1292	052	77	69	
25	72	79	077	77	73	
26	67	67	103	76	78	
27	63	54	128	76	82	
28	59	41	153	75	86	
29	55	28	179	75	90	
30	8·508 8750	8·510 1216	1·47204	2·3875	6·3194	
31	46	8·510 1203	230	74	6·3198	
32	42	8·510 1190	255	74	6·3202	
33	38	78	281	73	06	
34	33	65	306	73	10	
35	29	52	331	73	15	
36	25	39	357	72	19	
37	21	27	382	72	23	
38	16	14	408	71	27	
39	12	8·510 1101	433	71	31	
40	8·508 8708	8·510 1088	1·47459	2·3871	6·3235	7·796
41	04	76	484	70	39	
42	8·508 8700	63	509	70	43	
43	8·508 8695	50	535	69	47	
44	91	38	560	69	52	
45	87	25	586	69	56	
46	83	12	611	68	60	
47	78	8·510 1000	637	68	64	
48	74	8·510 0987	662	67	68	
49	70	74	688	67	72	
50	8·508 8666	8·510 0962	1·47713	2·3866	6·3276	
51	61	49	738	66	81	
52	57	36	764	66	85	
53	53	23	789	65	89	
54	49	8·510 0911	815	65	93	
55	45	8·510 0898	840	64	6·3297	
56	40	85	866	64	6·3301	
57	36	73	891	63	05	
58	32	60	917	63	09	
59	28	48	942	63	14	
60	8·508 8623	8·510 0835	1·47968	2·3862	6·3318	7·792

LATITUDE 50°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·43	log D diff. 1″ = −0·01	log E diff. 1″ = +0·07	log F diff. 10′ = −2·0
° ′						
50 00	$\bar{8}$·508 8623	$\bar{8}$·510 0835	$\bar{1}$·47968	$\bar{2}$·3862	$\bar{\bar{6}}$·3318	$\bar{\bar{7}}$·792
1	19	22	1·47993	62	22	
2	15	8·510 0809	1·48019	61	26	
3	11	8·510 0797	044	61	30	
4	06	84	070	60	34	
05	8·508 8602	71	095	60	39	
6	8·508 8598	59	121	60	43	
7	94	46	146	59	47	
8	90	33	172	59	51	
9	85	21	197	58	55	
10	8·508 8581	8·510 0708	1·48223	2·3858	6·3359	
11	77	8·510 0695	248	57	63	
12	73	83	274	57	68	
13	68	70	299	56	72	
14	64	57	325	56	76	
15	60	45	350	55	80	
16	56	32	376	55	84	
17	52	19	401	55	88	
18	47	8·510 0607	427	54	93	
19	43	8·510 0594	452	54	6·3397	
20	8·508 8539	8·510 0581	1·48478	2·3853	6·3401	7·788
21	35	69	504	53	05	
22	30	56	529	52	09	
23	26	43	555	52	14	
24	22	31	580	51	18	
25	18	18	606	51	22	
26	14	8·510 0505	631	50	26	
27	09	8·510 0493	657	50	30	
28	05	80	682	49	34	
29	8·508 8501	67	708	49	39	
30	8·508 8497	8·510 0455	1·48734	2·3848	6·3443	
31	93	42	759	48	47	
32	88	29	785	47	51	
33	84	17	810	47	55	
34	80	8·510 0404	836	46	60	
35	76	8·510 0392	861	46	64	
36	71	79	887	45	68	
37	67	66	913	45	72	
38	63	54	938	44	76	
39	59	41	964	44	81	
40	8·508 8455	8·510 0328	1·48989	2·3843	6·3485	7·784
41	50	16	1·49015	43	89	
42	46	8·510 0303	041	42	93	
43	42	8·510 0291	066	42	6·3497	
44	38	78	092	41	6·3502	
45	34	65	117	41	06	
46	29	53	143	40	10	
47	25	40	169	40	14	
48	21	27	194	39	18	
49	17	15	220	39	23	
50	8·508 8413	8·510 0202	1·49246	2·3838	6·3527	
51	08	8·510 0190	271	38	31	
52	04	77	297	37	35	
53	8·508 8400	64	322	37	40	
54	8·508 8396	52	348	36	44	
55	92	39	374	36	48	
56	87	27	399	35	52	
57	83	14	425	35	56	
58	79	8·510 0101	451	34	61	
59	75	8·510 0089	476	34	65	
60	8·508 8371	8·510 0076	1·49502	2·3833	6·3569	7·780

LATITUDE 51°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·43	log D diff. 1″ = −0·01	log E diff. 1″ = +0·07	log F diff. 10′ = −2·2
° ′						
51 00	$\bar{8}$·508 8371	$\bar{8}$·510 0076	$\bar{1}$·49502	$\bar{2}$·3833	$\bar{\bar{6}}$·3569	$\bar{\bar{7}}$·780
1	66	64	528	33	73	
2	62	51	553	32	78	
3	58	38	579	32	82	
4	54	26	605	31	86	
05	50	13	630	31	90	
6	45	8·510 0001	656	30	95	
7	41	8·509 9988	682	29	6·3599	
8	37	75	707	29	6·3603	
9	33	63	733	28	07	
10	8·508 8329	8·509 9950	1·49759	2·3828	6·3612	
11	24	38	785	27	16	
12	20	25	810	27	20	
13	16	13	836	26	24	
14	12	8·509 9900	862	26	28	
15	08	8·509 9887	887	25	33	
16	8·508 8303	75	913	25	37	
17	8·508 8299	62	939	24	41	
18	95	50	965	23	45	
19	91	37	1·49990	23	50	
20	8·508 8287	8·509 9825	1·50016	2·3822	6·3654	7·776
21	82	8·509 9812	042	22	58	
22	78	8·509 9799	067	21	63	
23	74	87	093	21	67	
24	70	74	119	20	71	
25	66	62	145	20	75	
26	62	49	170	19	80	
27	57	37	196	18	84	
28	53	24	222	18	88	
29	49	8·509 9711	248	17	92	
30	8·508 8245	8·509 9699	1·50273	2·3817	6·3697	
31	41	86	299	16	6·3701	
32	36	74	325	16	05	
33	32	61	351	15	10	
34	28	49	376	14	14	
35	24	36	402	14	18	
36	20	24	428	13	22	
37	16	8·509 9611	454	13	27	
38	11	8·509 9599	480	12	31	
39	07	86	505	11	35	
40	8·508 8203	8·509 9574	1·50531	2·3811	6·3740	7·772
41	8·508 8199	61	557	10	44	
42	95	48	583	10	48	
43	90	36	609	09	52	
44	86	23	634	08	57	
45	82	8·509 9511	660	08	61	
46	78	8·509 9498	686	07	65	
47	74	86	712	07	70	
48	70	73	738	06	74	
49	65	61	764	05	78	
50	8·508 8161	8·509 9448	1·50789	2·3805	6·3782	
51	57	36	815	04	87	
52	53	23	841	04	91	
53	49	8·509 9411	867	03	6·3795	
54	45	8·509 9398	893	02	6·3800	
55	40	86	919	02	04	
56	36	73	944	01	08	
57	32	61	970	01	13	
58	28	48	1·50996	2·3800	17	
59	24	36	1·51022	2·3799	21	
60	8·508 8120	8·509 9323	1·51048	2·3799	6·3826	7·767

LATITUDE 52°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·43	log D diff. 1″ = −0·01	log E diff. 1″ = +0·07	log F diff. 10′ = −2·3
° ′						
52 00	$\bar{8}$·508 8120	$\bar{8}$·509 9323	$\bar{1}$·51048	$\bar{2}$·3799	$\bar{\bar{6}}$·3826	$\bar{\bar{7}}$·767
1	15	8·509 9311	074	98	30	
2	11	8·509 9298	100	97	34	
3	07	86	126	97	39	
4	8·508 8103	73	151	96	43	
05	8·508 8099	61	177	96	47	
6	95	48	203	95	52	
7	90	36	229	94	56	
8	86	23	255	94	60	
9	82	8·509 9211	281	93	65	
10	8·508 8078	8·509 9198	1·51307	2·3792	6·3869	
11	74	86	333	92	73	
12	70	73	359	91	78	
13	65	61	385	91	82	
14	61	48	411	90	86	
15	57	36	436	89	91	
16	53	23	462	88	95	
17	49	8·509 9111	488	88	6·3899	
18	45	8·509 9099	514	87	6·3904	
19	41	86	540	87	08	
20	8·508 8036	8·509 9074	1·51566	2·3786	6·3912	7·763
21	32	61	592	85	17	
22	28	49	618	85	21	
23	24	36	644	84	25	
24	20	24	670	83	30	
25	16	8·509 9011	696	83	34	
26	11	8·509 8999	722	82	38	
27	07	86	748	81	43	
28	8·508 8003	74	774	81	47	
29	8·508 7999	62	800	80	51	
30	8·508 7995	8·509 8949	1·51826	2·3779	6·3956	
31	91	37	852	79	60	
32	87	24	878	78	65	
33	82	8·509 8912	904	78	69	
34	78	8·509 8899	930	77	73	
35	74	87	956	76	78	
36	70	74	1·51982	75	82	
37	66	62	1·52008	75	86	
38	62	50	034	74	91	
39	58	37	060	73	6·3995	
40	8·508 7953	8·509 8825	1·52086	2·3773	6·4000	7·758
41	49	12	112	72	04	
42	45	8·509 8800	138	71	08	
43	41	8·509 8788	164	71	13	
44	37	75	190	70	17	
45	33	63	216	69	21	
46	29	50	242	68	26	
47	24	38	268	68	30	
48	20	25	294	67	35	
49	16	13	320	66	39	
50	8·508 7912	8·509 8701	1·52347	2·3766	6·4043	
51	08	8·509 8688	373	65	48	
52	04	76	399	64	52	
53	8·508 7900	63	425	64	57	
54	8·508 7895	51	451	63	61	
55	91	39	477	62	65	
56	87	26	503	61	70	
57	83	14	529	61	74	
58	79	8·509 8602	555	60	79	
59	75	8·509 8589	581	59	83	
60	8·508 7871	8·509 8577	1·52608	2·3759	6·4088	7·753

LATITUDE 53°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·21	log C diff. 1″ = +0·44	log D diff. 1″ = −0·01	log E diff. 1″ = +0·07	log F diff. 10′ = −2·5
° ′						
53 00	$\bar{8}$·508 7871	$\bar{8}$·509 8577	$\bar{1}$·52608	$\bar{2}$·3759	$\bar{\bar{6}}$·4088	$\bar{\bar{7}}$·753
1	67	64	634	58	92	
2	62	52	660	57	6·4096	
3	58	40	686	56	6·4101	
4	54	27	712	56	05	
05	50	15	738	55	10	
6	46	8·509 8502	764	54	14	
7	42	8·509 8490	790	53	18	
8	38	78	817	53	23	
9	34	65	843	52	27	
10	8·508 7829	8·509 8453	1·52869	2·3751	6·4132	
11	25	41	895	51	36	
12	21	28	921	50	41	
13	17	16	947	49	45	
14	13	8·509 8404	1·52974	48	49	
15	09	8·509 8391	1·53000	48	54	
16	05	79	026	47	58	
17	8·508 7801	67	052	46	63	
18	8·508 7797	54	078	45	67	
19	92	42	105	45	72	
20	8·508 7788	8·509 8329	1·53131	2·3744	6·4176	7·748
21	84	17	157	43	80	
22	80	8·509 8305	183	42	85	
23	76	8·509 8292	209	42	89	
24	72	80	236	41	94	
25	68	68	262	40	6·4198	
26	64	55	288	39	6·4203	
27	60	43	314	39	07	
28	55	31	341	38	12	
29	51	18	367	37	16	
30	8·508 7747	8·509 8206	1·53393	2·3736	6·4221	
31	43	8·509 8194	419	36	25	
32	39	82	446	35	29	
33	35	69	472	34	34	
34	31	57	498	33	38	
35	27	45	524	33	43	
36	23	32	551	32	47	
37	18	20	577	31	52	
38	14	8·509 8108	603	30	56	
39	10	8·509 8095	630	29	61	
40	8·508 7706	8·509 8083	1·53656	2·3729	6·4265	7·743
41	8·508 7702	71	682	28	70	
42	8·508 7698	58	709	27	74	
43	94	46	735	26	79	
44	90	34	761	26	83	
45	86	22	788	25	88	
46	82	8·509 8009	814	24	92	
47	77	8·509 7997	840	23	6·4297	
48	73	85	867	22	6·4301	
49	69	72	893	22	06	
50	8·508 7665	8·509 7960	1·53919	2·3721	6·4310	
51	61	48	946	20	15	
52	57	36	972	19	19	
53	53	23	1·53998	18	24	
54	49	8·509 7911	1·54025	18	28	
55	45	8·509 7899	051	17	33	
56	41	87	077	16	37	
57	37	74	104	15	42	
58	32	62	130	14	46	
59	28	50	157	14	51	
60	8·508 7624	8·509 7838	1·54183	2·3713	6·4355	7·738

