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854

SMITHSONIAN

GEOGRAPHICAL TABLES

PREPARED BY

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ADVERTISEMENT.

In connection with the system of meteorological observations established by the Smithsonian Institution about 1850, a series of meteorological tables was compiled by Dr. Arnold Guyot, at the request of Secretary Henry, and was published in 1852 as a volume of the Miscellaneous Collections.

A second edition was published in 1857, and a third edition, with further amendments, in 1859.

Though primarily designed for meteorological observers reporting to the Smithsonian Institution, the tables were so widely used by meteorologists and physicists that, after twenty-five years of valuable service, the work was again revised, and a fourth edition was published in 1884.

In a few years the demand for the tables exhausted the edition, and it appeared to me desirable to recast the work entirely, rather than to undertake its revision again. After careful consideration I decided to publish the new work in three parts: Meteorological Tables, Geographical Tables, and Physical Tables, each representative of the latest knowledge in its field, and independent of the others; but the three forming a homogeneous series.

Although thus historically related to Doctor Guyot's Tables, the present work is so entirely changed with respect to material, arrangement, and presentation, that it is not a fifth edition of the older tables, but essentially a new publication.

The first volume of the new series of Smithsonian Tables (the Meteorological Tables) appeared in 1893. The present volume, forming the second of the series, the Geographical Tables, has been prepared by Professor R. S. Woodward, formerly of the United States Coast and Geodetic Survey, but now of Columbia College, New York, who has brought to the work a very wide experience both in field work and in the reduction of extensive geodetic observations.

S. P. Langley, *Secretary.*

PREFACE.

In the preparation of the following work two difficulties of quite different kinds presented themselves. The first of these was to make a judicious selection of matter suited to the needs of the average geographer, and at the same time to keep the volume within prescribed limits. Of the vast amount of material available, much must be omitted from any work of limited dimensions, and it was essential to adopt some rule of discrimination. The rule adopted and adhered to, so far as practicable, was to incorporate little material already accessible in good form elsewhere. Accordingly, while numerous references are made in the volume to such accessible material, an attempt has been made wherever feasible to introduce new matter, or matter not hitherto generally available.

The second difficulty arose from the present uncertainty in the relation of the British and metric units of length, or rather from the absence of any generally adopted ratio of the British yard to the metre. The dimensions of the earth adopted for the tables are those of General Clarke, published in 1866, and now most commonly used in geodesy. These dimensions are expressed in English feet, and in order to convert them into metres it is necessary to adopt a ratio of the foot to the metre. The ratio used by General Clarke, and hitherto generally used, is now known to be erroneous by about one one hundred thousandth part. The ratio used in this volume is that adopted provisionally by the Office of Standard Weights and Measures of the United States and legalized by Act of Congress in 1866. But inasmuch as a precise determination of this ratio is now in progress under the auspices of the International Bureau of Weights and Measures, and inasmuch as the value for the ratio found by this Bureau will doubtless be generally adopted, it has been thought best in the present edition to restrict quantities expressed in metric measures to limits which will require no change from the uncertainty in question. In conformity with this decision the dimensions of the earth are given in feet only, and, with a few unimportant exceptions, to which attention is called in the proper places, tables giving quantities in metres are limited to such a number of figures as are definitely known.

It is a matter of regret that, owing to the cause just stated, less prominence has been given in the tables to metric than to British units of length. On the other hand, it seems probable that the more general use of British units will meet the approval of the majority of those for whose use the volume is designed.

The introductory part of the volume is divided into seven sections under the heads, Useful Formulas, Mensuration, Units, Geodesy, Astronomy, Theory of Errors, and Explanation of Source and Use of Tables, respectively. In presenting the subjects embraced under the first six of these headings an attempt was made to give only those features leading directly to practical applications of the principles involved. It is hoped, however, that enough has been given of each subject to render the work of value in a broader sense to those who may desire to go beyond mere applications.

The most of the calculations required in the preparation of the tables were made by Mr. Charles H. Kummell and Mr. B. C. Washington, Jr. Their work was done with skill and fidelity, and it is believed that the systematic checks applied by them have rendered the tables they computed entirely trustworthy. Mention of the particular tables computed by each of them is made in the Explanation of Source and Use of Tables, where full credit is given also for data not specially prepared for the volume.

The Appendix to the present volume is that prepared by Mr. George E. Curtis for the Meteorological Tables. Its usefulness to the geographer is no less obvious and general than to the meteorologist.

The proofs have been read independently by Mr. Charles H. Kummell and the editor. The plate proofs, also, have been read by the editor; and while it is difficult to avoid errors in a first edition of a work containing many formulas and figures, it is believed that few, if any, important errata remain in this volume.

R. S. WOODWARD.

COLUMBIA COLLEGE, New York, N. Y., June 15, 1894

CONTENTS.

USEFUL FORMULAS.

MENSURATION.

UNITS.

GEODESY.

ASTRONOMY.

THEORY OF ERRORS.

EXPLANATION OF SOURCE AND USE OF TABLES.

TABLES.

APPENDIX.

USEFUL FORMULAS.

1. Algebraic.

a. **Arithmetic and geometric means.** The arithmetic mean of n quantities $a, b, c, \ldots$ is

$$\frac{1}{n}(a+b+c+\ldots);$$

their geometric mean is

$$(a\ b\ c\ldots)^{\frac{1}{n}}.$$

A case of special interest is

$$\sqrt{a\,b} = \tfrac{1}{2}(a+b)\left\{1-\left(\frac{a-b}{a+b}\right)^2\right\}^{\frac{1}{2}}.$$

b. **Arithmetic progression.** If a is the first term, and $a+d$, $a+2\,d$, $a+3\,d, \ldots$ are the successive terms, the nth or last term z is

$$z = a + (n-1)\,d.$$

The sum s of the n terms of this series is

$$\begin{aligned} s = \tfrac{1}{2}(a+z)\,n &= \{a + \tfrac{1}{2}(n-1)\,d\}\,n \\ &= \{z - \tfrac{1}{2}(n-1)\,d\}\,n \\ &= \tfrac{1}{2}(a+z)\left(\frac{z-a}{d}+1\right). \end{aligned}$$

c. **Geometric progression.** If a is the first term, and $a\,r$, $a\,r^2, \ldots$ are the successive terms, the nth or last term z is

$$z = a\,r^{n-1}.$$

The sum of the n terms is

$$s = \frac{a\,(r^n-1)}{r-1} = \frac{r\,z-a}{r-1} = \frac{z\,(r^n-1)}{(r-1)\,r^{n-1}}.$$

If $r < 1$ and $n = \infty$,

$$s = \frac{a}{1-r}.$$

d. **Sums of special series.**

$$\begin{aligned} 1+2+3+4+\ldots+n &= \tfrac{1}{2}\,n\,(n+1) \\ 2+4+6+8+\ldots+2\,n &= n\,(n+1) \\ 1+3+5+7+\ldots+(2\,n-1) &= n^2 \\ 1^2+2^2+3^2+4^2+\ldots+n^2 &= \tfrac{1}{6}\,n\,(n+1)\,(2\,n+1) \\ 1^3+2^3+3^3+4^3+\ldots+n^3 &= \tfrac{1}{4}\,n^2\,(n+1)^2. \end{aligned}$$

e. The binomial series and applications.

For $a > b$,

$$(a \pm b)^n = a^n \pm n\, a^{n-1} b + \frac{n(n-1)}{1\,.\,2} a^{n-2} b^2 \pm \frac{n(n-1)(n-2)}{1\,.\,2\,.\,3} a^{n-3} b^3 + \dots$$

For $x < 1$,

$$(1 \pm x)^n = 1 \pm n\,x + \frac{n(n-1)}{1\,.\,2} x^2 \pm \frac{n(n-1)(n-2)}{1\,.\,2\,.\,3} x^3 + \dots$$

$$\frac{1}{1+x} = 1 - x + x^2 - x^3 + x^4 - \dots$$

$$\frac{1}{1-x} = 1 + x + x^2 + x^3 + x^4 + \dots$$

$$\frac{1}{(1-x)^2} = 1 + 2\,x + 3\,x^2 + 4\,x^3 + 5\,x^4 + \dots$$

$$(1+x)^{\frac{1}{2}} = 1 + \tfrac{1}{2}x - \tfrac{1}{8}x^2 + \tfrac{1}{16}x^3 - \tfrac{5}{128}x^4 + \dots$$

$$(1-x)^{\frac{1}{2}} = 1 - \tfrac{1}{2}x - \tfrac{1}{8}x^2 - \tfrac{1}{16}x^3 - \tfrac{5}{128}x^4 - \dots$$

$$\frac{1}{(1+x)^{\frac{1}{2}}} = 1 - \tfrac{1}{2}x + \tfrac{3}{8}x^2 - \tfrac{5}{16}x^3 + \tfrac{35}{128}x^4 - \dots$$

$$\frac{1}{(1-x)^{\frac{1}{2}}} = 1 + \tfrac{1}{2}x + \tfrac{3}{8}x^2 + \tfrac{5}{16}x^3 + \tfrac{35}{128}x^4 + \dots$$

f. Exponential and logarithmic series.

For $-\infty < x < \infty$,

$$e^x = 1 + \frac{x}{1} + \frac{x^2}{1\,.\,2} + \frac{x^3}{1\,.\,2\,.\,3} + \frac{x^4}{1\,.\,2\,.\,3\,.\,4} + \dots$$

The number e is the base of the natural or "Napierian" system of logarithms. For $x = +1$, the above series gives

$$e = 2.718281828459 \dots$$

In the natural system the following series hold with the limitations indicated:

$$a^x = 1 + \frac{\log a}{1} x + \frac{(\log a)^2}{1\,.\,2} x^2 + \frac{(\log a)^3}{1\,.\,2\,.\,3} x^3 \dots$$

$$-\infty < x < \infty;$$

$$\log(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \frac{x^5}{5} - \dots$$

$$x \leqq 1;$$

$$\log(1-x) = -x - \frac{x^2}{2} - \frac{x^3}{3} - \frac{x^4}{4} - \frac{x^5}{5} - \dots$$

$$x < 1;$$

$$\log x = 2\left\{\frac{x-1}{x+1} + \frac{1}{3}\left(\frac{x-1}{x+1}\right)^3 + \frac{1}{5}\left(\frac{x-1}{x+1}\right)^5 + \frac{1}{7}\left(\frac{x-1}{x+1}\right)^7 + \dots\right\}$$

$$0 < x < \infty;$$

$$\log\frac{x+y}{x} = 2\left\{\frac{y}{2\,x+y} + \frac{1}{3}\left(\frac{y}{2\,x+y}\right)^3 + \frac{1}{5}\left(\frac{y}{2\,x+y}\right)^5 + \dots\right\}$$

$$y^2 < (2\,x+y)^2.$$

g. Relations of natural logarithms to other logarithms.

B = base of any system,
N = any number,
$L = \log N$ to base $B = \log_B N$,
$l = \log N$ to base $e = \log_e N$.

Then

$$N = e^l = B^L,$$
$$L = l \log_B e = l / \log_e B,$$

$\log_B e = 1/\log_e B = \mu$, say, which is called the *modulus* of the system whose base is B. In the common, or Briggean system,

$$\mu = \log_{10} e = 0.43429448 \ldots.$$
$$\log \mu = 9.6377843 - 10.$$

2. Trigonometric Formulas.

a. Signs of trigonometric functions.

Function.	1st Quadrant.	2d Quadrant.	3d Quadrant.	4th Quadrant.
sine	+	+	−	−
cosine	+	−	−	+
tangent . . .	+	−	+	−
cotangent . . .	+	−	+	−

b. Values of functions for special angles.

	0°	90°	180°	270°	360°	30°	45°	60°
sine	0	+1	0	−1	0	$\frac{1}{2}$	$\frac{1}{2}\sqrt{2}$	$\frac{1}{2}\sqrt{3}$
cosine . . .	+1	0	−1	0	+1	$\frac{1}{2}\sqrt{3}$	$\frac{1}{2}\sqrt{2}$	$\frac{1}{2}$
tangent . . .	0	∞	0	∞	0	$\frac{1}{3}\sqrt{3}$	1	$\sqrt{3}$
cotangent . .	∞	0	∞	0	∞	$\sqrt{3}$	1	$\frac{1}{3}\sqrt{3}$

c. Fundamental formulas.

$$\sin^2 a + \cos^2 a = 1, \qquad \tan a \cot a = 1,$$
$$\cos a \sec a = 1, \qquad \sin a \operatorname{cosec} a = 1,$$
$$\tan a = \frac{\sin a}{\cos a}, \qquad \cot a = \frac{\cos a}{\sin a},$$
$$1 + \tan^2 a = \frac{1}{\cos^2 a} = \sec^2 a, \qquad 1 + \cot^2 a = \frac{1}{\sin^2 a} = \operatorname{cosec}^2 a,$$
$$\text{versed} \sin a = 1 - \cos a.$$

d. Formulas involving two angles.

$$\sin(\alpha \pm \beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta,$$
$$\cos(\alpha \pm \beta) = \cos\alpha\cos\beta \mp \sin\alpha\sin\beta.$$

$$\tan(\alpha \pm \beta) = (\tan\alpha \pm \tan\beta)/(1 \mp \tan\alpha\tan\beta),$$
$$\cot(\alpha \pm \beta) = (\cot\alpha\cot\beta \mp 1)/(\cot\alpha \pm \cot\beta).$$

$$\sin\alpha + \sin\beta = 2\sin\tfrac{1}{2}(\alpha+\beta)\cos\tfrac{1}{2}(\alpha-\beta),$$
$$\sin\alpha - \sin\beta = 2\cos\tfrac{1}{2}(\alpha+\beta)\sin\tfrac{1}{2}(\alpha-\beta).$$

$$\cos\alpha + \cos\beta = 2\cos\tfrac{1}{2}(\alpha+\beta)\cos\tfrac{1}{2}(\alpha-\beta),$$
$$\cos\alpha - \cos\beta = -2\sin\tfrac{1}{2}(\alpha+\beta)\sin\tfrac{1}{2}(\alpha-\beta).$$

$$\tan\alpha \pm \tan\beta = \frac{\sin(\alpha \pm \beta)}{\cos\alpha\cos\beta},$$
$$\cot\alpha \pm \cot\beta = \frac{\sin(\beta \pm \alpha)}{\sin\alpha\sin\beta}.$$

$$2\sin\alpha\sin\beta = \cos(\alpha-\beta) - \cos(\alpha+\beta),$$
$$2\cos\alpha\cos\beta = \cos(\alpha-\beta) + \cos(\alpha+\beta),$$
$$2\sin\alpha\cos\beta = \sin(\alpha-\beta) + \sin(\alpha+\beta).$$

$$\frac{\sin\alpha + \sin\beta}{\sin\alpha - \sin\beta} = \tan\tfrac{1}{2}(\alpha+\beta)\cot\tfrac{1}{2}(\alpha-\beta),$$

$$\frac{\cos\alpha + \cos\beta}{\cos\alpha - \cos\beta} = -\cot\tfrac{1}{2}(\alpha+\beta)\cot\tfrac{1}{2}(\alpha-\beta).$$

e. Formulas involving multiple angles.

$$\sin 2\alpha = 2\sin\alpha\cos\alpha,$$
$$\sin 3\alpha = 3\sin\alpha\cos^2\alpha - \sin^3\alpha.$$

$$\cos 2\alpha = \cos^2\alpha - \sin^2\alpha = 1 - 2\sin^2\alpha = 2\cos^2\alpha - 1,$$
$$\cos 3\alpha = \cos^3\alpha - 3\sin^2\alpha\cos\alpha.$$

$$\tan\tfrac{1}{2}\alpha = \frac{\sin\alpha}{1+\cos\alpha} = \frac{1-\cos\alpha}{\sin\alpha} = \left(\frac{1-\cos\alpha}{1+\cos\alpha}\right)^{\frac{1}{2}},$$

$$\tan 2\alpha = \frac{2\tan\alpha}{1-\tan^2\alpha}, \qquad \cot 2\alpha = \frac{\cot^2\alpha - 1}{2\cot\alpha},$$

$$\sin\alpha = \frac{2\tan\frac{1}{2}\alpha}{1+\tan^2\frac{1}{2}\alpha}, \qquad \cos\alpha = \frac{1-\tan^2\frac{1}{2}\alpha}{1+\tan^2\frac{1}{2}\alpha}.$$

$$2\sin^2\alpha = 1 - \cos 2\alpha, \qquad 2\cos^2\alpha = 1 + \cos 2\alpha,$$
$$4\sin^3\alpha = 3\sin\alpha - \sin 3\alpha, \qquad 4\cos^3\alpha = 3\cos\alpha + \cos 3\alpha.$$

f. Exponential values. Moivre's formula.

e = base of natural logarithms,

$$i = \sqrt{-1}, \quad i^2 = -1, \quad i^3 = -i, \quad i^4 = 1, \text{ etc.}$$

$$\cos x = \tfrac{1}{2}(e^{ix} + e^{-ix}), \qquad \sin x = \tfrac{1}{2i}(e^{ix} - e^{-ix}),$$
$$\cos ix = \tfrac{1}{2}(e^{-x} + e^{x}), \qquad \sin ix = \tfrac{1}{2i}(e^{-x} - e^{x}).$$

$$(\cos x \pm i\sin x)^m = \cos mx \pm i\sin mx.$$

g. Values of functions in series.