LATITUDE 54°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·20	log C diff. 1″ = +0·44	log D diff. 1″ = −0·01	log E diff. 1″ = +0·08	log F diff. 10′ = −2·6
° ′						
54 00	$\bar{8}$·508 7624	$\bar{8}$·509 7838	$\bar{1}$·54183	$\bar{2}$·3713	$\bar{\bar{6}}$·4355	$\bar{\bar{7}}$·738
1	20	25	209	12	60	
2	16	13	236	11	64	
3	12	8·509 7801	262	10	69	
4	08	8·509 7789	288	09	73	
05	04	76	315	09	78	
6	8·508 7600	64	341	08	82	
7	8·508 7596	52	368	07	87	
8	92	40	394	06	91	
9	88	27	421	05	6·4396	
10	8·508 7584	8·509 7715	1·54447	2·3705	6·4400	
11	79	8·509 7703	474	04	05	
12	75	8·509 7691	500	03	09	
13	71	78	527	02	14	
14	67	66	553	01	18	
15	63	54	580	00	23	
16	59	42	606	2·3700	28	
17	55	30	633	2·3699	32	
18	51	17	659	98	37	
19	47	8·509 7605	686	97	41	
20	8·508 7543	8·509 7593	1·54712	2·3696	6·4446	7·733
21	39	81	739	95	50	
22	35	69	765	94	55	
23	31	56	792	94	59	
24	27	44	818	93	64	
25	22	32	845	92	68	
26	18	20	871	91	73	
27	14	8·509 7508	898	90	78	
28	10	8·509 7495	924	89	82	
29	06	83	951	88	87	
30	8·508 7502	8·509 7471	1·54977	2·3688	6·4491	
31	8·508 7498	59	1·55004	87	6·4496	
32	94	47	031	86	6·4500	
33	90	34	057	85	05	
34	86	22	084	84	09	
35	82	8·509 7410	110	83	14	
36	78	8·509 7398	137	82	19	
37	74	86	163	82	23	
38	70	74	190	81	28	
39	66	61	217	80	32	
40	8·508 7462	8·509 7349	1·55243	2·3679	6·4537	7·728
41	58	37	270	78	41	
42	53	25	297	77	46	
43	49	13	323	76	51	
44	45	8·509 7301	350	75	55	
45	41	8·509 7289	376	74	60	
46	37	76	403	74	64	
47	33	64	430	73	69	
48	29	52	456	72	74	
49	25	40	483	71	78	
50	8·508 7421	8·509 7228	1·55510	2·3670	6·4583	
51	17	16	536	69	87	
52	13	8·509 7204	563	68	92	
53	09	8·509 7191	590	67	6·4597	
54	05	79	616	66	6·4601	
55	8·508 7401	67	643	66	06	
56	8·508 7397	55	670	65	10	
57	93	43	696	64	15	
58	89	31	723	63	20	
59	85	19	750	62	24	
60	8·508 7381	8·509 7107	1·55777	2·3661	6·4629	7·723

LATITUDE 55°

Lat.		log A diff. 1″ = −0·07	log B diff. 1″ = −0·20	log C diff. 1″ = +0·45	log D diff. 1″ = −0·02	log E diff. 1″ = +0·08	log F diff. 10′ = −2·8
°	′						
55	00	$\bar{8}$·508 7381	$\bar{8}$·509 7107	$\bar{1}$·55777	$\bar{2}$·3661	$\bar{\bar{6}}$·4629	$\bar{\bar{7}}$·723
	1	77	8·509 7095	803	60	33	
	2	73	82	830	59	38	
	3	69	70	857	58	43	
	4	65	58	884	57	47	
	05	61	46	910	56	52	
	6	56	34	937	56	57	
	7	52	22	964	55	61	
	8	48	8·509 7010	1·55991	54	66	
	9	44	8·509 6998	1·56017	53	70	
	10	8·508 7340	8·509 6986	1·56044	2·3652	6·4675	
	11	36	74	071	51	80	
	12	32	62	098	50	84	
	13	28	49	125	49	89	
	14	24	37	151	48	94	
	15	20	25	178	47	6·4698	
	16	16	13	205	46	6·4703	
	17	12	8·509 6901	232	45	08	
	18	08	8·509 6889	259	44	12	
	19	04	77	286	43	17	
	20	8·508 7300	8·509 6865	1·56312	2·3642	6·4721	7·717
	21	8·508 7296	53	339	42	26	
	22	92	41	366	41	31	
	23	88	29	393	40	35	
	24	84	17	420	39	40	
	25	80	8·509 6805	447	38	45	
	26	76	8·509 6793	474	37	49	
	27	72	81	500	36	54	
	28	68	69	527	35	59	
	29	64	57	554	34	63	
	30	8·508 7260	8·509 6745	1·56581	2·3633	6·4768	
	31	56	33	608	32	73	
	32	52	21	635	31	77	
	33	48	8·509 6709	662	30	82	
	34	44	8·509 6696	689	29	87	
	35	40	84	716	28	91	
	36	36	72	743	27	6·4796	
	37	32	60	770	26	6·4801	
	38	28	48	797	25	05	
	39	24	36	823	24	10	
	40	8·508 7220	8·509 6624	1·56850	2·3623	6·4815	7·711
	41	16	12	877	22	20	
	42	12	8·509 6600	904	21	24	
	43	08	8·509 6588	931	20	29	
	44	04	76	958	19	34	
	45	8·508 7200	64	1·56985	18	38	
	46	8·508 7196	52	1·57012	17	43	
	47	92	40	039	16	48	
	48	88	28	066	15	52	
	49	84	16	093	14	57	
	50	8·508 7180	8·509 6505	1·57120	2·3613	6·4862	
	51	76	8·509 6493	147	12	66	
	52	72	81	174	11	71	
	53	68	69	201	10	76	
	54	64	57	229	09	81	
	55	60	45	256	08	85	
	56	56	33	283	07	90	
	57	52	21	310	06	6·4895	
	58	48	8·509 6409	337	05	6·4900	
	59	44	8·509 6397	364	04	04	
	60	8·508 7140	8·509 6385	1·57391	2·3603	6·4909	7·706

LATITUDE 56°

Lat.	log A′ diff. 1″ = −0·07	log B diff. 1″ = −0·20	log C diff. 1″ = +0·45	log D diff. 1″ = −0·02	log E diff. 1″ = +0·08	log F diff. 10′ = −3·0
° ′						
56 00	$\bar{8}$·508 7140	$\bar{8}$·509 6385	$\bar{1}$·57391	$\bar{2}$·3603	$\bar{\bar{6}}$·4909	$\bar{\bar{7}}$·706
1	36	73	418	02	14	
2	32	61	445	01	18	
3	28	49	472	2·3600	23	
4	24	37	499	2·3599	28	
05	20	25	526	98	33	
6	16	13	554	97	37	
7	12	8·509 6301	581	96	42	
8	08	8·509 6289	608	95	47	
9	04	77	635	94	52	
10	8·508 7100	8·509 6266	1·57662	2·3593	6·4956	
11	8·508 7096	54	689	92	61	
12	92	42	717	91	66	
13	88	30	744	90	71	
14	84	18	771	89	75	
15	80	8·509 6206	798	88	80	
16	76	8·509 6194	825	87	85	
17	72	82	852	86	90	
18	69	70	880	85	94	
19	65	58	907	84	6·4999	
20	8·508 7061	8·509 6147	1·57934	2·3583	6·5004	7·700
21	57	35	961	82	09	
22	53	23	1·57989	81	13	
23	49	8·509 6111	1·58016	80	18	
24	45	8·509 6099	043	78	23	
25	41	87	070	77	28	
26	37	75	098	76	32	
27	33	63	125	75	37	
28	29	51	152	74	42	
29	25	40	179	73	47	
30	8·508 7021	8·509 6028	1·58207	2·3572	6·5052	
31	17	16	234	71	56	
32	13	8·509 6004	261	70	61	
33	09	8·509 5992	289	69	66	
34	05	80	316	68	71	
35	8·508 7001	68	343	67	75	
36	8·508 6997	57	371	66	80	
37	93	45	398	65	85	
38	89	33	425	64	90	
39	86	21	453	62	95	
40	8·508 6982	8·509 5909	1·58480	2·3561	6·5099	7·694
41	78	8·509 5897	507	60	6·5104	
42	74	86	535	59	09	
43	70	74	562	58	14	
44	66	62	589	57	19	
45	62	50	617	56	24	
46	58	38	644	55	28	
47	54	27	672	54	33	
48	50	15	699	53	38	
49	46	8·509 5803	726	52	43	
50	8·508 6942	8·509 5791	1·58754	2·3550	6·5148	
51	38	79	781	49	52	
52	34	67	809	48	57	
53	30	56	836	47	62	
54	26	44	864	46	67	
55	23	32	891	45	72	
56	19	20	919	44	77	
57	15	8·509 5709	946	43	81	
58	11	8·509 5697	1·58974	42	86	
59	07	85	1·59001	41	91	
60	8·508 6903	8·509 5673	1·59028	2·3539	6·5196	7·688

LATITUDE 57°

Lat.	log A′ diff. 1″ = − 0·06	log B diff. 1″ = − 0·19	log C diff. 1″ = + 0·46	log D diff. 1″ = − 0·02	log E diff. 1″ = + 0·08	log F diff. 10′ = − 3·2
° ′						
57 00	$\bar{8}$·508 6903	$\bar{8}$·509 5673	$\bar{1}$·59028	$\bar{2}$·3539	$\bar{\bar{6}}$·5196	$\bar{\bar{7}}$·688
1	8·508 6899	61	056	38	6·5201	
2	95	50	083	37	06	
3	91	38	111	36	10	
4	87	26	139	35	15	
05	83	14	166	34	20	
6	79	8·509 5603	194	33	25	
7	75	8·509 5591	221	32	30	
8	72	79	249	30	35	
9	68	67	276	29	40	
10	8·508 6864	8·509 5556	1·59304	2·3528	6·5244	
11	60	44	331	27	49	
12	56	32	359	26	54	
13	52	20	387	25	59	
14	48	8·509 5509	414	24	64	
15	44	8·509 5497	442	22	69	
16	40	85	469	21	74	
17	36	73	497	20	79	
18	32	62	525	19	83	
19	28	50	552	18	88	
20	8·508 6825	8·509 5438	1·59580	2·3517	6·5293	7·682
21	21	27	608	16	6·5298	
22	17	15	635	14	6·5303	
23	13	8·509 5403	663	13	08	
24	09	8·509 5392	691	12	13	
25	05	80	718	11	18	
26	8·508 6801	68	746	10	22	
27	8·508 6797	56	774	09	27	
28	93	45	801	07	32	
29	90	33	829	06	37	
30	8·508 6786	8·509 5321	1·59857	2·3505	6·5342	
31	82	8·509 5310	885	04	47	
32	78	8·509 5298	912	03	52	
33	74	86	940	02	57	
34	70	75	968	2·3500	62	
35	66	63	1·59996	2·3499	67	
36	62	51	1·60023	98	72	
37	58	40	051	97	76	
38	54	28	079	96	81	
39	51	16	107	95	86	
40	8·508 6747	8·509 5205	1·60134	2·3493	6·5391	7·675
41	43	8·509 5193	162	92	6·5396	
42	39	81	190	91	6·5401	
43	35	70	218	90	06	
44	31	58	246	89	11	
45	27	46	274	87	16	
46	23	35	301	86	21	
47	20	23	329	85	26	
48	16	12	357	84	31	
49	12	8·509 5100	385	83	36	
50	8·508 6708	8·509 5088	1·60413	2·3481	6·5441	
51	04	77	441	80	46	
52	8·508 6700	65	469	79	50	
53	8·508 6696	54	496	78	55	
54	92	42	524	76	60	
55	89	30	552	75	65	
56	85	19	580	74	70	
57	81	8·509 5007	608	73	75	
58	77	8·509 4996	636	72	80	
59	73	84	664	70	85	
60	8·508 6669	8·509 4972	1·60692	2·3469	6·5490	7·669

LATITUDE 58°

Lat.	log A′ diff. 1″ = − 0·06	log B diff. 1″ = − 0·19	log C diff. 1″ = + 0·47	log D diff. 1″ = − 0·02	log E diff. 1″ = + 0·08	log F diff. 10′ = − 3·3
° ′						
58 00	$\bar{8}$·508 6669	$\bar{8}$·509 4972	$\bar{1}$·60692	$\bar{2}$·3469	$\bar{\bar{6}}$·5490	$\bar{\bar{7}}$·669
1	65	61	720	68	6·5495	
2	62	49	748	67	6·5500	
3	58	38	776	66	05	
4	54	26	804	64	10	
05	50	14	832	63	15	
6	46	8·509 4903	860	62	20	
7	42	8·509 4891	888	61	25	
8	38	80	916	59	30	
9	35	68	944	58	35	
10	8·508 6631	8·509 4857	1·60972	2·3457	6·5540	
11	27	45	1·61000	56	45	
12	23	33	028	54	50	
13	19	22	056	53	55	
14	15	8·509 4810	084	52	60	
15	11	8·509 4799	112	51	65	
16	08	87	140	49	70	
17	04	76	168	48	75	
18	8·508 6600	64	197	47	80	
19	8·508 6596	53	225	46	85	
20	8·508 6592	8·509 4741	1·61253	2·3444	6·5590	7·662
21	88	30	281	43	6·5595	
22	85	18	309	42	6·5600	
23	81	8·509 4707	337	41	05	
24	77	8·509 4695	365	39	10	
25	73	84	393	38	15	
26	69	72	422	37	20	
27	65	61	450	35	25	
28	62	49	478	34	30	
29	58	38	506	33	35	
30	8·508 6554	8·509 4626	1·61534	2·3432	6·5640	
31	50	15	563	30	45	
32	46	8·509 4603	591	29	50	
33	42	8·509 4592	619	28	55	
34	39	80	647	26	60	
35	35	69	675	25	65	
36	31	57	704	24	70	
37	27	46	732	23	75	
38	23	35	760	21	80	
39	20	23	789	20	86	
40	8·508 6516	8·509 4512	1·61817	2·3419	6·5691	7·656
41	12	8·509 4500	845	17	6·5696	
42	08	8·509 4489	873	16	6·5701	
43	04	77	902	15	06	
44	8·508 6500	66	930	14	11	
45	8·508 6497	54	958	12	16	
46	93	43	1·61987	11	21	
47	89	32	1·62015	10	26	
48	85	20	043	08	31	
49	81	8·509 4409	072	07	36	
50	8·508 6478	8·509 4397	1·62100	2·3406	6·5741	
51	74	86	129	04	46	
52	70	74	157	03	51	
53	66	63	185	02	56	
54	62	52	214	2·3400	62	
55	59	40	242	2·3399	67	
56	55	29	271	98	72	
57	51	17	299	96	77	
58	47	8·509 4306	327	95	82	
59	43	8·509 4295	356	94	87	
60	8·508 6440	8·509 4283	1·62384	2·3392	6·5792	7·649

LATITUDE 59°

Lat.	log A′ diff. 1″=−0·06	log B diff. 1″=−0·19	log C diff. 1″=+0·48	log D diff. 1″=−0·02	log E diff. 1″=+0·09	log F diff. 10′=−3·5
° ′						
59 00	$\bar{8}$·508 6440	$\bar{8}$·509 4283	$\bar{1}$·62384	$\bar{2}$·3392	$\bar{\bar{6}}$·5792	$\bar{\bar{7}}$·649
1	36	72	413	91	6·5797	
2	32	61	441	90	6·5802	
3	28	49	470	88	07	
4	24	38	498	87	13	
05	21	26	527	86	18	
6	17	15	555	84	23	
7	13	8·509 4204	584	83	28	
8	09	8·509 4192	612	82	33	
9	05	81	641	80	38	
10	8·508 6402	8·509 4170	1·62669	2·3379	6·5843	
11	8·508 6398	58	698	78	48	
12	94	47	727	76	54	
13	90	36	755	75	59	
14	87	24	784	74	64	
15	83	13	812	72	69	
16	79	8·509 4102	841	71	74	
17	75	8·509 4090	870	69	79	
18	71	79	898	68	84	
19	68	68	927	67	89	
20	8·508 6364	8·509 4056	1·62955	2·3365	6·5895	7·642
21	60	45	1·62984	64	6·5900	
22	56	34	1·63013	63	05	
23	53	22	041	61	10	
24	49	11	070	60	15	
25	45	8·509 4000	099	58	20	
26	41	8·509 3989	127	57	26	
27	38	77	156	56	31	
28	34	66	185	54	36	
29	30	55	214	53	41	
30	8·508 6326	8·509 3943	1·63242	2·3351	6·5946	
31	23	32	271	50	51	
32	19	21	300	49	57	
33	15	8·509 3910	329	47	62	
34	11	8·509 3898	357	46	67	
35	08	87	386	44	72	
36	04	76	415	43	77	
37	8·508 6300	65	444	42	82	
38	8·508 6296	53	473	40	88	
39	93	42	501	39	93	
40	8·508 6289	8·509 3831	1·63530	2·3337	6·5998	7·635
41	85	20	559	36	6·6003	
42	81	8·509 3808	588	35	08	
43	78	8·509 3797	617	33	14	
44	74	86	646	32	19	
45	70	75	674	30	24	
46	66	63	703	29	29	
47	63	52	732	28	34	
48	59	41	761	26	40	
49	55	30	790	25	45	
50	8·508 6251	8·509 3719	1·63819	2·3323	6·6050	
51	48	8·509 3708	848	22	55	
52	44	8·509 3696	877	20	61	
53	40	85	906	19	66	
54	36	74	935	17	71	
55	33	63	964	16	76	
56	29	52	1·63993	15	81	
57	25	40	1·64022	13	87	
58	22	29	051	12	92	
59	18	18	080	10	6·6097	
60	8·508 6214	8·509 3607	1·64109	2·3309	6·6102	7·627

LATITUDE 60°

Lat.	log A′ diff. 1″=−0·06	log B diff. 1″=−0·18	log C diff. 1″=+0·49	log D diff. 1″=−0·03	log E diff. 1″=+0·09	log F diff. 10′=−3·7
° ′						
60 00	$\bar{8}$·508 6214	$\bar{8}$·509 3607	$\bar{1}$·64109	$\bar{2}$·3309	$\bar{\bar{6}}$·6102	$\bar{\bar{7}}$·627
1	10	8·509 3596	138	07	08	
2	07	85	167	06	13	
3	8·508 6203	73	196	04	18	
4	8·508 6199	62	225	03	23	
05	96	51	254	02	29	
6	92	40	283	2·3300	34	
7	88	29	312	2·3299	39	
8	84	18	341	97	44	
9	81	8·509 3507	370	96	50	
10	8·508 6177	8·509 3495	1·64400	2·3294	6·6155	
11	73	84	429	93	60	
12	70	73	458	91	66	
13	66	62	487	90	71	
14	62	51	516	88	76	
15	58	40	545	87	81	
16	55	29	574	85	87	
17	51	18	604	84	92	
18	47	8·509 3407	633	82	6·6197	
19	44	8·509 3395	662	81	6·6203	
20	8·508 6140	8·509 3384	1·64691	2·3279	6·6208	7·620
21	36	73	720	78	13	
22	33	62	750	76	18	
23	29	51	779	75	24	
24	25	40	808	73	29	
25	21	29	838	72	34	
26	18	18	867	70	40	
27	14	8·509 3307	896	69	45	
28	10	8·509 3296	925	67	50	
29	07	85	955	66	56	
30	8·508 6103	8·509 3274	1·64984	2·3264	6·6261	
31	8·508 6099	63	1·65013	63	66	
32	96	52	043	61	72	
33	92	40	072	60	77	
34	88	29	101	58	82	
35	85	18	131	57	87	
36	81	8·509 3207	160	55	93	
37	77	8·509 3196	190	54	6·6298	
38	74	85	219	52	6·6304	
39	70	74	248	51	09	
40	8·508 6066	8·509 3163	1·65278	2·3249	6·6314	7·613
41	63	52	307	48	20	
42	59	41	337	46	25	
43	55	30	366	45	30	
44	52	19	396	43	36	
45	48	8·509 3108	425	41	41	
46	44	8·509 3097	455	40	46	
47	41	86	484	38	52	
48	37	75	514	37	57	
49	33	64	543	35	62	
50	8·508 6030	8·509 3053	1·65573	2·3234	6·6368	
51	26	42	602	32	73	
52	22	31	632	31	79	
53	19	20	661	29	84	
54	15	8·509 3010	691	28	89	
55	11	8·509 2999	721	26	6·6395	
56	08	88	750	24	6·6400	
57	04	77	780	23	05	
58	8·508 6000	66	809	21	11	
59	8·508 5997	55	839	20	16	
60	8·508 5993	8·509 2944	1·65869	2·3218	6·6422	7·605

LATITUDE 61°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·18	log C diff. 1″ = +0·50	log D diff. 1″ = −0·03	log E diff. 1″ = +0·09	log F diff. 10′ = −4·0
° ′						
61 00	$\bar{8}$·508 5993	$\bar{8}$·509 2944	$\bar{1}$·65869	$\bar{2}$·3218	$\bar{\bar{6}}$·6422	$\bar{\bar{7}}$·605
1	89	33	898	17	27	
2	86	22	928	15	32	
3	82	11	958	13	38	
4	79	8·509 2900	1·65987	12	43	
05	75	8·509 2889	1·66017	10	48	
6	71	78	047	09	54	
7	68	67	076	07	59	
8	64	56	106	06	65	
9	60	46	136	04	70	
10	8·508 5957	8·509 2835	1·66166	2·3202	6·6476	
11	53	24	195	2·3201	81	
12	49	13	225	2·3199	87	
13	46	8·509 2802	255	98	92	
14	42	8·509 2791	285	96	6·6497	
15	39	80	315	94	6·6503	
16	35	69	344	93	08	
17	31	58	374	91	14	
18	28	48	404	90	19	
19	24	37	434	88	25	
20	8·508 5920	8·509 2726	1·66464	2·3186	6·6530	7·597
21	17	15	494	85	36	
22	13	8·509 2704	524	83	41	
23	10	8·509 2693	553	81	46	
24	06	83	583	80	52	
25	8·508 5902	72	613	78	57	
26	8·508 5899	61	643	77	63	
27	95	50	673	75	68	
28	92	39	703	73	74	
29	88	28	733	72	79	
30	8·508 5884	8·509 2618	1·66763	2·3170	6·6585	
31	81	8·509 2607	793	68	90	
32	77	8·509 2596	823	67	6·6596	
33	74	85	853	65	6·6601	
34	70	74	883	64	07	
35	66	64	913	62	12	
36	63	53	943	60	18	
37	59	42	1·66973	58	23	
38	56	31	1·67003	57	29	
39	52	20	033	55	34	
40	8·508 5848	8·509 2510	1·67063	2·3154	6·6640	7·589
41	45	8·509 2499	094	52	45	
42	41	88	124	50	51	
43	38	77	154	49	56	
44	34	67	184	47	62	
45	30	56	214	45	67	
46	27	45	244	44	73	
47	23	34	274	42	78	
48	20	24	305	40	84	
49	16	13	335	39	89	
50	8·508 5813	8·509 2402	1·67365	2·3137	6·6695	
51	09	8·509 2391	395	35	6·6700	
52	05	81	425	34	06	
53	8·508 5802	70	456	32	12	
54	8·508 5798	59	486	30	17	
55	95	49	516	29	23	
56	91	38	547	27	28	
57	88	27	577	25	34	
58	84	16	607	23	39	
59	80	8·509 2306	637	22	45	
60	8·508 5777	8·509 2295	1·67668	2·3120	6·6750	7·581