For x in arc the following series hold within the limits indicated.

$$\sin x = x - \frac{x^3}{6} + \frac{x^5}{120} - \frac{x^7}{5040} + \cdots,$$

$$\cos x = 1 - \frac{x^2}{2} + \frac{x^4}{24} - \frac{x^6}{720} + \cdots,$$

$$-\infty < x < +\infty.$$

$$\tan x = x + \tfrac{1}{3} x^3 + \tfrac{2}{15} x^5 + \tfrac{17}{315} x^7 + \cdots,$$

$$\sec x = 1 + \tfrac{1}{2} x^2 + \tfrac{5}{24} x^4 + \tfrac{61}{720} x^6 + \cdots,$$

$$-\tfrac{1}{2}\pi < x < +\tfrac{1}{2}\pi.$$

$$\cot x = \frac{1}{x}\left(1 - \tfrac{1}{3} x^2 - \tfrac{1}{45} x^4 - \tfrac{2}{945} x^6 - \cdots\right),$$

$$\operatorname{cosec} x = \frac{1}{x}\left(1 + \tfrac{1}{6} x^2 + \tfrac{7}{360} x^4 + \tfrac{31}{15120} x^6 + \cdots\right),$$

$$-\pi < x < +\pi.$$

$$\text{arc} \sin x = x + \tfrac{1}{6} x^3 + \tfrac{3}{40} x^5 + \tfrac{5}{112} x^7 + \cdots,$$

$$\text{arc} \tan x = x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7} + \frac{x^9}{9} - \cdots,$$

$$-1 < x < +1.$$

$$x = \sin x + \tfrac{1}{6} \sin^3 x + \tfrac{3}{40} \sin^5 x + \tfrac{5}{112} \sin^7 x + \cdots,$$

$$-\tfrac{1}{2}\pi < x < +\tfrac{1}{2}\pi.$$

$$x = \tan x - \tfrac{1}{3} \tan^3 x + \tfrac{1}{5} \tan^5 x - \tfrac{1}{7} \tan^7 x + \cdots,$$

$$-\tfrac{1}{4}\pi < x < +\tfrac{1}{4}\pi.$$

$$\log \sin x = \log x - \mu\left(\tfrac{1}{6} x^2 + \tfrac{1}{180} x^4 + \tfrac{1}{2835} x^6 + \cdots\right),$$

x positive and $< \pi$,

$\mu =$ modulus of common logarithms. See p. xv.

$$\log \tan x = \log x + \mu\left(\tfrac{1}{3} x^2 + \tfrac{7}{90} x^4 + \tfrac{62}{2835} x^6 + \cdots\right),$$

x positive and $< \tfrac{1}{2}\pi$.

h. Conversion of arcs into angles and angles into arcs.

Denote by x°, x', and x'' respectively the angle (in degrees, minutes, or seconds) corresponding to the arc x. Then by equality of ratios

$$\frac{360^\circ}{x^\circ} = \frac{360 \times 60'}{x'} = \frac{360 \times 60 \times 60''}{x''} = \frac{2\pi}{x},$$

whence

$$x^\circ = x\,\frac{180^\circ}{\pi},$$

$$x' = x\,\frac{180 \times 60'}{\pi},$$

$$x'' = x\,\frac{180 \times 60 \times 60''}{\pi}.$$

Put

$$\frac{180^\circ}{\pi} = \rho^\circ = \text{number of degrees in the radius,}$$

$$\frac{180 \times 60'}{\pi} = \rho' = \text{number of minutes in the radius,}$$

$$\frac{180 \times 60 \times 60''}{\pi} = \rho'' = \text{number of seconds in the radius.}$$

Then

$$x^\circ = x\,\rho^\circ, \qquad x' = x\,\rho', \qquad x'' = x\,\rho''.$$

$$\rho^\circ = 57.^\circ 2957795, \qquad \log \rho^\circ = 1.75812263,$$
$$\rho' = 3437.'74677, \qquad \log \rho' = 3.53627388,$$
$$\rho'' = 206264.''806, \qquad \log \rho'' = 5.31442513.$$

3. Formulas for Solution of Plane Triangles.

a, b, c = sides of triangle,
α, β, γ = angles opposite to a, b, c, respectively,
A = area of triangle,
r = radius of inscribed circle,
R = radius of circumscribed circle,
$s = \frac{1}{2}(a + b + c)$.

$$\frac{a}{\sin \alpha} = \frac{b}{\sin \beta} = \frac{c}{\sin \gamma} = 2\,R.$$

$$a = b \cos \gamma + c \cos \beta, \qquad b = c \cos \alpha + a \cos \gamma, \qquad c = a \cos \beta + b \cos \alpha.$$

$$r = 4\,R \sin \tfrac{1}{2}\alpha \sin \tfrac{1}{2}\beta \sin \tfrac{1}{2}\gamma = \frac{a\,b\,c}{4\,R\,s}.$$

$$(a + b) \cos \tfrac{1}{2}(\alpha + \beta) = c \cos \tfrac{1}{2}(\alpha - \beta),$$
$$(a - b) \sin \tfrac{1}{2}(\alpha + \beta) = c \sin \tfrac{1}{2}(\alpha - \beta).$$

$$\frac{a + b}{a - b} = \frac{\tan \frac{1}{2}(\alpha + \beta)}{\tan \frac{1}{2}(\alpha - \beta)} = \frac{\tan \frac{1}{2}\gamma}{\tan \frac{1}{2}(\alpha - \beta)}.$$

$$a^2 = b^2 + c^2 - 2\,b\,c \cos \alpha = (b + c)^2 - 4\,b\,c \cos^2 \tfrac{1}{2}\alpha.$$

$$\sin \tfrac{1}{2}\alpha = \sqrt{\frac{(s - b)(s - c)}{b\,c}}, \qquad \cos \tfrac{1}{2}\alpha = \sqrt{\frac{s(s - a)}{b\,c}}.$$

$$\tan \tfrac{1}{2}\alpha = \sqrt{\frac{(s - b)(s - c)}{s(s - a)}} = \frac{r}{s - a}.$$

$$r = \sqrt{\frac{(s - a)(s - b)(s - c)}{s}}.$$

$$A = \tfrac{1}{2}\,a\,b \sin \gamma = \frac{a^2 \sin \beta \sin \gamma}{2 \sin \alpha} = 2\,R^2 \sin \alpha \sin \beta \sin \gamma$$
$$= r^2 \cot \tfrac{1}{2}\alpha \cot \tfrac{1}{2}\beta \cot \tfrac{1}{2}\gamma = \sqrt{s(s - a)(s - b)(s - c)}$$
$$= r\,s = \tfrac{1}{4}\,a\,b\,c\,/R.$$

In right angled triangles let

$a =$ altitude,
$b =$ base,
$c =$ hypothenuse,
$\gamma = 90°$.

Then

$$a = c \sin \alpha = c \cos \beta = b \tan \alpha = b \cot \beta,$$
$$b = c \sin \beta = c \cos \alpha = a \tan \beta = a \cot \alpha.$$

$$A = \tfrac{1}{2}\, a\, b = \tfrac{1}{2}\, a^2 \cot \alpha = \tfrac{1}{2}\, b^2 \tan \alpha = \tfrac{1}{4}\, c^2 \sin 2\, \alpha.$$

Table for solution of oblique triangles.

Given.	Sought.	Formula.
a, b, c	α	$\sin \tfrac{1}{2}\, \alpha = \sqrt{\dfrac{(s-b)(s-c)}{b\, c}}$, $\quad s = \tfrac{1}{2}(a+b+c)$,
		$\cos \tfrac{1}{2}\, \alpha = \sqrt{\dfrac{s(s-a)}{b\, c}}$,
		$\tan \tfrac{1}{2}\, \alpha = \sqrt{\dfrac{(s-b)(s-c)}{s(s-a)}}$.
	A	$A = \sqrt{s(s-a)(s-b)(s-c)}$.
a, b, α	β	$\sin \beta = b \sin \alpha / a$. When $a > b$, $\beta < 90°$ and but one value results. When $b > a$, β has two values.
	γ	$\gamma = 180° - (\alpha + \beta)$.
	c	$c = a \sin \gamma / \sin \alpha$.
	A	$A = \tfrac{1}{2}\, a\, b \sin \gamma$.
a, α, β	b	$b = a \sin \beta / \sin \alpha$.
	γ	$\gamma = 180° - (\alpha + \beta)$.
	c	$c = a \sin \gamma / \sin \alpha = a \sin (\alpha + \beta) / \sin \alpha$.
	A	$A = \tfrac{1}{2}\, a\, b \sin \gamma = \tfrac{1}{2}\, a^2 \sin \beta \sin \gamma / \sin \alpha$.
a, b, γ	α	$\tan \alpha = \dfrac{a \sin \gamma}{b - a \cos \gamma}$.
	α, β	$\tfrac{1}{2}(\alpha + \beta) = 90° - \tfrac{1}{2}\gamma$.
		$\tan \tfrac{1}{2}(\alpha - \beta) = \dfrac{a-b}{a+b} \cot \tfrac{1}{2}\gamma$.
		$c = (a^2 + b^2 - 2\, a\, b \cos \gamma)^{\frac{1}{2}}$,
		$= \{(a+b)^2 - 4\, a\, b \cos^2 \tfrac{1}{2}\gamma\}^{\frac{1}{2}}$,
		$= \{(a-b)^2 + 4\, a\, b \sin^2 \tfrac{1}{2}\gamma\}^{\frac{1}{2}}$,
		$= (a-b)/\cos \phi$, where $\tan \phi = 2\sqrt{a\, b} \sin \tfrac{1}{2}\gamma / (a-b)$,
		$= a \sin \gamma / \sin \alpha$.
	A	$A = \tfrac{1}{2}\, a\, b \sin \gamma$.

4. Formulas for Solution of Spherical Triangles.

a. Right angled spherical triangles.

$a, b, c =$ sides of triangle, c being the hypotenuse,
$\alpha, \beta, \gamma =$ angles opposite to a, b, c, respectively,
$\gamma = 90^\circ$.

$\sin a = \sin c \sin \alpha$, $\sin b = \sin c \sin \beta$,
$\tan a = \tan c \cos \beta$, $\tan b = \tan c \cos \alpha$,
$= \sin b \tan \alpha$, $= \sin a \tan \beta$;

$\cos \alpha = \cos a \sin \beta$, $\cos \beta = \cos b \sin \alpha$;

$\cos c = \cos a \cos b = \cot \alpha \cot \beta$.

b. Oblique angled triangles.

$a, b, c =$ sides of triangle,
$\alpha, \beta, \gamma =$ angles opposite to a, b, c, respectively,
$s = \frac{1}{2}(a + b + c)$,
$\sigma = \frac{1}{2}(\alpha + \beta + \gamma)$,
$\epsilon = \alpha + \beta + \gamma - 180^\circ =$ spherical excess,
$S =$ surface of triangle on sphere of radius r.

$$\frac{\sin a}{\sin \alpha} = \frac{\sin b}{\sin \beta} = \frac{\sin c}{\sin \gamma},$$

$$\cos a = \cos b \cos c + \sin b \sin c \cos \alpha,$$

$$\sin^2 \tfrac{1}{2} a = \frac{-\cos \sigma \cos (\sigma - \alpha)}{\sin \beta \sin \gamma}, \qquad \cos^2 \tfrac{1}{2} a = \frac{\cos (\sigma - \beta) \cos (\sigma - \gamma)}{\sin \beta \sin \gamma},$$

$$\tan^2 \tfrac{1}{2} a = \frac{-\cos \sigma \cos (\sigma - \alpha)}{\cos (\sigma - \beta) \cos (\sigma - \gamma)}.$$

$$\sin^2 \tfrac{1}{2} \alpha = \frac{\sin (s - b) \sin (s - c)}{\sin b \sin c}, \qquad \cos^2 \tfrac{1}{2} \alpha = \frac{\sin s \sin (s - a)}{\sin b \sin c},$$

$$\tan^2 \tfrac{1}{2} \alpha = \frac{\sin (s - b) \sin (s - c)}{\sin s \sin (s - a)}.$$

$$\cot \tfrac{1}{2} \epsilon = \frac{\cot \frac{1}{2} a \cot \frac{1}{2} b + \cos \gamma}{\sin \gamma},$$

$$\tan^2 \tfrac{1}{4} \epsilon = \tan \tfrac{1}{2} s \tan \tfrac{1}{2} (s - a) \tan \tfrac{1}{2} (s - b) \tan \tfrac{1}{2} (s - c).$$

$$S = \frac{\epsilon}{180^\circ} \pi r^2.$$

Napier's analogies.

$$\tan \tfrac{1}{2}(a + b) = \frac{\cos \frac{1}{2}(\alpha - \beta)}{\cos \frac{1}{2}(\alpha + \beta)} \tan \tfrac{1}{2} c, \quad \tan \tfrac{1}{2}(a - b) = \frac{\sin \frac{1}{2}(\alpha - \beta)}{\sin \frac{1}{2}(\alpha + \beta)} \tan \tfrac{1}{2} c,$$

$$\tan \tfrac{1}{2}(\alpha + \beta) = \frac{\cos \frac{1}{2}(a - b)}{\cos \frac{1}{2}(a + b)} \cot \tfrac{1}{2} \gamma, \quad \tan \tfrac{1}{2}(\alpha - \beta) = \frac{\sin \frac{1}{2}(a - b)}{\sin \frac{1}{2}(a + b)} \cot \tfrac{1}{2} \gamma.$$

Gauss's formulas.

$$\cos \tfrac{1}{2}(\alpha + \beta) \cos \tfrac{1}{2} c = \cos \tfrac{1}{2}(a + b) \sin \tfrac{1}{2} \gamma,$$
$$\sin \tfrac{1}{2}(\alpha + \beta) \cos \tfrac{1}{2} c = \cos \tfrac{1}{2}(a - b) \cos \tfrac{1}{2} \gamma,$$

$$\cos \tfrac{1}{2}(\alpha - \beta) \sin \tfrac{1}{2} c = \sin \tfrac{1}{2}(a + b) \sin \tfrac{1}{2} \gamma,$$
$$\sin \tfrac{1}{2}(\alpha - \beta) \sin \tfrac{1}{2} c = \sin \tfrac{1}{2}(a - b) \cos \tfrac{1}{2} \gamma.$$

5. Elementary Differential Formulas.

a. Algebraic.

$u, v, w, \ldots =$ variables subject to differentiation,
$a, b, c, \ldots =$ constants.

$$d(a + u) = du, \quad d(a\,u) = a\,du,$$
$$d(u + v + w + \ldots) = d\,u + d\,v + d\,w + \ldots,$$
$$d(u\,v) = u\,dv + v\,du,$$
$$d(u\,v\,w \ldots) = \left(\frac{du}{u} + \frac{dv}{v} + \frac{dw}{w} + \ldots\right) u\,v\,w \ldots,$$
$$d\left(\frac{u}{v}\right) = \frac{v\,du - u\,dv}{v^2} = \frac{du}{v} - \frac{u\,dv}{v^2},$$
$$d\left(\frac{a + b\,u}{h + g\,u}\right) = \frac{b\,h - a\,g}{(h + g\,u)^2}\,du.$$

$$dv^n = n\,v^{n-1}\,dv, \qquad d\sqrt{v} = \frac{dv}{2\sqrt{v}},$$
$$da^v = a^v \log a\,dv, \qquad de^v = e^v\,dv$$
($e =$ base of natural logarithms),
$$d \log v = dv/v.$$

$$dF(u, v, w \ldots) = \frac{\partial F}{\partial u}\,du + \frac{\partial F}{\partial v}\,dv + \frac{\partial F}{\partial w}\,dw + \ldots.$$

b. Trigonometric and inverse trigonometric.

$$d\sin x = \cos x\,dx, \qquad d\cos x = -\sin x\,dx,$$
$$d\tan x = \sec^2 x\,dx, \qquad d\cot x = -\operatorname{cosec}^2 x\,dx,$$
$$d\sec x = \sec^2 x \sin x\,dx, \qquad d\operatorname{cosec} x = -\operatorname{cosec}^2 x \cos x\,dx.$$

$$d\log \sin x = \cot x\,dx, \qquad d\log \cos x = -\tan x\,dx.$$

$$d\operatorname{arc} \sin x = \pm \frac{dx}{\sqrt{1 - x^2}}, \qquad d\operatorname{arc} \cos x = \mp \frac{dx}{\sqrt{1 - x^2}},$$

$$d\operatorname{arc} \tan x = \frac{dx}{1 + x^2}, \qquad d\operatorname{arc} \cot x = -\frac{dx}{1 + x^2}.$$

6. Taylor's and Maclaurin's Series.

a. Taylor's series.

If $u = f(x+h)$, any finite and continuous function of $x+h$, h being an arbitrary increment to x; and if du/dx, d^2u/dx^2, . . . are finite and determinate,

$$u = f(x+h) = f(x) + f'(x)\,h + f''(x)\frac{h^2}{2} + f'''(x)\frac{h^3}{1.\,2.\,3} + \cdots,$$

where $f(x), f'(x), f''(x)$, . . . are the values of $f(x+h)$, du/dx, d^2u/dx^2, . . . when $h = 0$. This is Taylor's series or theorem. The remainder after the first n terms in h is expressed by the definite integral

$$\frac{1}{1.\,2.\,3\ldots n}\int_0^h f^{n+1}(x+h-z)\,z^n\,dz.$$

b. Maclaurin's series.

If in Taylor's series we make $x = 0$, and $h = x$, the result is

$$u = f(x) = f(0) + f'(0)\,x + f''(0)\frac{x^2}{1\cdot 2} + f'''(0)\frac{x^3}{1.\,2.\,3} + \cdots,$$

where $f(0), f'(0), f''(0)$, . . . are the values of $f(x)$, du/dx, d^2u/dx^2, . . . when $x = 0$. This is Maclaurin's series or theorem. The remainder after the first n terms in x is expressed by the definite integral

$$\frac{1}{1\cdot 2\cdot 3\ldots n}\int_0^x f^{n+1}(x-z)\,z^n\,dz.$$

c. Example of Taylor's series.

$$u = f(x+h) = \log(x+h).$$

$$f(x) = \log x,$$

$$\frac{du}{dx} = \frac{1}{x+h}, \qquad f'(x) = +x^{-1},$$

$$\frac{d^2u}{dx^2} = -\frac{1}{(x+h)^2}, \qquad f''(x) = -x^{-2},$$

$$\frac{d^3u}{dx^3} = +\frac{2}{(x+h)^3}, \qquad f'''(x) = +2\,x^{-3},$$

$$\cdots\cdot \qquad \cdots\cdot$$

Hence for common logarithms, μ being the modulus,

$$\log(x+h) = \log x + \mu\left(x^{-1}h - \tfrac{1}{2}x^{-2}h^2 + \tfrac{1}{3}x^{-3}h^3 - \ldots\right),$$

and the sum of the remaining terms is

$$-\frac{\mu}{1\cdot 2\cdot 3}\int_0^h \frac{2\cdot 3}{(x+h-z)^4}\,z^3\,dz.$$

Since x is the least value of $(x + h - z)$ within the limits of this integral, the sum of the remaining terms is negative, and numerically

$$< \tfrac{1}{4}\mu \left(\frac{h}{x}\right)^4.$$

If, for example, $(h/x) = 1/100$, the remainder in question is less than $\frac{1}{4} \times 0.434 \times 10^{-8}$, or about one unit in the ninth place of decimals.

d. Example of Maclaurin's series.

$$u = f(x) = \sin x.$$

$$f(0) = 0,$$

$$\frac{du}{dx} = \cos x, \qquad f'(0) = +1,$$

$$\frac{d^2u}{dx^2} = -\sin x, \qquad f''(0) = 0,$$

$$\frac{d^3u}{dx^3} = -\cos x, \qquad f'''(0) = -1,$$

$$\ldots \qquad \ldots$$

Hence

$$f(x) = \sin x = x - \frac{x^3}{1 \cdot 2 \cdot 3} + \frac{x^5}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5} - \ldots,$$

and the sum of the remaining terms is

$$-\frac{1}{5\,!}\int_0^x \sin(x - z)\, z^5\, dz.$$

If g is the greatest value of $\sin(x - z)$ within the limits of this integral the remainder in question is negative and numerically

$$< \frac{g}{6} \times \frac{1}{5\,!}\, x^6.$$

If, for example, $x = \pi/6$ (the arc of 30°), $g = \frac{1}{2}$, and the remainder is numerically less than 0.0000143.

7. Elementary Formulas for Integration.

a. Indefinite integrals.

$$\int a\,dx = a\int dx = ax + C.$$

$$\int f(x)\,dx + \int \phi(x)\,dx = \int \{f(x) + \phi(x)\}\,dx.$$

If $x = \phi(y)$, and $dx = \phi'(y)\,dy$,

$$\int f(x)\,dx = \int f\{\phi(y)\}\,\phi'(y)\,dy.$$

$$\frac{d}{dy}\int f(x, y)\,dx = \int \frac{df(x, y)}{dy}\,dx.$$

Since $d(uv) = udv + vdu$,

$$\int udv = uv - \int vdu \text{; and}$$

if $u = f(x)$ and $v = \phi(x)$,

$$\int f(x)\,\frac{d\phi(x)}{dx}\,dx = f(x)\,\phi(x) - \int \phi(x)\frac{df(x)}{dx}\,dx.^*$$

$$\int dx \int f(x, y)\,dy = \int dy \int f(x, y)\,dx.$$

$$\int dx \int f(x)\,dx = x\int f(x)\,dx - \int xf(x)\,dx.$$

$$\int x^n dx = \frac{1}{n+1}\,x^{n-1} + C.$$

$$\int \frac{dx}{x^n} = -\,\frac{1}{n-1}\,x^{-(n-1)} + C, \qquad n > 1.$$

$$\int (a + b\,x)^n\,dx = \frac{(a + bx)^{n+1}}{(n+1)\,b} + C.$$

$$\int \frac{dx}{x} = \log x\,\dagger + C, \qquad \int \frac{dx}{a+bx} = b^{-1}\log(a + bx).$$

$$\int \frac{dx}{x^2} = -\,\frac{1}{x} + C, \qquad \int \frac{dx}{(a+bx)^2} = -\,\frac{1}{b\,(a+bx)} + C.$$

$$\int \frac{dx}{1+x^2} = \text{arc tan}\,x + C, \qquad \int \frac{-\,dx}{1+x^2} = \text{arc cot}\,x + C.$$

$$\int \frac{dx}{1-x^2} = \tfrac{1}{2}\log\frac{1+x}{1-x} + C, \qquad \int \frac{dx}{x^2-1} = \tfrac{1}{2}\log\frac{x-1}{x+1} + C.$$

$$\int \frac{dx}{a+bx^2} = (ab)^{-\frac{1}{2}}\,\text{arc tan}\,(b/a)^{\frac{1}{2}}\,x + C, \text{ for } a \text{ and } b \text{ both positive,}$$

$$= (ab)^{-\frac{1}{2}}\,\text{arc cot}\,(b/a)^{\frac{1}{2}}\,x + C, \text{ for } a \text{ and } b \text{ both negative,}$$

$$= \tfrac{1}{2}\,(-\,ab)^{-\frac{1}{2}}\log\frac{(-\,ab)^{\frac{1}{2}} - bx}{(-\,ab)^{\frac{1}{2}} + bx} + C, \text{ for } ab \text{ negative.}$$

$$\int \frac{dx}{a + 2\,bx + cx^2} = (ac - b^2)^{-\frac{1}{2}}\,\text{arc tan}\,\frac{b + cx}{(ac - b^2)^{\frac{1}{2}}} + C, \text{ for } ac - b^2 > 0,$$

$$= \tfrac{1}{2}\,(b^2 - ac)^{-\frac{1}{2}}\log\frac{(b^2 - ac)^{\frac{1}{2}} - b - cx}{(b^2 - ac)^{\frac{1}{2}} + b + cx} + C, \text{ for } b^2 - ac > 0.$$

$$\int (a + x^2)^{\frac{1}{2}}\,dx = \tfrac{1}{2}\,x\,(a + x^2)^{\frac{1}{2}} + \tfrac{1}{2}\,a\log\{x + (a + x^2)^{\frac{1}{2}}\} + C.$$

$$\int (a^2 - x^2)^{\frac{1}{2}}\,dx = \tfrac{1}{2}\,x\,(a^2 - x^2)^{\frac{1}{2}} + \tfrac{1}{2}\,a^2\,\text{arc sin}\,\frac{x}{a} + C.$$

$$\int (a + bx)^{\frac{1}{2}}\,dx = \tfrac{2}{3}\,(a + bx)^{\frac{3}{2}}/b + C.$$

* This is the formula for integration by parts.

† Natural logarithms are used in this and the following integrals. For relation of natural to common logarithms see section 1, g.

$$\int(a + 2\,bx + cx^2)^{\frac{1}{2}}\,dx = \tfrac{1}{2}\,(b + cx)\,(a + 2\,bx + cx^2)^{\frac{1}{2}}/c$$
$$+ \tfrac{1}{2}\,(ac - b^2)/c\int(a + 2\,bx + cx^2)^{-\frac{1}{2}}\,dx + C.$$

$$\int(a + bx)^{-\frac{1}{2}}\,dx = 2\,(a + bx)^{\frac{1}{2}}/b + C.$$

$$\int(\alpha + \beta x)\,(a + bx)^{-\frac{1}{2}}\,dx = \tfrac{2}{3}\,(3\,\alpha b - 2\,a\beta + \beta\,bx)\,(a + bx)^{\frac{1}{2}}/b^2 + C.$$

$$\int(a^2 - x^2)^{-\frac{1}{2}}\,dx = \pm\,\text{arc sin}\,\frac{x}{a} + C,$$
$$= \mp\,\text{arc cos}\,\frac{x}{a} + C,$$
$$= 2\,\text{arc tan}\left(\frac{a + x}{a - x}\right)^{\frac{1}{2}} + C.$$

$$\int(a + x^2)^{-\frac{1}{2}}\,dx = \log\,\{x + (a + x^2)^{\frac{1}{2}}\} + C,$$
$$= \tfrac{1}{2}\log\frac{x + (a + x^2)^{\frac{1}{2}}}{x - (a + x^2)^{\frac{1}{2}}} + C.$$

$$\int(a + 2\,bx + cx^2)^{-\frac{1}{2}}\,dx = \frac{1}{\sqrt{c}}\log\,\{b + cx + (ac + bcx + c^2x^2)^{\frac{1}{2}}\} + C, \text{ for } c > 0,$$
$$= -\frac{1}{\sqrt{-c}}\,\text{arc sin}\,\frac{b + cx}{(b^2 - ac)^{\frac{1}{2}}} + C, \text{ for } c < 0.$$

$$\int a^x dx = a^x/\log a + C, \qquad \int e^x dx = e^x + C.$$

$$\int\log x\,dx = x\log x - x + C.$$

$$\int(\log x)^n\,x^{-1}\,dx = \frac{1}{n + 1}\,(\log x)^{n+1} + C.$$

$$\int\sin x\,dx = -\cos x + C, \qquad \int\cos x\,dx = \sin x + C.$$

$$\int\sin^2 x\,dx = \tfrac{1}{2}\,x - \tfrac{1}{4}\sin 2\,x + C, \qquad \int\cos^2 x\,dx = \tfrac{1}{2}\,x + \tfrac{1}{4}\sin 2\,x + C.$$

$$\int\tan x\,dx = -\log\cos x + C, \qquad \int\cot x\,dx = \log\sin x + C.$$

$$\int\frac{dx}{\sin x} = \log\tan\tfrac{1}{2}\,x + C, \qquad \int\frac{dx}{\cos x} = \log\tan\tfrac{1}{2}\,(x + \tfrac{1}{2}\,\pi) + C.$$

$$\int\frac{dx}{\sin^2 x} = -\cot x + C, \qquad \int\frac{dx}{\cos^2 x} = \tan x + C.$$

$$\int e^{ax}\sin bx\,dx = \frac{a\sin bx - b\cos bx}{a^2 + b^2}\,e^{ax} + C.$$

$$\int e^{ax}\cos bx\,dx = \frac{a\cos bx + b\sin bx}{a^2 + b^2}\,e^{ax} + C.$$

$$\int\text{arc sin}\,x\,dx = x\,\text{arc sin}\,x \pm (1 - x^2)^{\frac{1}{2}} + C.$$

$$\int\text{arc cos}\,x\,dx = x\,\text{arc cos}\,x \mp (1 - x^2)^{\frac{1}{2}} + C.$$

$$\int\text{arc tan}\,x\,dx = x\,\text{arc tan}\,x - \tfrac{1}{2}\log\,(1 + x^2) + C.$$

$$\int\text{arc cot}\,x\,dx = x\,\text{arc cot}\,x + \tfrac{1}{2}\log\,(1 + x^2) + C.$$

b. Definite Integration.

$$\int_a^n \phi(x)\,dx = \int_a^b \phi(x)\,dx + \int_b^c \phi(x)\,dx + \ldots \int_m^n \phi(x)\,dx.$$

$$\int_a^b \phi(x)\,dx = -\int_b^a \phi(x)\,dx.$$

$$\int_0^a \phi(x)\,dx = \int_0^a \phi(a-x)\,dx.$$

If $\phi(x) = \phi(-x)$, an "even function" of x,

$$\int_0^a \phi(x)\,dx = \int_{-a}^0 \phi(x)\,dx = \tfrac{1}{2}\int_{-a}^a \phi(x)\,dx.$$

If $\phi(x) = -\phi(-x)$, an "odd function" of x,

$$\int_{-a}^0 \phi(x)\,dx = \int_0^a \phi(x)\,dx, \text{ and} \int_{-a}^{+a} \phi(x)\,dx = 0.$$

If A be the greatest and B the least value of $\phi(x)$ within the limits a and b,

$$A(b-a) > \int_a^b \phi(x)\,dx > B(b-a),$$

a formula useful in determining approximate values of integrals. See, e. g., section 6, d.