LATITUDE 62°

Lat.	log A′ diff. 1′ = −0·06	log B diff. 1″ = −0·18	log C diff. 1″ = +0·51	log D diff. 1″ = −0·03	log E diff. 1″ = +0·09	log F diff. 10′ = −4·2
° ′						
62 00	$\bar{8}$·508 5777	$\bar{8}$·509 2295	$\bar{1}$·67668	$\bar{2}$·3120	$\bar{\bar{6}}$·6750	$\bar{\bar{7}}$·581
1	73	84	698	18	56	
2	70	74	728	17	61	
3	66	63	759	15	67	
4	63	52	789	13	73	
05	59	42	820	12	78	
6	55	31	850	10	84	
7	52	20	880	08	89	
8	48	8·509 2210	911	06	6·6795	
9	45	8·509 2199	941	05	6·6801	
10	8·508 5741	8·509 2188	1·67972	2·3103	6·6806	
11	38	78	1·68002	01	12	
12	34	67	033	2·3100	17	
13	30	56	063	2·3098	23	
14	27	46	094	96	29	
15	24	35	124	94	34	
16	20	25	155	93	40	
17	16	14	185	91	45	
18	13	8·509 2103	216	89	51	
19	09	8·509 2093	246	87	57	
20	8·508 5706	8·509 2082	1·68277	2·3086	6·6862	7·573
21	8·508 5702	71	307	84	68	
22	8·508 5699	61	338	82	73	
23	95	50	369	80	79	
24	92	40	399	79	85	
25	88	29	430	77	90	
26	85	19	461	75	6·6896	
27	81	8·509 2008	491	74	6·6902	
28	78	8·509 1997	522	72	07	
29	74	87	553	70	13	
30	8·508 5671	8·509 1976	1·68583	2·3068	6·6919	
31	67	66	614	66	24	
32	64	55	645	65	30	
33	60	45	675	63	36	
34	56	34	706	61	41	
35	53	23	737	59	47	
36	49	13	768	58	53	
37	46	8·509 1902	799	56	58	
38	42	8·509 1892	829	54	64	
39	39	81	860	52	70	
40	8·508 5635	8·509 1871	1·68891	2·3050	6·6975	7·564
41	32	60	922	49	81	
42	28	50	953	47	87	
43	25	39	1·68984	45	92	
44	21	29	1·69014	43	6·6998	
45	18	18	045	42	6·7004	
46	14	8·509 1808	076	40	09	
47	11	8·509 1797	107	38	15	
48	07	87	138	36	21	
49	04	76	169	34	26	
50	8·508 5600	8·509 1766	1·69200	2·3033	6·7032	
51	8·508 5597	55	231	31	38	
52	93	45	262	29	44	
53	90	34	293	27	49	
54	86	24	324	25	55	
55	83	14	355	23	61	
56	80	8·509 1703	386	22	67	
57	76	8·509 1693	417	20	72	
58	73	82	448	18	78	
59	69	72	479	16	84	
60	8·508 5566	8·509 1661	1·69510	2·3014	6·7089	7·556

LATITUDE 63°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·17	log C diff. 1″ = +0·52	log D diff. 1″ = −0·03	log E diff. 1″ = +0·10	log F diff. 10′ = −4·5
° ′						
63 00	$\bar{8}$·508 5566	$\bar{8}$·509 1661	$\bar{1}$·69510	$\bar{2}$·3014	$\bar{\bar{6}}$·7089	$\bar{\bar{7}}$·556
1	62	51	541	13	6·7095	
2	59	40	572	11	6·7101	
3	55	30	603	09	07	
4	52	20	635	07	12	
05	48	8·509 1609	666	05	18	
6	45	8·509 1599	697	03	24	
7	41	88	728	02	30	
8	38	78	759	2·3000	35	
9	34	68	791	2·2998	41	
10	8·508 5531	8·509 1557	1·69822	2·2996	6·7147	
11	27	47	853	94	53	
12	24	36	884	92	59	
13	20	26	915	90	64	
14	17	16	947	89	70	
15	14	8·509 1505	1·69978	87	76	
16	10	8·509 1495	1·70009	85	82	
17	07	85	041	83	88	
18	03	74	072	81	93	
19	8·508 5500	64	103	79	6·7199	
20	8·508 5496	8·509 1454	1·70135	2·2977	6·7205	7·547
21	93	43	166	75	11	
22	89	33	197	74	17	
23	86	23	229	72	22	
24	83	12	260	70	28	
25	79	8·509 1402	292	68	34	
26	76	8·509 1392	323	66	40	
27	72	81	355	64	46	
28	69	71	386	62	51	
29	65	61	417	60	57	
30	8·508 5462	8·509 1350	1·70449	2·2958	6·7263	
31	58	40	480	57	69	
32	55	30	512	55	75	
33	52	19	544	53	81	
34	48	8·509 1309	575	51	86	
35	45	8·509 1299	607	49	92	
36	41	89	638	47	6·7298	
37	38	78	670	45	6·7304	
38	34	68	701	43	10	
39	31	58	733	41	16	
40	8·508 5428	8·509 1248	1·70765	2·2939	6·7322	7·538
41	24	37	796	37	28	
42	21	27	828	36	33	
43	17	17	860	34	39	
44	14	8·509 1207	891	32	45	
45	11	8·509 1196	923	30	51	
46	07	86	955	28	57	
47	04	76	1·70986	26	63	
48	8·508 5400	66	1·71018	24	69	
49	8·508 5397	55	050	22	75	
50	8·508 5394	8·509 1145	1·71082	2·2920	6·7381	
51	90	35	114	18	86	
52	87	25	145	16	92	
53	83	15	177	14	6·7398	
54	80	8·509 1104	209	12	6·7404	
55	77	8·509 1094	241	10	10	
56	73	84	273	08	16	
57	70	74	305	06	22	
58	66	64	337	04	28	
59	63	54	368	02	34	
60	8·508 5360	8·509 1043	1·71400	2·2901	6·7440	7·529

LATITUDE 64°

Lat.	log A′ diff. 1″ = −0·06	log B diff. 1″ = −0·17	log C diff. 1″ = +0·54	log D diff. 1″ = −0·03	log E diff. 1″ = +0·10	log F diff. 10′ = −4·7
° ′						
64 00	$\bar{8}$·508 5360	$\bar{8}$·509 1043	$\bar{1}$·71400	$\bar{2}$·2901	$\bar{\bar{6}}$·7440	$\bar{\bar{7}}$·529
1	56	33	432	2·2899	46	
2	53	23	464	97	52	
3	49	13	496	95	58	
4	46	8·509 1003	528	93	63	
05	43	8·509 0993	560	91	69	
6	39	82	592	89	75	
7	36	72	624	87	81	
8	33	62	656	85	87	
9	29	52	688	83	93	
10	8·508 5326	8·509 0942	1·71720	2·2881	6·7499	
11	22	32	752	79	6·7505	
12	19	22	785	77	11	
13	16	12	817	75	17	
14	12	8·509 0902	849	73	23	
15	09	8·509 0891	881	71	29	
16	06	81	913	69	35	
17	8·508 5302	71	945	67	41	
18	8·508 5299	61	1·71977	65	47	
19	96	51	1·72010	63	53	
20	8·508 5292	8·509 0841	1·72042	2·2861	6·7559	7·520
21	89	31	074	59	65	
22	85	21	106	57	71	
23	82	11	139	55	77	
24	79	8·509 0801	171	53	83	
25	75	8·509 0791	203	51	89	
26	72	81	235	49	6·7595	
27	69	71	268	47	6·7601	
28	65	61	300	45	07	
29	62	51	332	42	13	
30	8·508 5259	8·509 0741	1·72365	2·2840	6·7619	
31	55	31	397	38	25	
32	52	21	430	36	31	
33	49	11	462	34	37	
34	45	8·509 0701	495	32	43	
35	42	8·509 0691	527	30	49	
36	39	81	559	28	56	
37	35	71	592	26	62	
38	32	61	624	24	68	
39	29	51	657	22	74	
40	8·508 5225	8·509 0641	1·72689	2·2820	6·7680	7·511
41	22	31	722	18	86	
42	19	21	755	16	92	
43	15	11	787	14	6·7698	
44	12	8·509 0601	820	12	6·7704	
45	09	8·509 0591	852	10	10	
46	05	81	885	07	16	
47	8·508 5202	71	918	05	22	
48	8·508 5199	61	950	03	28	
49	95	51	1·72983	2·2801	35	
50	8·508 5192	8·509 0541	1·73016	2·2799	6·7741	
51	89	31	048	97	47	
52	86	21	081	95	53	
53	82	11	114	93	59	
54	79	8·509 0501	146	91	65	
55	76	8·509 0491	179	89	71	
56	72	82	212	87	77	
57	69	72	245	84	84	
58	66	62	278	82	90	
59	62	52	310	80	6·7796	
60	8·508 5159	8·509 0442	1·73343	2·2778	6·7802	7·501

LATITUDE 65°

Lat.	log A′ diff. 1″ = − 0·05	log B diff. 1″ = − 0·16	log C diff. 1″ = + 0·56	log D diff. 1″ = − 0·04	log E diff. 1″ = + 0·10	log F diff. 10′ = − 5·0
° ′						
65 00	$\bar{8}$·508 5159	$\bar{8}$·509 0442	$\bar{1}$·73343	$\bar{2}$·2778	$\bar{\bar{6}}$·7802	$\bar{\bar{7}}$·501
1	56	32	376	76	08	
2	52	22	409	74	14	
3	49	12	442	72	20	
4	46	8·509 0402	475	70	27	
05	43	8·509 0393	508	68	33	
6	39	83	541	65	39	
7	36	73	574	63	45	
8	33	63	607	61	51	
9	30	53	640	59	57	
10	8·508 5126	8·509 0344	1·73673	2·2757	6·7864	
11	23	34	706	55	70	
12	20	24	739	53	76	
13	17	14	772	50	82	
14	13	8·509 0304	805	48	88	
15	10	8·509 0295	838	46	6·7895	
16	07	85	871	44	6·7901	
17	03	75	904	42	07	
18	8·508 5100	65	937	40	13	
19	8·508 5097	55	1·73970	38	19	
20	8·508 5094	8·509 0245	1·74004	2·2735	6·7926	7·491
21	90	36	037	33	32	
22	87	26	070	31	38	
23	84	16	103	29	44	
24	81	8·509 0206	136	27	51	
25	77	8·509 0197	170	24	57	
26	74	87	203	22	63	
27	71	77	236	20	69	
28	68	67	270	18	76	
29	64	57	303	16	82	
30	8·508 5061	8·509 0148	1·74336	2·2714	6·7988	
31	58	38	370	11	6·7994	
32	54	28	403	09	6·8001	
33	51	18	436	07	07	
34	48	8·509 0109	470	05	13	
35	45	8·509 0099	503	03	19	
36	41	89	537	2·2700	26	
37	38	80	570	2·2698	32	
38	35	70	604	96	38	
39	32	60	637	94	44	
40	8·508 5029	8·509 0051	1·74670	2·2692	6·8051	7·481
41	25	41	704	89	57	
42	22	31	738	87	63	
43	19	22	771	85	70	
44	16	12	805	83	76	
45	13	8·509 0002	838	80	82	
46	09	8·508 9993	872	78	89	
47	06	83	906	76	6·8095	
48	03	73	939	74	6·8101	
49	8·508 5000	64	1·74973	72	07	
50	8·508 4996	8·508 9954	1·75007	2·2669	6·8114	
51	93	44	040	67	20	
52	90	35	074	65	27	
53	87	25	108	63	33	
54	84	15	142	60	39	
55	80	8·508 9906	175	58	46	
56	77	8·508 9896	209	56	52	
57	74	87	243	53	58	
58	71	77	277	51	65	
59	68	67	311	49	71	
60	8·508 4964	8·508 9858	1·75344	2·2647	6·8177	7·471