If $u = \int_a^b \phi(x)\,dx$,

$$\frac{du}{da} = -\phi(a), \qquad \frac{du}{db} = \phi(b).$$

$$\int_0^\infty \frac{dx}{1+x^2} = \tfrac{1}{2}\pi.$$

$$\int_0^1 \frac{dx}{1+x^2} = \int_1^\infty \frac{dx}{1+x^2} = \tfrac{1}{4}\pi.$$

$$\int_0^\infty \frac{dx}{a+bx^2} = \tfrac{1}{2}\pi/\sqrt{(ab)}, \qquad \int_0^a \frac{dx}{\sqrt{a^2-x^2}} = \tfrac{1}{2}\pi.$$

$$\int_0^\infty e^{-x^2}\,dx = \tfrac{1}{2}\sqrt{\pi}, \qquad \int_0^\infty e^{-a^2x^2}\,dx = \tfrac{1}{2}\sqrt{(\pi/a^2)}.$$

$$\int_0^\infty e^{-a^2x^2}\,x^{2n}\,dx = 1 \cdot 3 \cdot 5 \ldots (2n-1)\,a^{-n}\,(2a)^{-(n+1)}\sqrt{\pi}.$$

$$\int_0^\infty e^{-ax}\,x^{-\frac{1}{2}}\,dx = \sqrt{(\pi/a)}.$$

$$\int_0^\pi \sin mx \sin nx\,dx = \int_0^\pi \cos mx \cos nx\,dx = 0.$$

when m and n are unequal integers.

$$\int_0^\pi \sin mx \cos nx\,dx = \frac{2m}{m^2-n^2}, \text{ for } m \text{ and } n \text{ integers and } m-n \text{ odd,}$$

$$= 0, \text{ for } m \text{ and } n \text{ integers and } m-n \text{ even.}$$

$$\int_0^\pi \sin^2 mx\,dx = \int_0^\pi \cos^2 mx\,dx = \tfrac{1}{2}\pi, \text{ for } m \text{ an integer.}$$

$$\int_0^{\frac{1}{2}\pi} \sin^n x\,dx = \int_0^{\frac{1}{2}\pi} \cos^n x\,dx = \int_0^1 (1-x^2)^{\frac{1}{2}(n-1)}\,dx.$$

$$\int_0^\infty \frac{\sin x}{\sqrt{x}}\,dx = \int_0^\infty \frac{\cos x}{\sqrt{x}}\,dx = \sqrt{(\pi/2)}.$$

$$\int_0^\infty \sin x^2\,dx = \int_0^\infty \cos x^2\,dx = \tfrac{1}{2}\sqrt{(\pi/2)}.$$

$$\int_0^\infty e^{-a^2x^2}\cos 2bx\,dx = \tfrac{1}{2}\,e^{-(b/a)^2}\sqrt{(\pi/a)}.$$

$$\int_0^\infty e^{-a^2x^2}\sin 2bx\,dx = 0.$$

MENSURATION.

I. Lines.

a. In a circle.

$r =$ radius of circle,
$c =$ length of any chord,
$s =$ arc subtended by c,
$\alpha =$ angle corresponding to s,
$h =$ height of arc s above c, or perpendicular distance from middle point of arc to chord.

$$\text{Circumference} = 2\,\pi\,r,$$

$$\pi = 3.14\,159\,265, \qquad \log \pi = 0.49\,714\,987,$$

$$2\,\pi = 6.28\,318\,531, \qquad \log 2\,\pi = 0.79\,817\,987.$$

$$c = 2\,r \sin \tfrac{1}{2}\,\alpha, \qquad s = r\,\alpha.$$

Length of perpendicular from center on chord

$$= r \cos \tfrac{1}{2}\,\alpha$$

$$= (r^2 - \tfrac{1}{4}\,c^2)^{\frac{1}{2}}$$

$$= r\left\{1 - \tfrac{1}{2}\left(\frac{c}{2\,r}\right)^2 - \tfrac{1}{8}\left(\frac{c}{2\,r}\right)^4 - \tfrac{1}{16}\left(\frac{c}{2\,r}\right)^6 - \ldots\right\}.$$

$$h = r\,(1 - \cos \tfrac{1}{2}\,\alpha)$$

$$= 2\,r \sin^2 \tfrac{1}{4}\,\alpha$$

$$= r - (r^2 - \tfrac{1}{4}\,c^2)^{\frac{1}{2}}$$

$$= \tfrac{1}{8}\,r\left\{\left(\frac{c}{r}\right)^2 + \tfrac{1}{16}\left(\frac{c}{r}\right)^4 + \tfrac{1}{128}\left(\frac{c}{r}\right)^6 + \ldots\right\}.$$

$$s - c = \tfrac{1}{24}\,s\,(\alpha^2 - \tfrac{1}{80}\,\alpha^4 + \ldots)$$

$$= \tfrac{8}{3}\,\frac{h^2}{s}\left\{1 + \tfrac{28}{15}\left(\frac{h}{s}\right)^2 + \ldots\right\}.$$

$$\alpha = 8\left\{\frac{h}{s} + \tfrac{4}{3}\left(\frac{h}{s}\right)^8 + \ldots\right\}.$$

b. In regular polygon.

$r =$ radius of inscribed circle,
$R =$ radius of circumscribed circle,
$n =$ number of sides,
$s =$ length of any side,
$\beta =$ angle subtended by s,
$p =$ perimeter of polygon.

$\beta = 360°/n,$

$s = 2\ r \tan \frac{1}{2}\ \beta = 2\ R \sin \frac{1}{2}\ \beta,$

$p = n\ s = 2\ n\ r \tan \frac{1}{2}\ \beta = 2\ n\ R \sin \frac{1}{2}\ \beta.$

See table under c, below.

c. In ellipse.

a = semi-axis major,
b = semi-axis minor,
e = eccentricity $= (1 - b^2/a^2)^{\frac{1}{2}}$,
P = perimeter of ellipse,

$$n = (a - b)/(a + b)$$

$$= \frac{1 - \sqrt{1 - e^2}}{1 + \sqrt{1 - e^2}} = \frac{e^2}{4} + \frac{e^4}{8} + \frac{5\,e^6}{64} + \ldots.$$

Distance from centre to focus $= a\ e$,
Distance from focus to extremity of major axis $= a\ (1 - e)$,
Distance from focus to extremity of minor axis $= a$.

$$P = \pi\ (a + b)\ (1 + \tfrac{1}{4}\ n^2 + \tfrac{1}{16}\ n^4 + \tfrac{1}{256}\ n^6 + \ldots)$$

$= \pi\ (a + b)\ q$, say, where q stands for the series in n. The values of q corresponding to a few values of n are : —

n	q	n	q
0	1.0000	0.5	1.0635
0.1	1.0025	0.6	1.0922
0.2	1.0100	0.7	1.1267
0.3	1.0226	0.8	1.1677
0.4	1.0404	0.9	1.2155
		1.0	1.2732

2. Areas.

a. Area of plane triangle.

(See table on p. xix.)

b. Area of Trapezoid.

b_1 = upper base of trapezoid,
b_2 = lower base of trapezoid,
a = altitude of trapezoid, or perpendicular distance between bases.

$$\text{Area} = \tfrac{1}{2}\ (b_1 + b_2)\ a.$$

c. Area of regular polygon.

A = area,
r, R = radii of inscribed and circumscribed circles,
s = length of any side,
n = number of sides,
β = angle subtended by $s = 360°/n$.

$$A = n\, r^2 \tan \tfrac{1}{2}\beta = \tfrac{1}{2} n\, R^2 \sin \beta = \tfrac{1}{4} n\, s^2 \cot \tfrac{1}{2}\beta.$$

TABLE OF VALUES.

n	β	A	A	R	s
3	120°	$0.4330\, s^2$	$1.2990\, R^2$	$0.5774\, s$	$1.7321\, R$
4	90	1.0000	2.0000	0.7071	1.4142
5	72	1.7205	2.3776	0.8507	1.1756
6	60	2.5981	2.5981	1.0000	1.0000
7	$51\frac{3}{7}$	3.6339	2.7364	1.1524	0.8678
8	45	5.8284	2.8284	1.3066	0.7654
9	40	6.1818	2.8925	1.4619	0.6840
10	36	7.6942	2.9389	1.6180	0.6180
11	$32\frac{8}{11}$	9.3656	2.9735	1.7747	0.5635
12	30	11.1962	3.0000	1.9319	0.5176
13	$28\frac{9}{13}$	13.1858	3.0207	2.0893	0.4786
14	$25\frac{5}{7}$	15.3345	3.0372	2.2470	0.4450
15	24	17.6424	3.0505	2.4049	0.4158
16	$22\frac{1}{2}$	20.1094	3.0615	2.5629	0.3902

d. Area of circle, circular annulus, etc.

r = radius of circle,
d = diameter,
a = angle of any sector,
r_1, r_2 = smaller and greater radii of an annulus.

$$\text{Area of circle} = \pi\, r^2 = \tfrac{1}{4}\pi\, d^2,$$
$$\pi = 3.14\,159\,265, \quad \log \pi = 0.49\,714\,987.$$

$$\text{Area of sector} = a\, r^2, \text{ for } a \text{ in arc,}$$
$$= \pi\, r^2\, (a/360), \text{ for } a \text{ in degrees.}$$

$$\text{Area of annulus} = \pi\, (r_2^2 - r_1^2).$$

e. Area of ellipse.

a, b = semi axes respectively
e = eccentricity $= (a^2 - b^2)^{\frac{1}{2}}/a$
$= \{(a + b)(a - b)\}^{\frac{1}{2}}/a$.

Area of ellipse $= \pi\, a\, b$,

$= \pi\, a^2 \sqrt{1 - e^2}$,

$= \pi\, a^2 \cos \phi$, if $e = \sin \phi$.

f. Surface of sphere, etc.

$r =$ radius of sphere,

$\phi_1, \phi_2 =$ latitudes of parallels bounding a zone,

$\epsilon =$ spherical excess of a spherical triangle

$=$ sum of spherical angles less 180°,

Total surface $= 4\, \pi\, r^2$.

Surface of zone $= 2\, \pi\, r^2 (\sin \phi_2 - \sin \phi_1)$,

$= 4\, \pi\, r^2 \cos \frac{1}{2} (\phi_2 + \phi_1) \sin \frac{1}{2} (\phi_2 - \phi_1)$.

Surface of spherical triangle $= r^2\, \epsilon$, for ϵ in arc,

$= r^2\, \epsilon / \rho''$, for ϵ in seconds,

$\rho'' = 206\,264.8''$, $\quad \log \rho'' = 5.31\,442\,513$.

g. Surface of right cylinder.

$r =$ radius of bases of cylinder,

$h =$ altitude of cylinder.

Area cylindrical surface $= 2\, \pi\, r\, h$.

Total surface $= 2\, \pi\, r\, (r + h)$.

h. Surface of right cone.

$r =$ radius of base,

$h =$ altitude,

$s =$ slant height.

Conical surface $= \pi\, r\, s = \pi\, r\, (h^2 + r^2)^{\frac{1}{2}}$,

Total surface $= \pi\, r\, (s + r)$.

i. Surface of spheroid.

$a, b =$ semi axes,

$e =$ eccentricity $= \{(a + b)(a - b)\}^{\frac{1}{2}} / a$.

$$\text{Surface of oblate spheroid} = 2\, \pi\, a^2 \left\{ 1 + \frac{1 - e^2}{2\, e} \log \left(\frac{1 + e}{1 - e} \right) \right\}^*$$

$$= 4\, \pi\, a^2 (1 - \tfrac{1}{3} e^2 - \tfrac{1}{15} e^4 - \tfrac{1}{35} e^6 - \ldots).$$

$$\text{Surface of prolate spheroid} = 2\, \pi\, a\, b \left\{ (1 - e^2)^{\frac{1}{2}} + \frac{\text{arc} \sin e}{e} \right\}$$

$$= 4\, \pi\, a\, b\, (1 - \tfrac{1}{6} e^2 - \tfrac{1}{40} e^4 - \tfrac{1}{112} e^6 - \ldots).$$

* The logarithm in this formula refers to the natural or "Napierian" system. For areas of zones and quadrilaterals of an oblate spheroid, see pp. l–lii.

3. Volumes.

a. Volume of prism.

$A =$ area of base, $h =$ altitude, $V =$ volume.

$$V = A\,h.$$

For an oblique triangular prism whose edges a, b, c are inclined at an angle α to the base,

$$V = \tfrac{1}{3}\,(a + b + c)\,A \sin\alpha.$$

b. Volume of pyramid.

$A =$ area of base, $h =$ altitude, $V =$ volume.

$$V = \tfrac{1}{3}\,A\,h.$$

For a truncated pyramid whose parallel upper and lower bases have areas A_1 and A_2 respectively and whose distance apart is h,

$$V = \tfrac{1}{3}\,h\,(A_2 + \sqrt{A_2\,A_1} + A_1).$$

The volume of a wedge and obelisk may be expressed by means of the volumes of pyramids and prisms.

c. Volume of right circular cylinder.

$r =$ radius of base, $h =$ altitude, $V =$ volume.

$$V = \pi\,r^2\,h.$$

$$\pi = 3.14159265, \quad \log\pi = 0.49714987.$$

For an obliquely truncated cylinder (having a circular base) whose shortest and longest elements are h_1 and h_2 respectively,

$$V = \tfrac{1}{2}\,\pi\,r^2\,(h_2 + h_1).$$

For a hollow cylinder the radii of whose inner and outer surfaces are r_1 and r_2 respectively, and whose altitude is h,

$$V = \pi\,h\,(r_2^2 - r_1^2)$$

d. Volume of right cone with circular base.

$r =$ radius of base, $h =$ altitude, $V =$ volume.

$$V = \tfrac{1}{3}\,\pi\,r^2\,h.$$

For a right truncated cone the radii of whose upper and lower parallel bases are r_1 and r_2 respectively, and whose altitude is h,

$$V = \tfrac{1}{3}\,\pi\,h\,(r_2^2 + r_2\,r_1 + r_1^2).$$

e. Volume of sphere and spherical segments.

$r =$ radius of sphere, $h =$ altitude of segment, $V =$ volume.

For the entire sphere

$$V = \frac{4}{3}\pi r^3 = 4.1888\, r^3 \text{ approximately.}$$

(For π and log π see c above.)

For a spherical segment of height h

$$V = \pi h^2 (r - \tfrac{1}{3} h).$$

For a zone, or difference in volume of two segments whose altitudes are h_1 and h_2 respectively

$$V = \pi r (h_2^2 - h_1^2) - \tfrac{1}{3}\pi (h_2^3 - h_1^3)$$
$$= \tfrac{1}{6}\pi \Delta h (3 r_2^2 + 3 r_1^2 + \Delta h^2),$$

where r_1 and r_2 are the radii of the bases of the zone and $\Delta h = h_2 - h_1$.

f. Volume of ellipsoid.

a, b, c = semi axes, V = volume.

$$V = \tfrac{4}{3}\pi a b c.$$

For an ellipsoid of revolution about

the a-axis, $V = \frac{4}{3}\pi a b^2$,
the b-axis, $V = \frac{4}{3}\pi a^2 b$.

UNITS.

1. Standards of Length and Mass.

The only systems of units used extensively at the present day are the British and metric. The fundamental units in these systems are those of time, length, and mass. From these all other units are derived. The unit of time, the mean solar second, is common to both systems.

The standard unit of length in the British system is the Imperial Yard, which is defined to be the distance between two marks on a metallic bar, kept in the Tower of London, when the temperature of the bar is 60° F.

The standard unit of mass in the British system is the Imperial Pound Avoirdupois. It is a cylindrical mass of platinum marked "P. S. 1844, 1 lb.," preserved in the office of the Exchequer at Westminster.

In the metric system the standard unit of length is the Metre, now represented by numerous platinum iridium Prototypes prepared by the International Bureau of Weights and Measures.

The standard of mass in the metric system is the Kilogramme, now represented by numerous platinum iridium Prototypes prepared by the International Bureau of Weights and Measures.

Both systems of units have been legalized by the United States. Virtually, however, the material standards of length and mass of the United States are certain Prototype Metres and certain Prototype Kilogrammes. The present status of the two systems of units so far as it relates to the United States is set forth in the following statement from the Superintendent of Standard Weights and Measures, bearing the date April 5, 1893.

Fundamental Standards of Length and Mass.*

"While the Constitution of the United States authorizes Congress to 'fix the standard of weights and measures,' this power has never been definitely exercised, and but little legislation has been enacted upon the subject. Washington regarded the matter of sufficient importance to justify a special reference to it in his first annual message to Congress (January, 1790), and Jefferson, while Secretary of State, prepared a report at the request of the House of Representatives, in which he proposed (July, 1790) 'to reduce every branch to the decimal ratio already established for coins, and thus bring the calculation of the principal affairs of life within the arithmetic of every man who can multiply and divide.' The consideration of the subject being again urged by Washington, a committee

* Bulletin 26, U. S. Coast and Geodetic Survey. Washington: Government Printing Office, 1893. Published here by permission of Dr. T. C. Mendenhall, Superintendent Coast and Geodetic Survey.

of Congress reported in favor of Jefferson's plan, but no legislation followed. In the mean time the executive branch of the Government found it necessary to procure standards for use in the collection of revenue and other operations in which weights and measures were required, and the Troughton 82-inch brass scale was obtained for the Coast and Geodetic Survey in 1814, a platinum kilogramme and metre, by Gallatin, in 1821, and a Troy pound from London in 1827, also by Gallatin. In 1828 the latter was, by act of Congress, made the standard of mass for the Mint of the United States, and although totally unfit for such purpose it has since remained the standard for coinage purposes.

"In 1830 the Secretary of the Treasury was directed to cause a comparison to be made of the standards of weight and measure used at the principal custom-houses, as a result of which large discrepancies were disclosed in the weights and measures in use. The Treasury Department, being obliged to execute the constitutional provision that all duties, imposts, and excises shall be uniform throughout the United States, adopted the Troughton scale as the standard of length; the avoirdupois pound to be derived from the Troy pound of the Mint as the unit of mass. At the same time the Department adopted the wine gallon of 231 cubic inches for liquid measure and the Winchester bushel of 2 150·42 cubic inches for dry measure. In 1836 the Secretary of the Treasury was authorized to cause a complete set of all weights and measures, adopted as standards by the Department for the use of custom-houses and for other purposes, to be delivered to the Governor of each State in the Union for the use of the States respectively, the object being to encourage uniformity of weights and measures throughout the Union. At this time several States had adopted standards differing from those used in the Treasury Department, but after a time these were rejected, and finally nearly all the States formally adopted by act of legislature the standards which had been put in their hands by the National Government. Thus a good degree of uniformity was secured, although Congress had not adopted a standard of mass or of length other than for coinage purposes as already described.

"The next and in many respects the most important legislation upon the subject was the Act of July 28, 1866, making the use of the metric system lawful throughout the United States, and defining the weights and measures in common use in terms of the units of this system. This was the first *general* legislation upon the subject, and the metric system was thus the first, and thus far the only system made generally legal throughout the country.

"In 1875 an International Metric Convention was agreed upon by seventeen governments, including the United States, at which it was undertaken to establish and maintain at common expense a permanent International Bureau of Weights and Measures, the first object of which should be the preparation of a new international standard metre and a new international standard kilogramme, copies of which should be made for distribution among the contributing governments. Since the organization of the Bureau, the United States has regularly contributed to its support, and in 1889 the copies of the new international prototypes were ready for distribution. This was effected by lot, and the United States received metres Nos. 21 and 27, and kilogrammes Nos. 4 and 20. The metres and kilogrammes are made from the same material, which is an alloy of platinum with ten per cent of iridium.

"On January 2, 1890, the seals which had been placed on metre No. 27 and kilogramme No. 20, at the International Bureau of Weights and Measures near Paris, were broken in the Cabinet room of the Executive Mansion by the President of the United States, in the presence of the Secretary of State and the Secretary of the Treasury, together with a number of invited guests. They were thus adopted as the National Prototype Metre and Kilogramme.

"The Troughton scale, which in the early part of the century had been tentatively adopted as a standard of length, has long been recognized as quite unsuitable for such use, owing to its faulty construction and the inferiority of its graduation. For many years, in standardizing length measures, recourse to copies of the imperial yard of Great Britain had been necessary, and to the copies of the metre of the archives in the Office of Weights and Measures. The standard of mass originally selected was likewise unfit for use for similar reasons, and had been practically ignored.

"The recent receipt of the very accurate copies of the International Metric Standards, which are constructed in accord with the most advanced conceptions of modern metrology, enables comparisons to be made directly with those standards, as the equations of the National Prototypes are accurately known. It has seemed, therefore, that greater stability in weights and measures, as well as much higher accuracy in their comparison, can be secured by accepting the international prototypes as the fundamental standards of length and mass. It was doubtless the intention of Congress that this should be done when the International Metric Convention was entered into in 1875; otherwise there would be nothing gained from the annual contributions to its support which the Government has constantly made. Such action will also have the great advantage of putting us in direct relation in our weights and measures with all civilized nations, most of which have adopted the metric system for exclusive use. The practical effect upon our customary weights and measures is, of course, nothing. The most careful study of the relation of the yard and the metre has failed thus far to show that the relation as defined by Congress in the Act of 1866 is in error. The pound as there defined, in its relation to the kilogramme, differs from the imperial pound of Great Britain by not more than one part in one hundred thousand, an error, if it be so called, which utterly vanishes in comparison with the allowances in all ordinary transactions. Only the most refined scientific research will demand a closer approximation, and in scientific work the kilogramme itself is now universally used, both in this country and in England.*

* NOTE. — Reference to the Act of 1866 results in the establishment of the following: —

Equations.

$$1 \text{ yard} = \frac{3600}{3937} \text{ metre.}$$

$$1 \text{ pound avoirdupois} = \frac{1}{2.2046} \text{ kilo.}$$

A more precise value of the English pound avoirdupois is $\frac{1}{2.20462}$ kilo., differing from the above by about one part in one hundred thousand, but the equation established by law is sufficiently accurate for all ordinary conversions.

As already stated, in work of high precision the kilogramme is now all but universally used, and no conversion is required.

"In view of these facts, and the absence of any material normal standards of customary weights and measures, the Office of Weights and Measures, with the approval of the Secretary of the Treasury, will in the future regard the International Prototype Metre and Kilogramme as fundamental standards, and the customary units, the yard and the pound, will be derived therefrom in accordance with the Act of July 28, 1866. Indeed, this course has been practically forced upon this office for several years, but it is considered desirable to make this formal announcement for the information of all interested in the science of metrology or in measurements of precision.

T. C. MENDENHALL,
Superintendent of Standard Weights and Measures.

"Approved:
J. G. CARLISLE,
Secretary of the Treasury.
April 5, 1893."

No ratios of the yard to the metre and of the pound to the kilogramme have as yet been adopted by international agreement; but precise values of these ratios will doubtless be determined and adopted within a few years by the International Bureau of Weights and Measures. In the mean time, it will suffice for most purposes to use the values of the ratios adopted provisionally by the Office of Standard Weights and Measures of the United States. These values are —

$$1 \text{ yard} = \tfrac{3600}{3937} \text{ metres, or } 1 \text{ metre} = \tfrac{3937}{3600} \text{ yards,}$$
$$1 \text{ pound} = \tfrac{10000}{22046} \text{ kilogrammes, or } 1 \text{ kilogramme} = \tfrac{22046}{10000} \text{ pounds.}$$

These ratios were legalized by Act of Congress in 1866. Expressed decimally these values are* —

1 yard = 0.914 402 metres, 1 metre = 1.093 611 yards,
1 pound = 0.45 359 kilogrammes, 1 kilogramme = 2.20462 pounds.

The above values of the relations of the standards of the British and Metric systems of units are adopted in this work. Tables 1 and 2 give the equivalents of multiples of the standard units and also equivalents of multiples of the derived units of surface and volume. These tables are published by the Office of Standard Weights and Measures of the United States, and are here republished by permission of the Superintendent of that Office.

2. BRITISH MEASURES AND WEIGHTS.

a. Linear measures.

The unit of linear measure is the yard. Its principal sub-multiples and multiples are the inch; the foot; the rod, perch, or pole; the furlong; and the mile. The following table exhibits the relations among these measures: —

* The actual error of the relation of the yard to the metre may be as great as 1/200 000th part, and the actual error of the relation of the pound to the kilogramme as great as 1/100 000th part.

Inches.	Feet.	Yards.	Rods.	Furlongs.	Miles.
1	0.083	0.028	0.00505	0.00012626	0.0000157828
12	1.	0.333	0.06060	0.00151515	0.00018939
36	3.	1.	0.1818	0.004545	0.00056818
198	16.5	5.5	1.	0.025	0.003125
7920	660.	220.	40.	1.	0.125
63360	5280.	1760.	320.	8.	1.

Other measures are the —

Surveyor's or Gunter's chain = 4 rods = 66 feet = 100 links of 7.92 inches each.

Fathom = 6 feet; Cable length = 120 fathoms.

Hand = 4 inches; Palm = 3 inches; Span = 9 inches.

b. Surface or square measures.

The unit of square measure is the square yard. Its relations to the principal derived units in use are shown in the following table: —

Sq. feet.	Sq. yards.	Sq. rods.	Roods.	Acres.	Sq. miles.
1.	0.1111	0.00367309	0.000091827	0.000022957	
9.	1.	0.0330579	0.000826448	0.000206612	
272.25	30.25	1.	0.025	0.00625	
10890.	1210.	40.	1.	0.25	
43560.	4840.	160.	4.	1.	
27878400	3097600.	102400.	2560.	640.	1.

c. Measures of capacity.

The unit of capacity for dry measure is the bushel (2150.4 cubic inches about). The units of capacity for liquid measure are the British gallon (of 277.3 cubic inches about) and the wine gallon (of 231 cubic inches, nominally). The latter gallon is most commonly used in the United States. The following table shows the relations of the sub-multiples and multiples of the bushel and gallon: —

Dry Measures.				Liquids.				
Pint			$= \frac{1}{64}$ bushel.	Gill				$= \frac{1}{32}$ gall.
Quart	$= 2$ pints		$= \frac{1}{32}$ "	Pint	$=$	4	gills	$= \frac{1}{8}$ "
Peck	$= 8$ quarts		$= \frac{1}{4}$ "	Quart	$=$	2	pints	$= \frac{1}{4}$ "
Bushel	$= 4$ pecks		$= 1$ "	Gallon	$=$	4	quarts	$= 1$ "
				Barrel	$=$	$31\frac{1}{2}$	gallons	$= 31\frac{1}{2}$ "
				Hhd.	$=$	2	barrels	$= 63$ "

Besides the above measures of capacity the following volumetric units are used:—

Cubic foot = 1728 cubic inches.

Cubic yard = 27 cubic feet = 46656 cubic inches.

Board-measure foot = 1 square foot × 1 inch thickness = 144 cubic inches.

Perch (of masonry) = 1 perch (16.5 feet) length × 1 foot height × 1.5 feet thickness = 24.75 cubic feet; 25 cubic feet are commonly called a perch for convenience.

Cord (of wood) = 8 feet length × 4 feet breadth × 4 feet height.
= 128 cubic feet.

d. Measures of weight.

The unit of weight is the avoirdupois pound. One 7000th part of this is called a grain, and 5760 such grains make the troy pound. The sub-multiples and multiples of these two pounds are exhibited in the following table:—

Avoirdupois.			Troy.		
Dram		$= \frac{1}{256}$ lb.	Grain		$= \frac{1}{5760}$ lb.
Ounce	$= 16$ drs.	$= \frac{1}{16}$ "	Pennyweight	$= 20$ grs.	$= \frac{1}{240}$ "
Pound	$= 16$ ozs.	$= 1$ "	Ounce	$= 24$ dwt.	$= \frac{1}{12}$ "
Quarter	$= 28$ lbs.	$= 28$ "	Pound	$= 12$ ozs.	$= 1$ "
Hundred-wt.	$= 4$ qrs.	$= 112$ "			
Long ton	$= 20$ cwt.	$= 2240$ "			
Short ton	$=$	$= 2000$ "			

3. Metric Measures and Weights.

As explained in section 1 above, the standards of length and mass in the metric system are the metre and the kilogramme. Two material representatives of each of these standards are possessed by the United States and preserved at the Office of Standard Weights and Measures at Washington, D. C.

The standards of length are Prototype Metres Nos. 21 and 27. These are platinum iridium bars of X cross section, and their lengths are defined by lines ruled on their neutral surfaces. Their lengths at any temperature t Centigrade are given by the following equations: —

$$\text{Prototype No. 21} = 1^{m} + 2.^{\mu}5 + 8.^{\mu}665\,t + 0.^{\mu}00\,100\,t^2,$$
$$\text{Prototype No. 27} = 1^{m} - 1.^{\mu}6 + 8.^{\mu}657\,t + 0.^{\mu}00\,100\,t^2,$$

where the symbol μ stands for one micron, or one millionth of a metre. The probable errors of these Prototypes may be taken as not exceeding $\pm\,0.^{\mu}2$, or 1/5 000 000th of a metre for temperatures between 0° and 30° C.

The standards of mass are Prototype Kilogrammes Nos. 4 and 20. They are cylindrical masses of platinum iridium. Their masses and volumes are given by the following equations: —

	Mass.	Volume.
Prototype Kilogramme No. 4	$= 1^{kg} - 0.^{mg}075,$	$46.^{ml}418,$
Prototype Kilogramme No. 20	$= 1^{kg} - 0.^{mg}039,$	$46.^{ml}402,$

where the —

Symbol kg stands for one kilogramme,
Symbol mg stands for one milligramme $= 0.^{kg}000001$,
Symbol ml stands for one millilitre = one cubic centimetre.

The definitive probable error assigned to the Prototype Kilogrammes by the International Bureau is $\pm\,0.^{mg}002$, or 1/500 000 000th of a kilogramme.

The act of Congress approved July 28, 1866, authorizing the use of the metric system in the United States, provides that the tables in a schedule annexed shall be recognized "as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing, in customary weights and measures, the weights and measures of the metric system." The following copy of that schedule gives the denominations of the multiples and sub-multiples of the measures of length, surface, capacity, and weight in the metric system as well as their legalized equivalents in British units.

Schedule annexed to Act of July 28, 1866.

Measures of Length.