LATITUDE 66°

Lat.	log A′ diff. 1″ = −0·05	log B diff. 1″ = −0·16	log C diff. 1″ = +0·57	log D diff. 1″ = −0·04	log E diff. 1″ = +0·11	log F diff. 10′ = −5·3
° ′						
66 00	$\bar{8}$·508 4964	$\bar{8}$·508 9858	$\bar{1}$·75344	$\bar{2}$·2647	$\bar{\bar{6}}$·8177	$\bar{\bar{7}}$·471
1	61	48	378	44	84	
2	58	39	412	42	90	
3	55	29	446	40	6·8196	
4	52	20	480	38	6·8203	
05	48	10	514	35	09	
6	45	8·508 9801	548	33	16	
7	42	8·508 9791	582	31	22	
8	39	82	616	28	28	
9	36	72	650	26	35	
10	8·508 4933	8·508 9762	1·75684	2·2624	6·8241	
11	29	53	718	22	48	
12	26	43	752	19	54	
13	23	34	786	17	61	
14	20	24	820	15	67	
15	17	14	854	12	73	
16	13	8·508 9705	889	10	80	
17	10	8·508 9696	923	08	86	
18	07	86	957	05	93	
19	04	77	1·75991	03	6·8299	
20	8·508 4901	8·508 9667	1·76025	2·2601	6·8306	7·461
21	8·508 4898	58	060	2·2598	12	
22	95	48	094	96	19	
23	91	39	128	94	25	
24	88	29	163	91	31	
25	85	20	197	89	38	
26	82	11	231	87	44	
27	79	8·508 9601	266	84	51	
28	76	8·508 9592	300	82	57	
29	73	82	334	80	64	
30	8·508 4869	8·508 9573	1·76369	2·2578	6·8370	
31	66	63	403	75	77	
32	63	54	438	73	83	
33	60	44	472	70	90	
34	57	35	507	68	6·8396	
35	54	25	541	66	6·8403	
36	50	16	576	63	09	
37	47	8·508 9507	610	61	16	
38	44	8·508 9497	645	59	22	
39	41	88	679	56	29	
40	8·508 4838	8·508 9478	1·76714	2·2554	6·8436	7·450
41	35	69	749	51	42	
42	32	60	783	49	49	
43	29	51	818	47	55	
44	26	41	853	44	62	
45	22	32	887	42	68	
46	19	23	922	39	75	
47	16	13	957	37	81	
48	13	8·508 9404	1·76991	35	88	
49	10	8·508 9395	1·77026	32	6·8495	
50	8·508 4807	8·508 9385	1·77061	2·2530	6·8501	
51	04	76	096	27	08	
52	8·508 4801	66	131	25	14	
53	8·508 4797	57	166	23	21	
54	94	48	200	20	27	
55	91	38	235	18	34	
56	88	29	270	15	41	
57	85	20	305	13	47	
58	82	10	340	11	54	
59	79	8·508 9301	375	08	60	
60	8·508 4776	8·508 9292	1·77410	2·2506	6·8567	7·440

LATITUDE 67°

Lat.	log A′ diff. 1″ = −0·05	log B diff. 1″ = −0·15	log C diff. 1″ = +0·59	log D diff. 1″ = −0·04	log E diff. 1″ = +0·11	log F diff. 10′ = −5·6
° ′						
67 00	$\bar{8}$·508 4776	$\bar{8}$·508 9292	$\bar{1}$·77410	$\bar{2}$·2506	$\bar{\bar{6}}$·8567	$\bar{\bar{7}}$·440
1	73	83	445	03	74	
2	70	73	480	2·2501	80	
3	66	64	515	2·2498	87	
4	63	55	550	96	6·8594	
05	60	46	585	93	6·8600	
6	57	36	620	91	07	
7	54	27	656	89	14	
8	51	18	691	86	20	
9	48	8·508 9208	726	84	27	
10	8·508 4745	8·508 9199	1·77761	2·2481	6·8634	
11	42	90	796	79	40	
12	39	81	831	76	47	
13	36	72	867	74	54	
14	33	62	902	71	60	
15	30	53	937	69	67	
16	26	44	1·77973	66	74	
17	23	35	1·78008	64	80	
18	20	26	043	61	87	
19	17	16	079	59	6·8694	
20	8·508 4714	8·508 9107	1·78114	2·2456	6·8700	7·429
21	11	8·508 9098	149	54	07	
22	08	89	185	51	14	
23	05	80	220	49	20	
24	8·508 4702	71	256	46	27	
25	8·508 4699	62	291	44	34	
26	96	52	327	41	41	
27	93	43	362	39	47	
28	90	34	398	36	54	
29	87	25	433	34	61	
30	8·508 4684	8·508 9016	1·78469	2·2431	6·8768	
31	81	8·508 9007	505	29	74	
32	78	8·508 8998	540	26	81	
33	75	88	576	24	88	
34	72	79	612	21	6·8795	
35	68	70	647	19	6·8802	
36	65	61	683	16	08	
37	62	52	719	14	15	
38	59	43	755	11	22	
39	56	34	790	09	29	
40	8·508 4653	8·508 8925	1·78826	2·2406	6·8835	7·418
41	50	16	862	03	42	
42	47	8·508 8907	898	2·2401	49	
43	44	8·508 8898	934	2·2398	56	
44	41	89	1·78970	96	63	
45	38	80	1·79006	93	70	
46	35	71	042	91	76	
47	32	62	078	88	83	
48	29	53	114	86	90	
49	26	44	150	83	6·8897	
50	8·508 4623	8·508 8834	1·79186	2·2380	6·8904	
51	20	25	222	78	10	
52	17	16	258	75	17	
53	14	8·508 8807	294	73	24	
54	11	8·508 8798	330	70	31	
55	08	89	366	67	38	
56	05	80	402	65	45	
57	8·508 4602	71	438	62	52	
58	8·508 4599	62	474	60	59	
59	96	54	511	57	65	
60	8·508 4593	8·508 8745	1·79547	2·2354	6·8972	7·406

LATITUDE 68°

Lat.	log A′ diff. 1″ = − 0·05	log B diff. 1″ = − 0·15	log C diff. 1″ = + 0·62	log D diff. 1″ = − 0·4	log E diff. 1″ = + 0·12	log F diff. 10′ = − 5·9
° ′						
68 00	$\bar{8}$·508 4593	$\bar{8}$·508 8745	$\bar{1}$·79547	$\bar{2}$·2354	$\bar{\bar{6}}$·8972	$\bar{\bar{7}}$·406
1	90	36	583	52	79	
2	87	27	620	49	86	
3	84	18	656	47	6·8993	
4	81	09	692	44	6·9000	
05	78	8·508 8700	728	41	07	
6	76	8·508 8691	765	39	14	
7	73	82	801	36	21	
8	70	73	838	33	28	
9	67	64	874	31	35	
10	8·508 4564	8·508 8656	1·79911	2·2328	6·9042	
11	61	47	947	26	48	
12	58	38	1·79984	23	55	
13	55	29	1·80020	20	62	
14	52	20	057	18	69	
15	49	11	093	15	76	
16	46	8·508 8602	130	12	83	
17	43	8·508 8593	166	10	90	
18	40	84	203	07	6·9097	
19	37	75	240	04	6·9104	
20	8·508 4534	8·508 8566	1·80276	2·2302	6·9111	7·395
21	31	58	313	2·2299	18	
22	28	49	350	96	25	
23	25	40	387	94	32	
24	22	31	423	91	39	
25	19	22	460	88	46	
26	16	13	497	85	53	
27	13	8·508 8505	534	83	60	
28	10	8·508 8496	571	80	67	
29	07	87	608	77	74	
30	8·508 4504	8·508 8478	1·80645	2·2275	6·9181	
31	8·508 4501	69	682	72	88	
32	8·508 4499	60	719	69	6·9195	
33	96	52	756	67	6·9203	
34	93	43	793	64	10	
35	90	34	830	61	17	
36	87	25	867	58	24	
37	84	17	904	56	31	
38	81	8·508 8408	941	53	38	
39	78	8·508 8399	1·80978	50	45	
40	8·508 4475	8·508 8390	1·81015	2·2248	6·9252	7·383
41	72	82	052	45	59	
42	70	73	089	42	66	
43	67	64	127	39	73	
44	64	56	164	36	80	
45	61	47	201	34	88	
46	58	38	239	31	6·9295	
47	55	30	276	28	6·9302	
48	52	21	313	26	09	
49	49	12	350	23	16	
50	8·508 4446	8·508 8303	1·81388	2·2220	6·9323	
51	43	8·508 8295	425	17	30	
52	40	86	463	14	37	
53	38	77	500	12	45	
54	35	68	538	09	52	
55	32	60	575	06	59	
56	29	51	613	03	66	
57	26	43	650	2·2201	73	
58	23	34	688	2·2198	80	
59	20	25	726	95	88	
60	8·508 4417	8·508 8217	1·81763	2·2192	6·9395	7·371

LATITUDE 69°

Lat.	log A′ diff. 1″ = −0·05	log B diff. 1″ = −0·14	log C diff. 1″ = +0·64	log D diff. 1″ = −0·05	log E diff. 1″ = +0·12	log F diff. 10′ = −6·2
° ′						
69 00	$\bar{8}$·508 4417	$\bar{8}$·508 8217	$\bar{1}$·81763	$\bar{2}$·2192	$\bar{\bar{6}}$·9395	$\bar{\bar{7}}$·371
1	14	08	801	89	6·9402	
2	12	8·508 8200	838	87	09	
3	09	8·508 8191	876	84	16	
4	06	82	914	81	24	
5	03	74	952	78	31	
6	8·508 4400	65	1·81989	75	38	
7	8·508 4397	57	1·82027	72	45	
8	94	48	065	70	52	
9	92	39	103	67	60	
10	8·508 4389	8·508 8131	1·82141	2·2164	6·9467	
11	86	22	179	61	74	
12	83	14	217	58	82	
13	80	8·508 8105	255	55	89	
14	77	8·508 8096	293	53	6·9496	
15	74	88	330	50	6·9503	
16	71	79	369	47	11	
17	69	71	407	44	18	
18	66	62	445	41	25	
19	63	54	483	38	32	
20	8·508 4360	8·508 8045	1·82521	2·2136	6·9540	7·358
21	57	37	559	33	47	
22	55	28	597	30	54	
23	52	20	636	27	62	
24	49	11	674	24	69	
25	46	8·508 8003	712	21	76	
26	43	8·508 7994	750	18	84	
27	40	86	789	15	91	
28	37	77	827	12	6·9598	
29	35	69	865	10	6·9606	
30	8·508 4332	8·508 7960	1·82904	2·2107	6·9613	
31	29	52	942	04	20	
32	26	43	1·82981	2·2101	28	
33	23	35	1·83019	2·2098	35	
34	21	26	058	95	42	
35	18	18	096	92	50	
36	15	09	135	89	57	
37	12	8·508 7901	173	86	65	
38	09	8·508 7893	212	83	72	
39	06	84	250	80	79	
40	8·508 4304	8·508 7876	1·83289	2·2078	6·9687	7·346
41	8·508 4301	67	328	75	6·9694	
42	8·508 4298	59	366	72	6·9702	
43	95	51	405	69	09	
44	93	42	444	66	16	
45	90	34	483	63	24	
46	87	26	521	60	31	
47	84	17	560	57	39	
48	81	09	599	54	46	
49	79	8·508 7801	638	51	54	
50	8·508 4276	8·508 7792	1·83677	2·2048	6·9761	
51	73	84	716	45	69	
52	70	75	755	42	76	
53	67	67	794	39	84	
54	65	59	833	36	91	
55	62	50	872	33	6·9799	
56	59	42	911	30	6·9806	
57	56	34	950	27	14	
58	54	25	1·83989	24	21	
59	51	17	1·84028	21	29	
60	8·508 4248	8·508 7709	1·84068	2·2018	6·9836	7·333

LATITUDE 70°

Lat.	log A′ diff. 1″ = −0·04	log B diff. 1″ = −0·14	log C diff. 1″ = +0·67	log D diff. 1″ = −0·05	log E diff. 1″ = +0·13	log F diff. 10′ = −6·7
° ′						
70 00	$\bar{8}$·508 4248	$\bar{8}$·508 7709	$\bar{1}$·84068	$\bar{2}$·2018	$\bar{\bar{6}}$·9836	$\bar{\bar{7}}$·333
1	45	8·508 7701	107	15	44	
2	43	8·508 7692	146	12	51	
3	40	84	185	09	59	
4	37	76	225	06	66	
05	34	68	264	03	74	
6	32	59	303	2·2000	81	
7	29	51	343	2·1997	89	
8	26	43	382	94	6·9896	
9	23	35	421	91	6·9904	
10	8·508 4221	8·508 7626	1·84461	2·1988	6·9912	
11	18	18	500	85	19	
12	15	10	540	82	27	
13	12	8·508 7602	579	79	34	
14	10	8·508 7594	619	76	42	
15	07	86	658	73	50	
16	04	78	698	70	57	
17	8·508 4201	69	738	66	65	
18	8·508 4199	61	778	63	73	
19	96	52	817	60	80	
20	8·508 4193	8·508 7544	1·84857	2·1957	6·9988	7·320
21	90	36	897	54	6·9995	
22	88	28	937	51	7·0003	
23	85	20	1·84976	48	11	
24	82	12	1·85016	45	18	
25	80	8·508 7504	056	42	26	
26	77	8·508 7495	096	39	34	
27	74	87	136	36	41	
28	71	79	176	33	49	
29	69	71	216	29	57	
30	8·508 4166	8·508 7462	1·85256	2·1926	7·0064	
31	63	54	296	23	72	
32	60	46	336	20	80	
33	58	38	376	17	88	
34	55	30	416	14	7·0095	
35	52	22	456	11	7·0103	
36	50	14	497	08	11	
37	47	8·508 7406	537	04	19	
38	44	8·508 7398	577	2·1901	26	
39	42	90	618	2·1898	34	
40	8·508 4139	8·508 7382	1·85658	2·1895	7·0142	7·307
41	36	74	698	92	50	
42	34	66	739	89	57	
43	31	58	779	85	65	
44	28	50	819	82	73	
45	26	42	860	79	81	
46	23	34	900	76	88	
47	20	26	941	73	7·0196	
48	18	18	1·85981	70	7·0204	
49	15	10	1·86022	66	12	
50	8·508 4112	8·508 7302	1·86063	2·1863	7·0220	
51	10	8·508 7294	103	60	27	
52	07	86	144	57	35	
53	04	77	185	54	43	
54	8·508 4101	69	225	50	51	
55	8·508 4099	61	266	47	59	
56	96	53	307	44	67	
57	93	45	348	41	75	
58	91	38	389	38	82	
59	88	30	430	34	90	
60	8·508 4086	8·508 7222	1·86470	2·1831	7·0298	7·293