Metric Denominations.	Values in Metres.	Equivalents in Denominations in Use.
Myriametre	10000.	6.2137 miles.
Kilometre	1000.	0.62137 mile, or 3280 feet and 10 inches.
Hectometre	100.	328 feet and 1 inch.
Decametre	10.	393.7 inches.
Metre	1.	39.37 inches.
Decimetre	0.1	3.937 inches.
Centimetre	0.01	0.3937 inch.
Millimetre	0.001	0.0394 inch.

Measures of Surface.

Metric Denominations.	Values in Square Metres.	Equivalents in Denominations in Use.
Hectare	10000	2.471 acres.
Are	100	119.6 square yards.
Centare	1	1550 square inches.

Measures of Capacity.

Metric Denominations and Values.			Equivalents in Denominations in Use.	
Names.	No. of Litres.	Cubic Measure.	Dry Measure.	Liquid or Wine Measure.
Kilolitre or stere	1000.	1 cubic metre	1.308 cubic yards	264.17 gallons.
Hectolitre	100.	0.1 cubic metre	2 bus. and 3.35 pks.	26.417 gallons.
Decalitre	10.	10 cubic decimetres	9.08 quarts	2.6417 gallons.
Litre	1.	1 cubic decimetre	0.908 quart	1.0567 quarts.
Decilitre	0.1	0.1 cubic decimetre	6.1022 cubic inches	0.845 gill.
Centilitre	0.01	10 cubic centimetres	0.6102 cubic inch	0.338 fluid-ounce.
Millilitre	0.001	1 cubic centimetre	0.061 cubic inch	0.27 fluid-drachm.

Measures of Weight.

Metric Denominations and Values.			Equivalents in Denominations in Use.
Names.	Number of Grammes.	Weight of what Quantity of Water at Maximum Density.	Avoirdupois Weight.
Millier or tonneau	1000000.	1 cubic metre	2204.6 pounds.
Quintal	100000.	1 hectolitre	220.46 pounds.
Myriagramme	10000.	10 litres	22.046 pounds.
Kilogramme, or kilo	1000.	1 litre	2.2046 pounds.
Hectogramme	100.	1 decilitre	3.5274 ounces.
Decagramme	10.	10 cubic centimetres	0.3527 ounce.
Gramme	1.	1 cubic centimetre	15.432 grains.
Decigramme	0.1	0.1 cubic centimetre	1.5432 grains.
Centigramme	0.01	10 cubic millimetres	0.1543 grain.
Milligramme	0.001	1 cubic millimetre	0.0154 grain.

4. The C. G. S. System of Units.

The C. G. S. system of units is a metric system in which the fundamental units are the centimetre, the gramme, and the mean solar second. It is the system now generally used for the expression of physical quantities.

The most important of the derived units in the C. G. S. system, their equivalents in terms of ordinary units, and their dimensions in terms of the fundamental units of length, mass, and time, are given in the Appendix to this volume.

For an elaborate consideration of the subject of units and their interrelations the reader may be referred to "Units and Physical Constants," by J. D. Everett, London, Macmillan & Co., 12mo, 4th ed., 1891.

GEODESY.

1. Form of the Earth. The Earth's Spheroid. The Geoid.

The shape of the earth is defined essentially by the sea surface, which embraces about three fourths of the entire surface. The sea surface is an equipotential surface due to the attraction of the earth's mass and to the centrifugal force of its rotation. We may imagine this surface to extend through the continents, and thus to be continuous. Its position at any continental point is the height at which water would stand if a canal connected the point with the ocean.

Geodetic measurements show that this surface is represented very closely by an oblate spheroid, whose shorter axis coincides with the rotation axis of the earth. This is called the earth's spheroid. The actual sea surface, on the other hand, is called the geoid. With respect to the spheroid the geoid is a wavy surface lying partly above and partly below; but the extent of the divergence of the two surfaces is probably confined to a few hundred feet.

2. Adopted Dimensions of Earth's Spheroid.

The dimensions of the earth's spheroid here adopted are those of General A. R. Clarke, published in 1866, to wit:—

Semi major axis, $a = 20\,926\,062$ English feet.
Semi minor axis, $b = 20\,855\,121$ " "

3. Auxiliary Quantities.

The following quantities are of frequent use in geodetic formulas:—

$$e = \sqrt{\frac{a^2 - b^2}{a^2}}, \text{ the eccentricity of generating ellipse,}$$

$$f = \frac{a - b}{a}, \text{ the flattening, ellipticity, or compression,}$$

$$n = \frac{a - b}{a + b}.$$

$$b = a\sqrt{1 - e^2} = a(1 - f) = a\frac{1 - n}{1 + n}.$$

$$e^2 = 2f - f^2.$$

$$f = 1 - \sqrt{1 - e^2} = \frac{e^2}{2} + \frac{e^4}{8} + \frac{e^6}{16} + \frac{5e^8}{128} + \cdots$$

$$= \frac{2n}{1 + n} = 2(n - n^2 + n^3 - n^4 + \ldots).$$

$$n = \frac{f}{2-f} = (\tfrac{1}{2}f) + (\tfrac{1}{2}f)^2 + (\tfrac{1}{2}f)^3 + (\tfrac{1}{2}f)^4 + \dots$$

$$e^2 = \frac{4\,n}{(1+n)^2} = 4\,(n - 2\,n^2 + 3\,n^3 - 4\,n^4 + \dots).$$

$$m = \frac{e^2}{2-e^2} = \frac{e^2}{2} + \frac{e^4}{4} + \frac{e^6}{8} + \frac{e^8}{16} + \dots$$

$$n = \frac{1-\sqrt{1-e^2}}{1+\sqrt{1-e^2}} = \frac{e^2}{4} + \frac{e^4}{8} + \frac{5\,e^6}{64} + \frac{7\,e^8}{128} + \dots$$

The numerical values of the most useful of these quantities and their logarithms are —

	log
$a = 20\,926\,062$ feet,	7.3206875,
$b = 20\,855\,121$ feet,	7.3192127,
$e^2 = 0.00676866$,	7.8305030 — 10,
$m = 0.003339583$,	7.5309454 — 10,
$n = 0.00169792$,	7.2299162 — 10.

4. Equations to Generating Ellipse of Spheroid.

With the origin at the centre of the ellipse, and with its axes as coördinate axes, the equation in Cartesian co-ordinates is

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1, \qquad (1)$$

a and b being the major and minor axes respectively, and x and y being parallel to those axes respectively.

For many purposes it is useful to replace equation (1) by the two following: —

$$x = a \cos\,\theta, \quad y = b \sin\,\theta, \qquad (2)$$

which give (1) by the elimination of θ. This angle is called the reduced latitude. See section 5.

5. Latitudes used in Geodesy.

Three different latitudes are used in geodesy, namely: (1) Astronomical or geographical latitude; (2) geocentric latitude; (3) reduced latitude. The astronomical latitude of a place is the angle between the normal (or plumb line) at that place and the plane of the earth's equator; or when the plumb line at the place coincides with the normal to the generating ellipse, it is the angle between that normal and the major axis of the ellipse. The geocentric latitude of a place is the angle between the equator and a line drawn from the place to the earth's centre; or it is the angle between the radius-vector of the place and the equator. The reduced latitude is defined by equations (2) in section 4 above. The geometrical relations of these different latitudes are shown in Fig. 1 by the notation given below.

In order to express the analytical relations between the different latitudes let

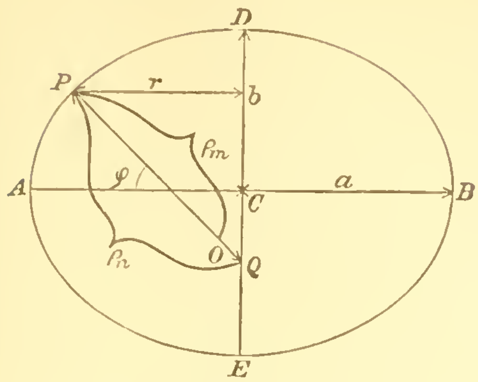


Fig. 1.

$\phi =$ the astronomical latitude,
$\psi =$ the geocentric latitude,
$\theta =$ the reduced latitude.

Then, referring to equations (1) and (2) under section 4 above, and to Fig. 1, it appears that

$$\tan\phi = -\frac{dx}{dy} = +\frac{a^2 y}{b^2 x},$$

$$\tan\psi = \frac{y}{x}, \qquad \tan\theta = \frac{ay}{bx}.$$

Hence
$$\tan\psi = \frac{b^2}{a^2}\tan\phi = (1 - e^2)\tan\phi,$$
$$\tan\theta = (1 - e^2)^{\frac{1}{2}}\tan\phi = (1 - e^2)^{-\frac{1}{2}}\tan\psi.$$

$$\phi - \psi = m\sin 2\phi - m^2\sin 4\phi + \ldots,$$
$$\phi - \theta = n\sin 2\phi - \tfrac{1}{2}n^2\sin 4\phi + \ldots.$$

For the adopted spheroid

$$\log(1 - e^2) = 9.9970504,$$

and

$$\phi - \psi \text{ (in seconds)} = 700.''44\sin 2\phi - 1.''19\sin 4\phi,$$
$$\phi - \theta \text{ (in seconds)} = 350.''22\sin 2\phi - 0.''30\sin 4\phi.$$

6. Radii of Curvature.

$\rho_m =$ radius of curvature of meridian section of spheroid at any point whose latitude is $\phi = PO$, Fig. 1,

$\rho_n =$ radius of curvature of normal section perpendicular to the meridian at the same point $= PQ$, Fig. 1,

$\rho_a =$ radius of curvature of normal section making angle α with the meridian at same point.

$$\rho_m = a(1 - e^2)(1 - e^2\sin^2\phi)^{-\frac{3}{2}},$$
$$\rho_n = a(1 - e^2\sin^2\phi)^{-\frac{1}{2}},$$
$$\frac{1}{\rho_a} = \frac{\cos^2\alpha}{\rho_m} + \frac{\sin^2\alpha}{\rho_n}$$
$$= \frac{1}{a}\left(1 + \frac{e^2}{1 - e^2}\cos^2\phi\cos^2\alpha\right)(1 - e^2\sin^2\phi)^{\frac{1}{2}}.$$

$$\log(1 - e^2\sin^2\phi)^{-\frac{1}{2}} = +\log(1 + n) - \mu\, n\cos 2\phi + \tfrac{1}{2}\mu\, n^2\cos 4\phi - \tfrac{1}{3}\mu\, n^3\cos 6\phi + \ldots.$$

$\mu =$ modulus of common logarithms and n is same as in section 3. For the adopted spheroid —

Radius of curvature of meridian section ρ_m in feet.

$$\begin{aligned}\log \rho_m = &+ 7.3199482 \\ &- [4.34482] \cos 2\phi \\ &+ [1.274] \cos 4\phi \\ &- \dots\end{aligned}$$

Radius of curvature of normal section ρ_n in feet.

$$\begin{aligned}\log \rho_n = &+ 7.3214243 \\ &- [3.86770] \cos 2\phi \\ &+ [0.797] \cos 4\phi \\ &- \dots\end{aligned}$$

The numbers in brackets in these formulas are logarithms to be added to the logarithms of cos 2ϕ and cos 4ϕ. The numbers corresponding to the sums of these logarithms will be in units of the seventh decimal place of the first constant. Thus, for $\phi = 0$,

$$\begin{aligned}\log \rho_n = &\ 7.3214243 \\ &- \quad 7373.9 \\ &+ \qquad 6.3 \\ = &\ 7.3206875 = \log a.\end{aligned}$$

7. Length of Arcs of Meridians and Parallels of Latitude.

a. Arcs of Meridian.

For the computation of short meridional arcs lying between given parallels of latitude the following simple formulas suffice:

$$\begin{aligned}\Delta\phi &= \phi_2 - \phi_1, \\ \phi &= \tfrac{1}{2}(\phi_2 + \phi_1), \\ \Delta M &= \rho_m \, \Delta\phi.\end{aligned} \qquad (1)$$

In these, ϕ_1 and ϕ_2 are the latitudes of the ends of the arc, ΔM is the required length, and ρ_m is the meridian radius of curvature for the latitude ϕ of the middle point of the arc. The formula for ΔM implies that $\Delta\phi$ is expressed in parts of the radius. If $\Delta\phi$ is expressed in seconds, minutes, or degrees of arc, the formula becomes —

Meridional distance ΔM in feet.

$$\begin{aligned}\Delta M &= \frac{\rho_m \, \Delta\phi \text{ (in seconds)}}{206264.8}, \\ &= \frac{\rho_m \, \Delta\phi \text{ (in minutes)}}{3437.747}, \\ &= \frac{\rho_m \, \Delta\phi \text{ (in degrees)}}{57.29578};\end{aligned} \qquad (2)$$

$$\begin{aligned}\log (1/206264.8) &= 4.6855749 - 10, \\ \log (1/3437.747) &= 6.4637261 - 10, \\ \log (1/57.29578) &= 8.2418774 - 10.\end{aligned}$$

$\phi_1, \phi_2 =$ end latitudes of arc, $\quad \Delta\phi = \phi_2 - \phi_1$,
$\rho_m =$ meridian radius of curvature for $\phi = \frac{1}{2}(\phi_2 + \phi_1)$; $\quad$ for log ρ_m see Table 10.

The relations (2) will answer most practical purposes when $\Delta\phi$ does not exceed 5°. A comparison with the precise formula (3) below shows in fact that the error of (2) is very nearly

$$\tfrac{1}{8}\, e^2\, \Delta\phi^2 \cos 2\phi \, . \, \Delta M,$$

which vanishes for $\phi = 45°$, and which for $\Delta\phi = 5°$ is at most $\frac{1}{155000}\,\Delta M$, or about 11 feet.

Numerical example. Suppose —

$$\phi_2 = 37°\ 29'\ 48.''17,$$
$$\phi_1 = 35°\ 48'\ 29.''89.$$

Then

$$\phi = \tfrac{1}{2}(\phi_2 + \phi_1) = 36°\ 39'\ \ 09.''03,$$
$$\Delta\phi = \ \ \phi_2 - \phi_1 = \ \ 1°\ 41'\ \ 18.''28,$$
$$= 6078.''28.$$

From the first of (2)

cons't. log	4.6855749 − 10
Table 10, log ρ_m	7.3193112
log $\Delta\phi$	3.7837807
ΔM = 614705 feet, log ΔM	5.7886668

The values of ΔM for intervals of 10″, 20″ . . . 60″, and for 10′, 20′ . . . 60′ are given in Table 17 for each degree of latitude from 0° to 90°.

For precise computation of long meridional arcs the following formula is adequate: —

$$\begin{aligned}\Delta M = A_0\,\Delta\phi &- A_1 \cos 2\phi \sin \Delta\phi \\ &+ A_2 \cos 4\phi \sin 2\Delta\phi \\ &- A_3 \cos 6\phi \sin 3\Delta\phi \\ &+ A_4 \cos 8\phi \sin 4\Delta\phi \\ &- \ldots\end{aligned} \qquad (3)$$

In this, ΔM, ϕ, and $\Delta\phi$ have the same meanings as above, and A_0, A_1, . . . are functions of a and e or of a and n.

Thus, in terms of a and n,

$$\begin{aligned}A_0 &= a\,(1+n)^{-1}\,(1 + \tfrac{1}{4}\,n^2 + \tfrac{1}{64}\,n^4 + \ldots),\\ A_1 &= 3a\,(1+n)^{-1}\,(n - \tfrac{1}{8}\,n^3 - \ldots),\\ A_2 &= \tfrac{15}{8}\,a\,(1+n)^{-1}\,(n^2 - \tfrac{1}{4}\,n^4 - \ldots),\\ A_3 &= \tfrac{35}{24}\,a\,(1+n)^{-1}\,(n^3 - \ldots),\\ A_4 &= \tfrac{315}{256}\,a\,(1+n)^{-1}\,(n^4 - \ldots).\end{aligned}$$

Introducing the adopted values of a and n, these constants become —

		log.
A_0 =	20 890 606 feet,	7.3199510,
A_1 =	106 411 feet,	5.0269880,
A_2 =	113 feet,	2.0528,
A_3 =	0.15 feet,	9.174 − 10.