LATITUDE 71°

Lat.	log A′ diff. 1″ = −0·04	log B diff. 1″ = −0·13	log C diff. 1″ = +0·70	log D diff. 1″ = −0·05	log E diff. 1″ = +0·13	log F diff. 10′ = −7·2
° ′						
71 00	$\bar{8}$·508 4086	$\bar{8}$·508 7222	$\bar{1}$·86470	$\bar{2}$·1831	$\bar{\bar{7}}$·0298	$\bar{\bar{7}}$·293
1	83	14	511	28	7·0306	
2	80	8·508 7206	552	25	14	
3	78	8·508 7198	593	21	22	
4	75	90	634	18	30	
05	72	82	675	15	38	
6	70	74	717	12	46	
7	67	66	758	08	54	
8	64	58	799	05	62	
9	62	50	840	2·1802	70	
10	8·508 4059	8·508 7142	1·86881	2·1799	7·0378	
11	57	34	923	95	85	
12	54	27	1·86964	92	7·0393	
13	51	19	1·87005	89	7·0401	
14	49	11	046	86	09	
15	46	8·508 7103	088	82	17	
16	43	8·508 7095	129	79	25	
17	41	87	171	76	33	
18	38	79	212	72	41	
19	36	72	254	69	49	
20	8·508 4033	8·508 7064	1·87295	2·1766	7·0457	7·279
21	30	56	337	62	65	
22	28	48	378	59	73	
23	25	40	420	56	82	
24	23	33	462	52	90	
25	20	25	503	49	7·0498	
26	17	17	545	46	7·0506	
27	15	09	587	42	14	
28	12	8·508 7002	629	39	22	
29	10	8·508 6994	671	36	30	
30	8·508 4007	8·508 6986	1·87712	2·1732	7·0538	
31	05	78	754	29	46	
32	8·508 4002	71	796	26	54	
33	8·508 3999	63	838	22	62	
34	97	55	880	19	70	
35	94	47	922	16	79	
36	92	40	1·87964	12	87	
37	89	32	1·88006	09	7·0595	
38	86	24	049	06	7·0603	
39	84	16	091	2·1702	11	
40	8·508 3981	8·508 6908	1·88133	2·1699	7·0619	7·265
41	79	8·508 6901	175	95	27	
42	76	8·508 6893	217	92	36	
43	74	85	260	89	44	
44	71	78	302	85	52	
45	68	70	344	82	60	
46	66	62	387	78	68	
47	63	55	429	75	77	
48	61	47	472	72	85	
49	58	40	514	68	7·0693	
50	8·508 3956	8·508 6832	1·88557	2·1665	7·0701	
51	53	24	599	61	09	
52	51	17	642	58	18	
53	48	09	685	54	26	
54	46	8·508 6802	727	51	34	
55	43	8·508 6794	770	48	42	
56	41	86	813	44	51	
57	38	79	855	41	59	
58	36	71	898	37	67	
59	33	64	941	34	75	
60	8·508 3930	8·508 6756	1·88984	2·1630	7·0784	7·250

APPENDIX.—HISTORICAL DATA AND DEVELOPMENT OF FORMULÆ.

[Reprinted with minor changes from Appendix No. 9, U. S. Coast and Geodetic Survey Report for 1894.]

DIMENSIONS OF SPHEROID.

The linear dimensions of Bessel's spheroid were originally expressed in toises. Their metric equivalents as generally adopted are given below. The dimensions of Clarke's spheroid (of 1866) are stated by him in feet, toises, and meters. (See Appendix to Comparisons of the Standards of Length, etc., by Capt. A. R. Clarke, under the direction of Col. Sir H. James, etc., London, 1866, p. 287.) The dimensions in meters are:

	According to Bessel (1841).	According to Clarke (1866).
Equatorial semi-axis = a	6 377 397. 2	6 378 206. 4
Polar semi-axis = b	6 356 079. 0	6 356 583. 8
b/a =	298. 15 / 299. 15	[a] 293. 98 / 294. 98

Strictly speaking, the latter dimensions, to be expressed, as they must be, in terms of the prototype meter, should be slightly changed, for the reason that Clarke's results depend primarily on the yard and the relation of the yard and meter as found by him, 1 yard=0.91439180 ^{m} (or 1 foot=0.30479727 ^{m}), [b] should now be changed to conform to the more correct relation,[c] viz: 1 foot= 0.30480061 ^{m}, or 1 meter=3.2808333 feet; the difference, however, is unimportant, since either spheroid might have been adopted, and it would be inexpedient to recompute the tables of factors.

Arc measures in a country, if of sufficient extent, may be utilized for deducing or choosing a special spheroid adapted to its surface, as was, for instance, the case with the Clarke spheroid, which is supposed to conform better to the compact area of the United States than the one previously in use.

FORMULÆ AND FACTORS FOR THE COMPUTATION OF GEODETIC LATITUDES, LONGITUDES, AND AZIMUTHS.

When the geographical coordinates of latitude and longitude of a point on the earth's surface and the distance and azimuth to another point are known, the problem of computing the latitude and longitude of the second point and the reverse azimuth may be treated in two different ways.

We may either solve the spheroidal triangle formed by the two points and the pole as a whole, arriving at trigonometrical functions of the required colatitude, azimuth, and difference of longitude, or we may develop expressions for the differences of the required and the given quantities.

The former or direct method has the inconvenience of requiring the use of 10 places of decimals in the computation, in order to give the positions with a degree of exactness corresponding to that of the known distance between the two points, while the second leads to very convenient expressions, on account of the smallness of the differential arcs in ordinary triangulation.

[a] The best value for the reciprocal of the flattening of the earth, as derived in 1917 from gravity results at 219 stations in the United States and 155 stations in other parts of the world, is 297.4. [See U. S. Coast and Geodetic Survey Special Publication No. 40, pp. 113 to 134.]

[b] This is equivalent to 1 meter=39.370432 inches, whereas the value adopted (November, 1891) by the United States Office of Standard Weights and Measures is 1 meter=39.3700 inches, which agrees with the legal value adopted in the United States.

[c] See Appendix No. 16, U. S. Coast and Geodetic Survey Report for 1890, "On the relation of the yard to the meter," by O. H. Tittmann, assistant.

When, however, the arc between the two points reaches several degrees in length, the direct method must be resorted to. This solution has been very completely and elegantly effected by Bessel, and is given in Astronomische Nachrichten, No. 86, 1826.

Adopting the second method, we follow in the main Puissant (Traité de Géodésie)[a] in the development of the difference of latitude of two points on the spheroid in terms of the distance, azimuth, and latitude of the given point. It will be desirable first to recall the expressions of several lines of an ellipse in terms involving the latitude ϕ, which is the angle the normal to any point on the ellipse makes with the major axis.

Designating the major or equatorial semi-axis by a and the minor or polar semi-axis by b then the ellipticity ϵ or the ratio of their difference to the former is

$$\epsilon=\frac{a-b}{a}$$

The eccentricity e is expressed by

$$e^2=\frac{a^2-b^2}{a^2}$$

and shown in fig. 1 by cf, the distance from the center to the focus.

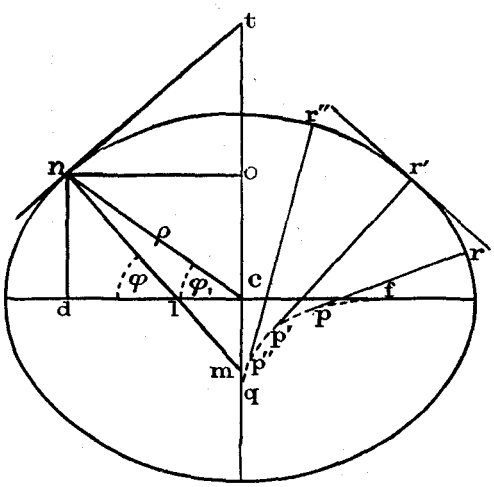

FIG. 1.

The normal nl terminating at the major axis equals

$$\frac{a\,(1-e^2)}{(1-e^2\,sin^2\,\varphi)^{1/2}}$$

The normal nm produced to the minor axis is

$$N=\frac{a}{(1-e^2\sin^2\varphi)^{1/2}}$$

The abscissa cd or no equals $N\cos\varphi$. This is the radius of a parallel on the spheroid.
The tangent nt ending at the minor axis equals $N\cot\varphi$.
The ordinate nd equals

$$\frac{a(1-e^2)\sin\varphi}{(1-e^2\sin^2\varphi)^{1/2}}$$

The reduced latitude being ψ, we have

$$\tan\psi=\frac{b}{a}\tan\varphi$$

The radius vector $\rho=a\,(1-e^2\sin^2\psi)^{1/2}$,

[a] Traité de Géodésie, par L. Puissant, troisième edition, Tome I, Chap. XV, p. 347 and fol., Paris, 1842.

The radius of curvature rp, r′p′, r″p″ · · · at any point of the ellipse r, r′, r″ · · · is

$$R=\frac{a(1-e^2)}{(1-e^2\sin^2\varphi)^{\frac{3}{2}}}$$

The terminal points f, p, p′, p″, q form an evolute; at the Equator where $\sin\varphi=0$, $R=\frac{b^2}{a}$ and the center of curvature is in the focus; at the pole, where $\sin\varphi=1$, $R=\frac{a^2}{b}$.

The radius of curvature R and the normal N are principal quantities used in geodesy. It will be observed that radii of curvature for different latitudes do not intersect unless produced, and that when they lie also in different meridional planes on the spheroid they will not intersect at all.

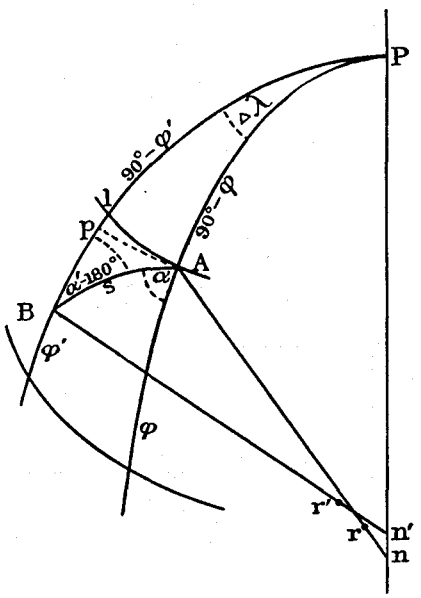

FIG. 2.

A and B in fig. 2 are two points on a spheroid of revolution, having the latitudes φ, φ', and joined by the geodetic line AB$=s$, making the angles with the meridian PAB$=180°-\alpha$, and PBA$=\alpha'-180°$. The azimuths α, α' are reckoned from south around by west in consequence of the latitudes being reckoned, by settled custom, from the Equator toward the poles, otherwise the meridional coordinate of a point would be more properly measured from the pole and the azimuth of a line reckoned from the north. The angle APB between the two meridional planes passing through A and B is the difference of their longitudes λ, λ', which being reckoned positive to the westward we have $\lambda'-\lambda=\Delta\lambda$. Furthermore, An, Bn′, Ar, Br′ indicate the normals N, N', and the radii of curvature in the meridian R, R', at the points A and B.