It appears, therefore, that the first three terms of (3) will give ΔM with an accuracy considerably surpassing that of the constant A_0. In the use of (3) it will generally be most convenient to express $\Delta\phi$ in degrees, and in this case A_0 must be divided by the number of degrees in the radius, viz.: 57.2957795 [1.7581226]. Applying this value and writing the logarithms of A_0, A_1, etc., in rectangular brackets in place of A_0, A_1, etc., (3) becomes

Meridional distance ΔM in feet.

$$\begin{aligned}\Delta M = &[5.5618284]\ \Delta\phi \text{ (in degrees)}\\ &-[5.0269880] \cos 2\phi \sin \Delta\phi\\ &+[2.0528] \cos 4\phi \sin 2\Delta\phi\\ &-\ldots\end{aligned} \qquad (4)$$

$2\phi = \phi_2 + \phi_1$, $\Delta\phi = \phi_2 - \phi_1$, ϕ_1, ϕ_2 = end latitudes of arc.

Formula (4) will suffice for the calculation of any portion or the whole of a quadrant. The length of a quadrant is the value of the first term of (4) when $\phi = 45°$ and $\Delta\phi = 90°$, since all of the remaining terms vanish.

Numerical examples. — 1°. Suppose

$$\phi_1 = 0° \text{ and } \phi_2 = 45°.$$

Then
$$2\phi = 45°,$$
$$\Delta\phi = 45°.$$

		log.
	cons't	5.5618284
	45	1.6532125
1st term + 16 407 443 feet	1st term	7.2150409
	cos 2ϕ	9.8494850 — 10
	sin $\Delta\phi$	9.8494850 — 10
	cons't	5.0269880
2d term — 53 205.7 feet	2d term	4.7259580

The third term of the series vanishes by reason of the factor $\cos 4\phi = \cos 90° = 0$. The sum of the first two terms, or length of a meridional arc from the equator to the parallel of 45°, is 16 354 237 feet.

2°. Suppose $\phi_1 = 45°$ and $\phi_2 = 90°$.

Then
$$2\phi = 135°,$$
$$\Delta\phi = 45°.$$

The numerical values of the terms will be the same as in the previous example, but the sign of the second term will be *plus*. Hence the length of the meridional arc between the parallel of 45° and the adjacent pole is 16 460 649 feet. The sum of these two computed distances, or the length of a quadrant, is 32 814 886 feet.

This agrees as it should with the length given by (4) when $2\phi = 90°$ and $\Delta\phi = 90°$.*

b. Arcs of parallel.

The radius of any parallel of latitude is equal to the product of the radius of curvature of the normal section for the same latitude by the cosine of that latitude. That is, see FIG. 1, r being the radius of the parallel —

$$r = \rho_n \cos\phi,$$

and the entire length of the parallel is —

$$2\pi r = 2\pi\rho_n \cos\phi.$$

Designate the portion of a parallel lying between meridians whose longitudes are λ_1 and λ_2 by ΔP, and call the difference of longitude $\lambda_2 - \lambda_1$, $\Delta\lambda$.

Then —

Arc of parallel ΔP in feet.

$$\begin{aligned}\Delta P &= \frac{2\pi\rho_n\cos\phi}{1296000}\Delta\lambda \text{ (in seconds)},\\ &= \frac{2\pi\rho_n\cos\phi}{21600}\Delta\lambda \text{ (in minutes)},\\ &= \frac{2\pi\rho_n\cos\phi}{360}\Delta\lambda \text{ (in degrees)}.\end{aligned} \qquad (1)$$

$$\begin{aligned}\log(2\pi/1296000) &= 4.6855749 - 10,\\ \log(2\pi/21600) &= 6.4637261 - 10,\\ \log(2\pi/360) &= 8.2418774 - 10.\end{aligned}$$

λ_1, λ_2, = end longitudes of arc, $\Delta\lambda = \lambda_2 - \lambda_1$,

ρ_n = radius of curvature of normal section for latitude of parallel; for log ρ_n see Table 11.

Numerical Example. — Suppose $\phi = 35°$, and $\Delta\lambda = 72°$. Then from the third of (9)

		log.
cons't		8.2418774 — 10
Table 11,	ρ_n	7.3211716
	$\cos\phi$	9.9133645 — 10
	$\Delta\lambda$	1.8573325
ΔP = 21 564 827 feet,	ΔP	7.3337460

* The best formula for computing the entire length of a meridian curve is this:

$$\pi(a+b)\left(1 + \tfrac{1}{4}n^2 + \tfrac{1}{64}n^4 + \ldots\right),$$

in which a, b, and n are the same as defined in section 2. For the values here adopted —

	log.
$(1 + \frac{1}{4}n^2 + \ldots)$	0.0000003
$(a+b)$	7.6209807
π	0.4971499
length	8.1181309

The length of the perimeter of the generating ellipse, or the meridian circumference of the earth, is, therefore —

131 259 550 feet = 24 859.76 miles.

The values of ΔP for intervals of 10″, 20″ . . . 60″, and for 10′, 20′ . . . 60′ are given in Table 18 for each degree of latitude from 0° to 90°.

8. Radius-Vector of Earth's Spheroid.

$$\begin{aligned}\rho &= \text{radius-vector}\\ &= \sqrt{x^2 + y^2}\\ &= a\,(1 - 2e^2 \sin^2\phi + e^4 \sin^2\phi)^{\frac{1}{2}}\,(1 - e^2 \sin^2\phi)^{-\frac{1}{2}}.\end{aligned}$$

$$\begin{aligned}\log\rho = \log \frac{a\,(2 - e^2)}{1 + \sqrt{1 - e^2}} &+ \mu\,(m - n)\cos 2\phi\\ &- \tfrac{1}{2}\,\mu\,(m^2 - n^2)\cos 4\phi\\ &+ \tfrac{1}{3}\,\mu\,(m^3 - n^3)\cos 6\phi\\ &- \ldots\end{aligned}$$

For the adopted spheroid

$$\begin{aligned}\log(\rho \text{ in feet}) = 7.3199520 &+ [3.86769]\cos 2\phi\\ &- [1.2737]\cos 4\phi,\end{aligned}$$

the logarithms for the terms in ϕ corresponding to units of the seventh decimal place. Thus, for $\phi = 0$,

$$\begin{aligned}\log\rho &= 7.3199520\\ &+ \quad 7373.8\\ &- \quad\quad 18.8\\ &= 7.3206875 = \log a.\end{aligned}$$

9. Areas of Zones and Quadrilaterals of the Earth's Surface.

An expression for the area of a zone of the earth's surface or of a quadrilateral bounded by meridians and parallels may be found in the following manner: —

The area of an elementary zone dZ, whose middle latitude is ϕ and whose width is $\rho_m\,d\phi$, is (see Fig. 1),

$$\begin{aligned}dZ &= 2\,\pi\,r\,\rho_m\,d\phi\\ &= 2\,\pi\,\rho_m\,\rho_n \cos\phi\,d\phi.\end{aligned}$$

By means of the relations in section 6 this becomes

$$\begin{aligned}dZ &= 2\,\pi\,a^2\,(1 - e^2)\,\frac{\cos\phi\,d\phi}{(1 - e^2\sin^2\phi)^2}\\ &= 2\,\pi\,a^2\,\frac{1 - e^2}{e}\,\frac{d\,(e\sin\phi)}{(1 - e^2\sin^2\phi)^2}.\end{aligned} \qquad (1)$$

The integral of this between limits corresponding to ϕ_1 and ϕ_2, or the area of a zone bounded by parallels whose latitudes are ϕ_1 and ϕ_2 respectively, is

$$Z = \pi\,a^2\,\frac{1 - e^2}{e}\left\{\begin{aligned}&\frac{e\sin\phi_2}{1 - e^2\sin^2\phi_2} - \frac{e\sin\phi_1}{1 - e^2\sin^2\phi_1}\\ &+ \tfrac{1}{2}\,\text{Nap. log}\,\frac{(1 + e\sin\phi_2)\,(1 - e\sin\phi_1)}{(1 - e\sin\phi_2)\,(1 + e\sin\phi_1)}\end{aligned}\right\}. \qquad (2)$$

To get the area of the entire surface of the spheroid, make $\phi_1 = -\frac{1}{2}\pi$ and $\phi_2 = +\frac{1}{2}\pi$ in (2). The result is

$$\text{Surface of spheroid} = 2\pi a^2 \left[1 + \frac{1 - e^2}{2e} \text{ Nap. log} \left(\frac{1+e}{1-e}\right)\right]. \quad (3)$$

For numerical applications it is most advantageous to express (3) in a series of powers of e. Thus, by Maclaurin's theorem,

$$\text{Surface of spheroid} = 4\pi a^2 \left(1 - \frac{e^2}{3} - \frac{e^4}{15} - \frac{e^6}{35} - \ldots\right). \quad (4)$$

For the calculation of areas of zones and quadrilaterals it is also most advantageous to expand (2) in a series of powers of $e \sin\phi_1$ and $e \sin\phi_2$ and express the result in terms of multiples of the half sum and half difference of ϕ_1 and ϕ_2. Thus, (2) readily assumes the form

$$Z = 2\pi a^2 (1 - e^2) \left[(\sin\phi_2 - \sin\phi_1) + \frac{2}{3} e^2 (\sin^3\phi_2 - \sin^3\phi_1) + \ldots\right].$$

From this, by substitution and reduction, there results

$$Z = 2\pi \left\{ \begin{array}{l} C_1 \cos\phi \sin\frac{1}{2}\Delta\phi - C_2 \cos 3\phi \sin\frac{3}{2}\Delta\phi \\ + C_3 \cos 5\phi \sin\frac{5}{2}\Delta\phi - . \end{array} \right\}, \quad (5)$$

wherein

$$\begin{aligned} \phi &= \tfrac{1}{2}(\phi_2 + \phi_1), \\ \Delta\phi &= \phi_2 - \phi_1, \\ C_1 &= 2a^2 \left(1 - \frac{e^2}{2} - \frac{e^4}{8} - \frac{e^6}{16} - \ldots\right), \\ C_2 &= 2a^2 \left(\frac{e^2}{6} + \frac{e^4}{48} + 0 + \ldots\right), \quad (6) \\ C_3 &= 2a^2 \left(\frac{3e^4}{80} + \frac{e^6}{40} + \ldots\right). \end{aligned}$$

If Q be the area of a quadrilateral bounded by the parallels whose latitudes are ϕ_1 and ϕ_2 and by meridians whose difference of longitude is $\Delta\lambda$,

$$Q = \frac{\Delta\lambda}{2\pi} Z.$$

Hence, using the English mile as unit of length, (5) and (6) give for the adopted spheroid —

Area of quadrilateral in square miles.

$$Q = \Delta\lambda \text{ (in degrees)} \left\{ \begin{array}{l} c_1 \cos\phi \sin\frac{1}{2}\Delta\phi - c_2 \cos 3\phi \sin\frac{3}{2}\Delta\phi \\ + c_3 \cos 5\phi \sin\frac{5}{2}\Delta\phi - \ldots \end{array} \right\},$$

$$\begin{aligned} \log c_1{}^* &= 5.7375398, \\ \log c_2 &= 2.79173, \quad (7) \\ \log c_3 &= 9.976 - 10. \end{aligned}$$

$\phi = \frac{1}{2}(\phi_2 + \phi_1)$, $\Delta\phi = \phi_2 - \phi_1$,

ϕ_1, ϕ_2 = latitudes of bounding parallels,

$\Delta\lambda$ = difference of longitude of bounding meridians.

* c_1, c_2, c_3 are obtained from C_1, C_2, C_3 respectively by dividing the latter by the number of degrees in the radius, viz: 57.29578.

Numerical examples. — 1°. Suppose $\phi_1 = 0$, $\phi_2 = 90°$ and $\Delta\lambda = 360°$. Then (7) should give the area of a hemispheroid. The calculation runs thus :

	log.		log.		log.
c_1	5.7375398	c_2	2.79173	c_3	9.976 — 10
cos ϕ	9.8494850 — 10	cos 3 ϕ	9.84948_n — 10	cos 5 ϕ	9.849_n — 10
sin $\frac{1}{2}$ $\Delta\phi$	9.8494850 — 10	sin $\frac{3}{2}$ $\Delta\phi$	9.84949 — 10	sin $\frac{5}{2}$ $\Delta\phi$	9.848_n — 10
360	2.5563025	360	2.55630	360	2.556
Sum	7.9928123		5.04700_n		2.229

Hence —

$$
\begin{aligned}
&\text{1st term} = +\ 98358591 \\
&\text{2d term} = +\ \quad 111429 \\
&\text{3d term} = +\ \qquad 169 \\
Q = \ &\text{sum} = \quad 98470189
\end{aligned}
$$

Twice this is the area of the spheroidal surface of the earth ; *i. e.*, 196 940 378 square miles.

2°. The last result may be checked by (4). Thus,

$$
\begin{aligned}
&\left(\frac{e^2}{3} + \frac{e^4}{15} + \ldots\right) &&= 0.00225928 \\
&\log\left(1 - \frac{e^2}{3} - \ldots\right) &&= 9.9990177 \\
&\log a^2 &&= 7.1961072 \\
&\log 4\,\pi &&= 1.0992099 \\
&\log(196940407) &&= 8.2943348
\end{aligned}
$$

This number agrees with the number derived above as closely as 7-place logarithms will permit, the discrepancy between the two values being about $\frac{1}{6000000}$ part of the area. Hence, with a precision somewhat greater than the precision of the elements of the adopted spheroid warrants,

Area earth's surface = 196 940 400 square miles.

The areas of quadrilaterals of the earth's surface bounded by meridians and parallels of 1°, 30′, 15′, and 10′ extent respectively, in latitude and longitude, are given in Tables 25 to 29.