This being premised and the latitude φ of the point A being given, as well as the length s of the geodetic line AB and its azimuth α, we propose to find the latitude φ' of the point B, the angle $\Delta\lambda$, and the reverse azimuth α', by solving the geodetic triangle ABP. Writing γ, γ', for the co-latitudes, ξ for $180°-\alpha$, and σ for the arc AB referred to radius$=1$, we have in a spherical triangle for γ' the following equation:

$$\cos\gamma'=\cos\gamma\cos\sigma+\sin\gamma\sin\sigma\cos\xi \qquad (1)$$

Observing now that σ is always a small arc, rarely exceeding 1°, and generally less than 30′, we can develop the increment of γ with reference to that of σ in a rapidly converging series, and will have, by Taylor's theorem,

$$\gamma'=\gamma+\left[\frac{d\gamma'}{d\sigma}\right]\sigma+\frac{1}{2}\left[\frac{d^2\gamma'}{d\sigma^2}\right]\sigma^2+\frac{1}{6}\left[\frac{d^3\gamma'}{d\sigma^3}\right]\sigma^3+\cdots\cdots \qquad (a)$$

$\left[\frac{d\gamma'}{d\sigma}\right]$, $\left[\frac{d^2\gamma'}{d\sigma^2}\right]$, etc., denoting the values of these derivatives for $\gamma'=\gamma$ and $\sigma=0$.

By differentiating (1) with γ' and σ variable, we obtain the following results:

$$-\sin\gamma'\frac{d\gamma'}{d\sigma}=-\cos\gamma\sin\sigma+\sin\gamma\cos\sigma\cos\xi$$

$$-\sin\gamma'\frac{d^2\gamma'}{d\sigma^2}-\cos\gamma'\left(\frac{d\gamma'}{d\sigma}\right)^2=-\cos\gamma\cos\sigma-\sin\gamma\sin\sigma\cos\xi$$

$$-\sin\gamma'\frac{d^3\gamma'}{d\sigma^3}-3\cos\gamma'\frac{d\gamma'}{d\sigma}\frac{d^2\gamma'}{d\sigma^2}+\sin\gamma'\left(\frac{d\gamma'}{d\sigma}\right)^3=\cos\gamma\sin\sigma-\sin\gamma\cos\sigma\cos\xi.$$

When these derivatives are evaluated for $\gamma'=\gamma$ and $\sigma=0$, we get

$$\left[\frac{d\gamma'}{d\sigma}\right]=-\cos\xi$$

$$\left[\frac{d^2\gamma'}{d\sigma^2}\right]=\sin^2\xi\cot\gamma$$

$$\left[\frac{d^3\gamma'}{d\sigma^3}\right]=\sin^2\xi\cos\xi\,(1+3\cot^2\gamma)$$

Introducing these values in (a) we obtain

$$\gamma'-\gamma=-\sigma\cos\xi+\frac{1}{2}\sigma^2\sin^2\xi\cot\gamma+\frac{1}{6}\sigma^3\sin^2\xi\cos\xi\,(1+3\cot^2\gamma)+\cdots\cdots$$

and substituting φ, φ' and α in this expression, we have for the difference of latitude

$$\varphi-\varphi'=\sigma\cos\alpha+\frac{1}{2}\sigma^2\sin^2\alpha\tan\varphi-\frac{1}{6}\sigma^3\sin^2\alpha\cos\alpha\,(1+3\tan^2\varphi)+\cdots\cdots \qquad (b)$$

It will be readily seen that the first term expresses approximately the distance on the meridian PB from B to p, the foot of the perpendicular from A; the second term, the distance, very nearly, from p to the parallel passing through A; while the third term is a further approximation, and so on.

Referring now our case to an imaginary sphere of radius equal to N, with its center at the point where the normal An intersects the polar diameter of the spheroid, we have

$$\sigma=\frac{s}{N}$$

substituting which, we get

$$\varphi-\varphi'=\frac{s\cos\alpha}{N}+\frac{1}{2}\frac{s^2\sin^2\alpha\tan\varphi}{N^2}-\frac{1}{6}\frac{s^3\sin^2\alpha\cos\alpha}{N^3}(1+3\tan^2\varphi)+\cdots \qquad (c)$$

This difference of latitude is, however, referred to a sphere whose radius is N and requires still to be transformed by referring it to one whose radius is R_m, the radius of curvature in the meridian for the middle latitude. Since we do not at first know the middle latitude, it is more convenient to refer to the radius of curvature R of the starting point, the latitude of which is known, and then find the small correction due to the ratio of R to R_m.

Multiplying then equation (c) by $\frac{N}{R}$ and dividing, moreover, by arc $1''$, in order to express $\varphi-\varphi'$ in seconds of arc, we get

$$-\delta\varphi=\frac{s}{R\,\text{arc}\,1''}\cos\alpha+\frac{1}{2}\frac{s^2}{R\,N\,\text{arc}\,1''}\sin^2\alpha\tan\varphi-\frac{1}{6}\frac{s^3}{R\,N^2\,\text{arc}\,1''}\sin^2\alpha\cos\alpha\,(1+3\tan^2\varphi)+\cdots \qquad (d)$$

The computation of this series is facilitated by tables giving the logarithms of the following factors to the argument of φ, viz:

$$B=\frac{1}{R\,\text{arc}\,1''} \qquad\qquad C=\frac{\tan\varphi}{2\,R\,N\,\text{arc}\,1''}$$

Moreover, substituting in the third term the value of the first term, designated by h, we can write it

$$\frac{1}{6}h\cdot\frac{s^2\sin^2\alpha}{N^2}(1+3\tan^2\varphi)$$

and tabulate another factor

$$E=\frac{1+3\tan^2\varphi}{6\,N^2},$$

when our formula for computation becomes

$$-\delta\varphi = s\cos\alpha\cdot B + s^2\sin^2\alpha\cdot C - h\cdot s^2\sin^2\alpha\cdot E + \cdots \qquad (e)$$

In order, finally, to obtain the true $\Delta\varphi$ referred to R_m we must increase $\delta\varphi$ by $\frac{R-R_m}{R_m}\delta\varphi$

Now

$$R-R_m = a(1-e^2)\left(\frac{1}{(1-e^2\sin^2\varphi)^{3/2}} - \frac{1}{(1-e^2\sin^2\varphi_m)^{3/2}}\right) = a(1-e^2)\,\frac{\frac{3}{2}e^2(\sin^2\varphi-\sin^2\varphi_m)}{(1-e^2\sin^2\varphi)^{3/2}(1-e^2\sin^2\varphi_m)^{3/2}}$$

by developing and neglecting terms involving higher powers of e^2; but

$$\sin^2\varphi-\sin^2\varphi_m = \sin(\varphi-\varphi_m)\sin(\varphi+\varphi_m) = \delta\varphi\sin 1''\sin\varphi\cos\varphi$$

very nearly, because $\frac{1}{2}\sin 2\varphi = \sin\varphi\cos\varphi$; hence we write

$$\frac{R-R_m}{R_m} = \frac{a(1-e^2)\,\frac{3}{2}e^2\,\delta\varphi\sin 1''\sin\varphi\cos\varphi}{(1-e^2\sin^2\varphi)^{3/2}(1-e^2\sin^2\varphi_m)^{3/2}} \times \frac{(1-e^2\sin^2\varphi_m)^{3/2}}{a(1-e^2)} = \frac{\frac{3}{2}e^2\,\delta\varphi\sin 1''\sin\varphi\cos\varphi}{(1-e^2\sin^2\varphi)^{3/2}}$$

nearly, but making

$$D = \frac{\frac{3}{2}e^2\sin\varphi\cos\varphi\,\mathrm{arc}\,1''}{(1-e^2\sin^2\varphi)^{3/2}}$$

we get for the desired corrective term [a]

$$\frac{R-R_m}{R_m}\,\delta\varphi = (\delta\varphi)^2 D$$

and we finally have for the true difference of latitude

$$-\Delta\varphi = s\cos\alpha\cdot B + s^2\sin^2\alpha\cdot C + (\delta\varphi)^2\cdot D - h\cdot s^2\sin^2\alpha\cdot E \qquad (1)$$

which formula, although of a somewhat complicated derivation, is very simple and convenient in practical computation with the aid of the tabulated log. factors B, C, D, E. The term [b] $(\delta\varphi)^2 D$ is here interposed between the second and third terms of the series proper, because the latter is frequently not required, being insensible when the distance s is less than about 10 statute miles or log s (s in meters) less than 4.23. The term $(\delta\varphi)^2 D$ should be used whenever log h exceeds 2.31, and h^2 may be substituted for $(\delta\varphi)^2$ in all cases where log s does not exceed 4.93.

The term depending on the fourth differential coefficient, neglected in equation (a), never exceeds $0''.002$ for $\sigma = 1°$ or $s = 100$ kilometers, and may therefore be safely neglected in practice.[c]

---

[a] In his The Theory and Practice of Surveying Prof. J. B. Johnson develops this corrective term in a direct manner as contrasted with the approximate and laborious method given in the text, and points out that the $\frac{3}{2}$ power in the denominator of D should be replaced by unity. This has been done in the appended tables, although the defect is not more than 0.001 of the value of this term, which is itself very small.—C. A. S.

[b] This term was devised by the writer of this article in 1846, while arranging the formulæ for use in the Coast Survey and putting them into the form above given, in which they have been employed ever since.—J. E. H.

[c] This additional term has, however, been lately developed by M. H. Doolittle, of the computing division, who finds that it can be given as a function of the factors A, C, and E of the tables, thus requiring no special tabulation. It is as follows:

The additional term of Taylor's theorem

$$\frac{1}{24}\frac{d^4\gamma}{d\sigma^4}\sigma^4 = -\frac{1}{24}\sigma^4\sin^2\xi\cot\gamma\left[(1-3\cos^2\xi)(1+3\cot^2\gamma) - 6\cos^2\xi\,\mathrm{cosec}^2\gamma\right]$$

Substituting $90°-\varphi$ for γ, $180°-\alpha$ for ξ, $\frac{s}{N}$ for σ, and multiplying by $\frac{N}{R\,\mathrm{arc}\,1''}$ in the same manner as for the other terms

$$\begin{aligned}\frac{1}{24}\frac{d^4\gamma}{d\sigma^4}\sigma^4 = &-\frac{1}{24}\frac{s^4}{RN^3\,\mathrm{arc}\,1''}\sin^2\alpha\tan\varphi(1+3\tan^2\varphi)\\ &+\frac{1}{8}\frac{s^4}{RN^3\,\mathrm{arc}\,1''}\sin^2\alpha\cos^2\alpha\tan\varphi(1+3\tan^2\varphi)\\ &+\frac{1}{4}\frac{s^4}{RN^3\,\mathrm{arc}\,1''}\sin^2\alpha\cos^2\alpha\tan\varphi\sec^2\varphi\end{aligned}$$

Denoting the second term $s^2\sin^2\alpha\,C$ in formula (e) by C_1

$$C_1 E = \frac{s^2\sin^2\alpha\tan\varphi(1+3\tan^2\varphi)}{12\,RN^3\,\mathrm{arc}\,1''}$$

$$A^2 C_1 = \frac{s^2\sin^2\alpha\tan\varphi}{2\,RN^3\,\mathrm{arc}^3\,1''}$$

For secondary triangulation and when the sides do not exceed about 12 statute miles, or say 20 kilometers, the formula (1) may be advantageously reduced to the following:

$$-\Delta\varphi = s \cos \alpha \cdot B + s^2 \sin^2 \alpha \cdot C + h^2 \cdot D \qquad (2)$$

In order next to deduce the angle ABP (fig. 2) between the meridional planes passing through A and B and intersecting in the polar axis, or the difference $\Delta\lambda$ of the longitudes λ and λ' of the points A and B, counted from east to west, we avail ourselves of the latitude φ' of B, which has become known by the previous calculation, and have simply, using the same notation as before,

$$\sin \gamma' : \sin \xi = \sin \sigma : \sin \Delta\lambda$$

Referring σ to a sphere the radius of which is the normal $Bn' = N'$, we have $\sigma = \frac{s}{N'}$ and assuming for the present the small arcs σ and $\Delta\lambda$ proportional to their sines, we obtain

$$\Delta\lambda = \frac{s \sin \alpha}{N' \cos \varphi' \text{ arc } 1''} \quad . \quad . \quad . \qquad (3)$$

dividing by arc $1''$ in order to obtain $\Delta\lambda$ expressed in seconds of arc. The table gives the logarithm of the factor $A = \frac{1}{N \text{ arc } 1''}$, which must be taken out for φ'. We have

$$\Delta\lambda = \frac{s \sin \alpha}{\cos \varphi'} A$$

In order to correct for the assumption that the small arcs s and $\Delta\lambda$ are proportional to their sines we use a table giving the differences of the logarithms of the arcs and sines. This table is given before the tabulation of the factors A to F. In using it take out the differences for the arguments log. s and log. $\Delta\lambda$ the first with a negative, the second with a positive sign, and add their algebraic sum to log. $\Delta\lambda$.

We obtain finally the reverse azimuth α' by considering that in the spherical triangle APB (fig. 2) we have the following relation

$$\cot \frac{1}{2} (\xi + \xi') = \tan \frac{1}{2} (\Delta\lambda) \frac{\cos \frac{1}{2} (\gamma' + \gamma)}{\cos \frac{1}{2} (\gamma' - \gamma)} = \tan \frac{1}{2} (\Delta\lambda) \frac{\sin \frac{1}{2} (\varphi' + \varphi)}{\cos \frac{1}{2} (\varphi' - \varphi)}$$

but $\xi = 180° - \alpha$, therefore

$$\cot \frac{1}{2} (180° - \alpha + \xi') = -\tan \frac{1}{2} (\xi' - \alpha)$$

and

$$-\tan \frac{1}{2} (\Delta\alpha) = \tan \frac{1}{2} (\Delta\lambda) \frac{\sin \frac{1}{2} (\varphi' + \varphi)}{\cos \frac{1}{2} (\varphi' - \varphi)}$$

Assuming the tangents of $\frac{1}{2} \Delta\alpha$ and $\frac{1}{2} \Delta\lambda$ proportional to their arcs, and writing $\varphi_m = \frac{1}{2} (\varphi + \varphi')$ for the middle latitude, we have

$$-\Delta\alpha = \Delta\lambda \frac{\sin \varphi_m}{\cos \frac{1}{2} (\Delta\varphi)} \text{ and } \alpha' = \alpha + 180° + \Delta\alpha$$

---

and we finally obtain

$$-\Delta\varphi = s \cos \alpha . B + s^2 \sin^2 \alpha . C + (\delta \varphi)^2 . D - h . s^2 \sin^2 \alpha . E$$

$$-\frac{1}{2} s^2 C_1 E + \frac{3}{2} s^2 \cos^2 \alpha . C_1 E + \frac{1}{2} s^2 \cos^2 \alpha \sec^2 \varphi . A^2 C_1 \text{ arc}^2 1''$$

In the line from Ibepah to Ogden, in Utah, 230 kilometers long, the additional term amounted to $0''.038$. In Puissant's time no such long lines had to be provided for as have since been observed in triangulations; e. g., in California, Nevada, Utah, and Colorado, where several sides reach to nearly 2° in length, or slightly surpass this limit, with a maximum sight of 2¾°. The formulæ applicable for the computation of the largest triangles that it is possible to measure, given in Clarke's Geodesy (Oxford, 1880), and in Appendix No. 9, Coast and Geodetic Survey Report for 1885, pages 462–464, and employed in the British Ordnance Survey, also in the extension of La Caille's arc in South Africa, may be employed for a check computation, but they demand the use of not less than 9-place logarithms.

For distances greater than any that can be directly observed, see development of formulæ in series by Dr. F. R. Helmert "Theorieen der Höheren Geodäsie, Leipzig, 1880," Vol. I, pages 296–298. It includes terms of the fifth order.

DECEMBER, 1894.

When the difference of longitude is very large it becomes necessary to correct for the error in the assumption that $\tan \frac{1}{2} (\Delta\alpha) : \tan \frac{1}{2} (\Delta\lambda) = \Delta\alpha : \Delta\lambda$. By an obvious transformation we find the correction to be $\frac{1}{12} (\Delta\lambda)^3 \sin \varphi_m \cos^2 \varphi_m \sin^2 1''$, for which we write $(\Delta\lambda)^3 F$ where log. F is to be taken from the table (see last column of table of factors). This term is only $0''.01$ when log. $\Delta\lambda = 3.36$ and need never be used for secondary triangulation. A convenient table for finding the reciprocal of $\cos \frac{1}{2} (\Delta\varphi)$ is given on page 18.

DEVELOPMENT OF FORMULA FOR SPHERICAL EXCESS.

In developing the formula for the spherical excess in the ellipsoidal triangle used in geodetic surveying, let us first assume that the triangle under consideration is a spherical one situated on a sphere whose radius is the mean radius of curvature for the figure on the ellipsoid of revolution. Next, imagine a triangle similar to this spherical one on a sphere of unit radius. Now it is obvious that the spherical excess of this similar triangle on the sphere of unit radius is exactly equal to that of the original spherical triangle.

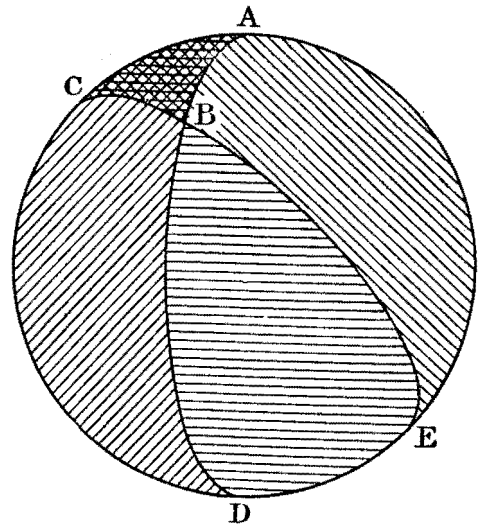

FIG. 3.

Let fig. 3 represent the unit sphere with the triangle ABC similar to the original spherical triangle. Since the sides are arcs of great circles, it is permissible to take one of them, as AC, in the plane of the paper for representation in the figure. Let us suppose AB and CB, two arcs of great circles, to be produced to cut the great circle AC at D and E, respectively.

Now, if we express the three spherical angles A, B, and C in circular measure, and call K the area of the surface of the entire hemisphere shown in the figure, then we have

Area of surface of lune $ACDB$ equals $A/\pi \times K$,

Area of surface of lune $CBEA$ equals $C/\pi \times K$,

Total area of surfaces BDE and ABC equals $B/\pi \times K$.

Now, call S the area of the surface of the spherical triangle ABC, and we have

$$K + 2S = K\,(A/\pi + B/\pi + C/\pi)$$

or

$$K/\pi\,(A + B + C) - K = 2S$$

But $K = 2\pi$, since the radius of the sphere under consideration is unity. Therefore

$$2\,(A + B + C) - 2\pi = 2S$$

Or

$$A + B + C - \pi = S \qquad [1]$$

This proves that the spherical excess in radians of triangle ABC is equal to the area of the triangle. Or, coming back to the original spherical triangle on the earth, and remembering that its spherical excess is the same as that of this similar triangle on the unit sphere, we have proved that the spherical excess of any spherical triangle, expressed in radians, is equal to the area of a similar triangle on a sphere of unit radius.

Now let us call S' the area of the geodetic triangle on the earth, and ρ the mean radius of curvature of the ellipsoidal surface of this triangle. Designate the spherical excess in radians by ϵ. Then, since $S'/S=\rho^2/1^2$, we have from (1)

$$\epsilon=S=S'/\rho^2$$

If a and b are the lengths of the sides opposite the angles A and B, respectively, in the geodetic triangle whose area is S', then, since the triangles used in triangulation are so small that in computing their areas they may be treated as plane triangles, we have

$$\epsilon=S'/\rho^2=\frac{\frac{1}{2}\,a\,b\sin C}{\rho^2} \qquad [2]$$

The next step is to derive the formula for ρ. If we represent by R the radius of curvature in the direction of the meridian and by N the radius of curvature in the direction perpendicular to the meridian, we have

$$\rho^2=RN \qquad [3]$$

Let us derive expressions for R and N from which we can then easily obtain an expression for ρ.

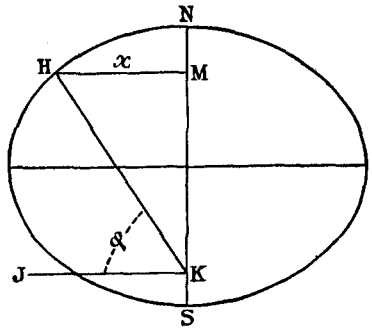

FIG. 4.

First, let us consider N. Suppose fig. 4 to represent the ellipse in the plane of the meridian of the point H where the radius of curvature of the surface is to be determined. Draw HM perpendicular to the minor axis NS. Suppose HK to be a normal to the ellipse at H cutting NS at K. Draw KJ perpendicular to NS. Then angle HKJ$=\varphi$, the latitude of the place. HM$=x$. HK, called the great normal, is equal to the radius of curvature N in the plane perpendicular to the meridian.

$$N=\mathrm{HK}=x/\cos\varphi \qquad [4]$$

The equation of the ellipse is $x^2/a^2+y^2/b^2=1$ and $e^2=\frac{a^2-b^2}{a^2}$. The equation of the ellipse may be written $y^2=(a^2-x^2)\,(1-e^2)$ or $y=(\sqrt{a^2-x^2})\,(\sqrt{1-e^2})$.

Now the slope of the curve at H is $dy/dx=-\cot\varphi$.

But

$$\frac{dy}{dx}=\sqrt{1-e^2}\left(\frac{-x}{\sqrt{a^2-x^2}}\right)$$

Therefore

$$-\cot\varphi=\frac{-x\sqrt{1-e^2}}{\sqrt{a^2-x^2}}$$

Squaring and clearing of fractions,

$$x^2\,[(1-e^2)+\cot^2\varphi]=a^2\cot^2\varphi$$

or

$$x^2\,(1-e^2\sin^2\varphi)=a^2\cos^2\varphi$$

or

$$x=\frac{a\cos\varphi}{(1-e^2\sin^2\varphi)^{1/2}} \qquad [5]$$

Then substitute [5] in [4] and we have

$$N=\frac{a}{(1-e^2\sin^2\varphi)^{1/2}} \qquad [6]$$

Next let us consider R. Deriving an expression for this amounts to deriving the radius of curvature of the ellipse at the point H, whose abscissa is x and whose latitude is φ. In the ordinary calculus expression

$$R=\frac{[1+(dy/dx)^2]^{3/2}}{d^2y/dx^2}$$

we have

$$dy/dx=-\cot\varphi=\frac{-x\sqrt{1-e^2}}{\sqrt{a^2-x^2}}$$

and differentiating

$$d^2y/dx^2=\frac{-\sqrt{a^2-x^2}\,\sqrt{1-e^2}+x\sqrt{1-e^2}\,\frac{-x}{\sqrt{a^2-x^2}}}{a^2-x^2}=\frac{-a^2\sqrt{1-e^2}}{(a^2-x^2)^{3/2}}$$

Substituting the value of x from [5]

$$d^2y/dx^2=\frac{-a^2\sqrt{1-e^2}}{\left[a^2-\frac{a^2\cos^2\varphi}{1-e^2\sin^2\varphi}\right]^{3/2}}=\frac{-a^2\sqrt{1-e^2}\,(1-e^2\sin^2\varphi)^{3/2}}{(a^2-a^2e^2\sin^2\varphi-a^2\cos^2\varphi)^{3/2}}=\frac{-(1-e^2\sin^2\varphi)^{3/2}}{a\sin^3\varphi\,(1-e^2)}$$

Then, neglecting the negative sign,

$$R=\frac{[1+(dy/dx)^2]^{3/2}}{d^2y/dx^2}=\frac{(1+\cot^2\varphi)^{3/2}}{\frac{(1-e^2\sin^2\varphi)^{3/2}}{a\sin^3\varphi\,(1-e^2)}}$$

$$R=\frac{\frac{1}{\sin^3\varphi}}{\frac{(1-e^2\sin^2\varphi)^{3/2}}{a\sin^3\varphi\,(1-e^2)}}=\frac{a\,(1-e^2)}{(1-e^2\sin^2\varphi)^{3/2}} \qquad [7]$$

Then, substituting [6] and [7] in [3], we have

$$\rho^2=\frac{a}{\sqrt{1-e^2\sin^2\varphi}}\times\frac{a(1-e^2)}{(1-e^2\sin^2\varphi)^{3/2}}$$

or

$$\rho^2=\frac{a^2(1-e^2)}{(1-e^2\sin^2\varphi)^2} \qquad [8]$$

Substituting [8] in [2], we have

$$\epsilon=\frac{ab\sin C(1-e^2\sin^2\varphi)^2}{2a^2(1-e^2)}$$

where ϵ is expressed in radians. Then if ϵ be expressed in seconds, we have

$$\epsilon=\frac{ab\sin C(1-e^2\sin^2\varphi)^2}{2a^2(1-e^2)\sin 1''}$$

Now let

$$m=\frac{(1-e^2\sin^2\varphi)^2}{2a^2(1-e^2)\sin 1''}$$

and we have

$$\epsilon=ab\sin C\times m$$

which is the formula given on page 7.