10. Spheres of Equal Volume and Equal Surface with Earth's Spheroid.

r_1 = radius of sphere having same volume as the earth's spheroid,
r_2 = radius of sphere having same surface as that spheroid.

$$
\begin{aligned}
r_1 &= \sqrt[3]{a^2 b} \\
&= a\left(1 - \tfrac{1}{6}e^2 - \tfrac{5}{72}e^4 - \tfrac{55}{1296}e^6 - \ldots\right).
\end{aligned}
$$

$$r_2 = a\left(1 - \frac{e^2}{3} - \frac{e^4}{15} - \frac{e^6}{35} - \dots\right)^{\frac{1}{2}}$$

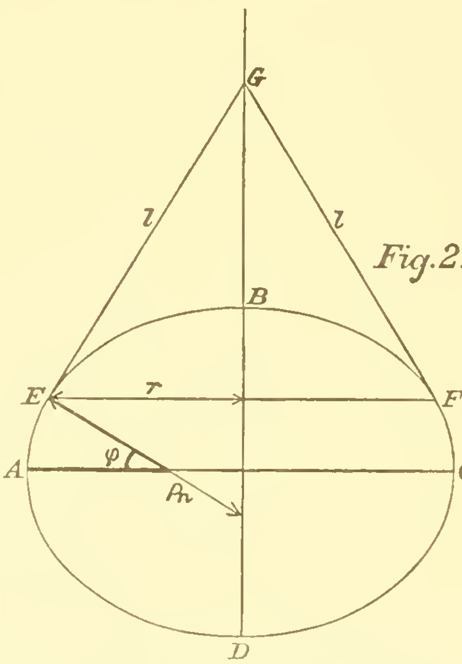
$$= a\left(1 - \tfrac{1}{6}e^2 - \tfrac{17}{360}e^4 - \tfrac{67}{3024}e^6 - \dots\right).$$

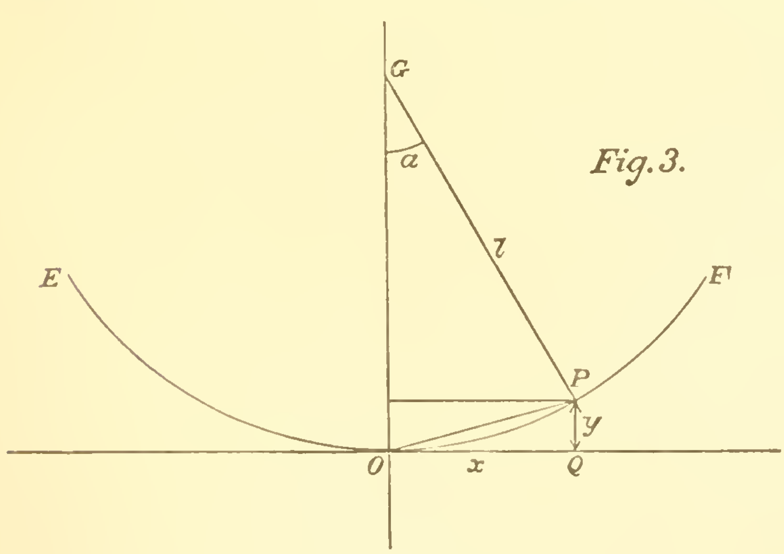
$$a - r_1 = \tfrac{1}{6}ae^2\left(1 + \tfrac{5}{12}e^2 + \dots\right) = 0.00113\,a, \text{ about.}$$

$$r_2 - r_1 = \tfrac{1}{45}ae^4 + \dots = 0.000001\,a, \text{ about.}$$

11. Co-ordinates for the Polyconic Projection of Maps.

In the polyconic system of map projection every parallel of latitude appears on the map as the developed circumference of the base of a right cone tangent to the spheroid along that parallel. Thus the parallel EF (Fig. 2) will appear in projection as the arc of a circle EOF (Fig. 3) whose radius $OG = l$ is equal to the slant height of the tangent cone EFG (Fig. 2). Evidently one meridian and only one will appear as a straight line. This meridian is generally made the central meridian of the area to be projected. The distances along this central meridian between consecutive parallels are made equal (on the scale of the map) to the real distances along the surface of the spheroid. The circles in which the parallels are developed are not concentric, but their centres all lie on the central meridian. The meridians are concave toward the central meridian, and, except near the corners of maps showing large areas, they cross the parallels at angles differing little from right angles.





In the practical work of map making, the meridians and parallels are most advantageously defined by the co-ordinates of their points of intersection. These co-ordinates may be expressed in the following manner: For any parallel, as EOF (Fig. 3), take the origin O at the intersection with the central meridian, and let the rectangular axes of Y (OG) and X (OQ) be respectively coincident with and perpendicular to this meridian. Call the interval in longitude between the central meridian and the next adjacent one $\Delta\lambda$, and denote the angle at the centre G subtended by the developed arc OP by α.

Then from FIG. 3 it appears that

$$x = l \sin \alpha,$$
$$y = 2\, l \sin^2 \tfrac{1}{2}\alpha.$$

But from FIGS. 2 and 3,

$$l = \rho_n \cot \phi,$$
$$l\alpha = r\, \Delta\lambda = \rho_n\, \Delta\lambda \cos \phi,$$

whence

$$\alpha = \Delta\lambda \sin \phi.$$

Hence, in terms of known quantities there result

$$x = \rho_n \cot \phi \sin (\Delta\lambda \sin \phi),$$
$$y = 2\, \rho_n \cot \phi \sin^2 \tfrac{1}{2} (\Delta\lambda \sin \phi). \qquad (1)$$

Numerical example. — Suppose $\phi = 40°$ and $\Delta\lambda = 25° = 90000''$.

Then

$$\log 90000'' = 4.9542425,$$
$$\log \sin 40° = 9.8080675 - 10,$$
$$\log 57850.''88 = 4.7623100;$$
$$\Delta\lambda \sin \phi = 16° \; 04' \; 10.''88,$$
$$\tfrac{1}{2} (\Delta\lambda \sin \phi) = 8° \; 02' \; 05.''44.$$

	log.		log.
$\sin (\Delta\lambda \sin \phi)$	9.4421760 — 10	$\sin \frac{1}{2} (\Delta\lambda \sin \phi)$	9.1454305 — 10
$\cot \phi$	0.0761865	$\sin \frac{1}{2} (\Delta\lambda \sin \phi)$	9.1454305 — 10
ρ_n, Table 11	7.3212956	$\cot \phi$	0.0761865
		ρ_n, Table 11	7.3212956
		2	0.3010300
x	6.8396581	y	5.9893731
	$x = 6\,912\,865$ feet	$y = 975\,828$ feet.	

The equations (1) are exact expressions for the co-ordinates. But when $\Delta\lambda$ is small, one may use the first terms in the expansions of $\sin (\Delta\lambda \sin \phi)$ and $\sin^2 \frac{1}{2}(\Delta\lambda \sin \phi)$ and reach results of a much simpler form.

Thus,

$$\sin (\Delta\lambda \sin \phi) = \Delta\lambda \sin \phi - \tfrac{1}{6}(\Delta\lambda \sin \phi)^3 + \ldots,$$
$$\sin^2 \tfrac{1}{2}(\Delta\phi \sin \phi) = \tfrac{1}{4}(\Delta\lambda \sin \phi)^2 - \tfrac{1}{48}(\Delta\lambda \sin \phi)^4 + \ldots;$$

whence, to terms of the second order,

$$x = \rho_n\, \Delta\lambda \cos \phi \, [1 - \tfrac{1}{6}(\Delta\lambda \sin \phi)^2],$$
$$y = \tfrac{1}{4}\, \rho_n\, (\Delta\lambda)^2 \sin 2\phi \, [1 - \tfrac{1}{12}(\Delta\lambda \sin\phi)^2]. \qquad (2)$$

If the terms of the second order in these equations be neglected, the value of x will be too great by an amount somewhat less than $\frac{1}{6}(\Delta\lambda \sin \phi)^2 \cdot x$, and the value of y will be too great by an amount somewhat less than $\frac{1}{12}(\Delta\lambda \sin \phi)^2 \cdot y$. An idea of the magnitudes of these fractions of x and y may be gained from the following table, which gives the values of $\frac{1}{6}(\Delta\lambda \sin \phi)^2$ for a few values of the arguments $\Delta\lambda$ and ϕ.

Values of $\frac{1}{6}(\Delta\lambda \sin \phi)^2$.

$\Delta\lambda$	ϕ		
	20°	40°	60°
0			
1	1/168000	1/47700	1/26260
2	1/42000	1/11900	1/6560
3	1/18700	1/5300	1/2920

It appears from this table that the first terms of (2) will suffice in computing the co-ordinates for projection of all maps on ordinary scales, and of less extent in longitude than 2° from the middle meridian. For example, the value of x for $\Delta\lambda = 2°$, and $\phi = 40°$, and for a scale of two miles to one inch (1/126720), is 53.063 inches less 1/11900 part, or about 0.004 inch, which may properly be regarded as a vanishing quantity in map construction. For the computation of the co-ordinates given in the tables 19 to 24, where $\Delta\lambda$ does not exceed 1°, it is amply sufficient, therefore, to use

$$x = \rho_n \, \Delta\lambda \cos \phi,$$
$$y = \tfrac{1}{4} \rho_n \, (\Delta\lambda)^2 \sin 2\phi. \qquad (3)$$

In these formulas and in (2), if $\Delta\lambda$ is expressed in seconds, minutes, or degrees, it must be divided by the number of seconds, minutes, or degrees in the radius. The logarithms of the reciprocals of these numbers are given on p. xlvi. In the construction of tables like 19 to 24, it is most convenient, when English units are used, to express $\Delta\lambda$ in minutes and x and y in inches. For this purpose, supposing log ρ_n to be taken from Table 11, if s be the scale of the map, or scale factor, equations (3) become —

Co-ordinates x and y in inches for scale s.

$$x = \frac{12}{3437 \cdot 747} \rho_n \, s \, \Delta\lambda \cos \phi,$$

$$y = \frac{3}{(3437 \cdot 747)^2} \rho_n \, s \, (\Delta\lambda)^2 \sin 2\phi,$$

$$\Delta\lambda \text{ in minutes}; \qquad (4)$$

$$\log (12/3437 \cdot 747) = 7.54291 - 10,$$
$$\log (3/(3437 \cdot 747)^2) = 3.4046 - 10.$$

Tables 19 to 24 give the values of x and y for various scales and for the zone of the earth's surface lying between 0° and 80°.

Numerical example. — Suppose $\phi = 40°$ and $\Delta\lambda = 15'$; and let the scale of the map be one mile to the inch, or $s = 1/63360$. Then the calculation by (4) runs thus :

log.		log.	
cons't	7.54291 — 10	cons't	3.4046 — 10
ρ_n	7.32130	ρ_n	7.3213
s	5.19818 — 10	s	5.1982 — 10
15	1.17609	$(15)^2$	2.3522
cos ϕ	9.88425 — 10	sin 2ϕ	9.9934 — 10
x	1.12273	y	8.2697 — 10
	In.		In.
$x =$	13.266	$y =$	0.01861.

These values of x and y, it will be observed, agree with those corresponding to the same arguments in Table 22.

When many values for the same scale are to be computed, log s should, of course, be combined with the constant logarithms of (4). Moreover, since in (4) x varies as $\Delta\lambda$ and y as $(\Delta\lambda)^2$, when several pairs of co-ordinates are to be computed for the same latitude, it will be most advantageous to compute the pair corresponding to the greatest common divisor of the several values of $\Delta\lambda$ and derive the other pairs by direct multiplication.

12. Lines on a Spheroid.

The most important lines on a spheroid used in geodesy are (*a*) the curve of a vertical section; (*b*) the geodesic line; and (*c*) the alignment curve. Imagine two points in the surface of a spheroid, and denote them by P_1 and P_2 respectively. The vertical plane at P_1 containing P_2 and the vertical plane at P_2 containing P_1 give vertical section curves or lines. The curves cut out by these two planes coincide only when P_1 and P_2 are in a meridian plane. The geodesic line is the shortest line joining P_1 and P_2, and lying in the surface of the spheroid. The alignment curve on a spheroid is a curve whose vertical tangent plane at every point of its length contains the terminal points P_1 and P_2. The curve (*a*) lies wholly in one plane, while (*b*) and (*c*) are curves of double curvature. In the case of a triangle formed by joining three points on a spheroid by lines lying in its surface, the curves of class (*a*) give two distinct sets of triangle sides, while the curves of classes (*b*) and (*c*) give but one set of sides each. For all intervisible points on the surface of the earth, these different lines differ immaterially in length; the only appreciable differences they present are in their azimuths (see formula under b below). Of the three classes of curves the first two only are of special importance.

a. Characteristic property of curves of vertical section.

Let $\alpha_{1.2}$ = azimuth of vertical section at P_1 through P_2,
$\alpha_{2.1}$ = azimuth of vertical section at P_2 through P_1,
θ_1, θ_2 = reduced latitudes of P_1 and P_2 respectively,
δ_1, δ_2 = angles of depression at P_1 and P_2 respectively of the chord joining these points.

Then the characteristic property of the vertical section curve joining P_1 and P_2 is

$$\sin \alpha_{1.2} \cos \theta_1 \cos \delta_1 = \sin (\alpha_{2.1} - 180^\circ) \cos \theta_2 \cos \delta_2.$$

The azimuths $\alpha_{1.2}$ and $\alpha_{2.1}$, it will be observed, are the astronomical azimuths, or the azimuths which would be determined astronomically by means of an altitude and azimuth instrument.

b. Characteristic property of geodesic line.

Let $\alpha'_{1.2}$ = azimuth of geodesic line at P_1,
$\alpha'_{2.1}$ = azimuth of geodesic line at P_2,
θ_1, θ_2 = reduced latitudes of P_1 and P_2 respectively.

Then the characteristic property of the geodesic line is

$$\sin \alpha_{1.2} \cos \theta_1 = \sin (180° - \alpha_{2.1}) \cos \theta_2 = \cos \theta_0,$$

where θ_0 is the reduced latitude of the point where the geodesic through P_1 and P_2 is at right angles to a meridian plane.

The difference between the astronomical azimuth $\alpha_{1.2}$ and the geodesic azimuth $\alpha'_{1.2}$ is expressed by the following formula:

$$\alpha_{1.2} - \alpha'_{1.2} \text{ (in seconds)} = \tfrac{1}{12} \rho'' e^2 \left(\frac{s}{a}\right)^2 \cos^2 \phi \sin 2\alpha_{1.2},$$

where s = length of geodesic line $P_1 P_2$,
a = major semi-axis of spheroid,
e = eccentricity of spheroid,
ρ'' = 206264.''8,
ϕ = astronomical latitude of P_1,
$\alpha_{1.2}$ = azimuth (astronomical or geodesic) of $P_1 P_2$,

$$\log \tfrac{1}{12} \rho'' \left(\frac{e}{a}\right)^2 = 7.4244 - 20, \text{ for } a \text{ in feet.}$$

Thus, for $\phi = 0$ and $\alpha_{1.2} = 45°$, for which $\cos^2 \phi \sin 2\alpha_{1.2} = 1$, the above formula gives

$$\begin{aligned} \alpha_{1.2} - \alpha'_{1.2} &= 0.''074, \text{ for } s = 100 \text{ miles}, \\ &= 0.296, \text{ for } s = 200 \text{ miles}, \\ &= \ldots; \end{aligned}$$

so that for most geodetic work this difference is of little if any importance.

13. Solution of Spheroidal Triangles.

The data for solution of a spheroidal triangle ordinarily presented are the measured angles and the length of one side. This latter may be either a geodesic line or a vertical section curve, since their lengths are in general sensibly equal. Such triangles are most conveniently solved in accordance with the rule afforded by Legendre's theorem, which asserts that the sides of a spheroidal triangle (of any measurable size on the earth) are sensibly equal to the sides of a plane triangle having a base of the same length and angles equal respectively to the spheroidal angles diminished each by one third of the excess of the spheroidal triangle. In other words, the computation of spheroidal triangles is thus made to depend on the computation of plane triangles.

a. Spherical or spheroidal excess.

The excess of a spheroidal triangle of ordinary extent on the earth is given by

$$\epsilon \text{ (in seconds)} = \rho'' \frac{S}{\rho_m \, \rho_n},$$

where S is the area of the spheroidal or corresponding plane triangle; ρ_m, ρ_n are the principal radii of curvature for the mean latitude of the vertices of the triangle; and $\rho'' = 206\,264.''8$. For a sphere, $\rho_m = \rho_n =$ radius of the sphere.

Denote the angles of the spheroidal triangle by A, B, C, respectively; the corresponding angles of the plane triangle by α, β, γ (as on p. xviii); and the sides common to the two triangles by a, b, c. Then

$$S = \tfrac{1}{2}\, ab \sin \gamma = \tfrac{1}{2}\, bc \sin \alpha = \tfrac{1}{2}\, ca \sin \beta.$$

$$\alpha = A - \tfrac{1}{3}\,\epsilon, \qquad \beta = B - \tfrac{1}{3}\,\epsilon, \qquad \gamma = C - \tfrac{1}{3}\,\epsilon.$$

Tables 13 and 14 give the values of $\log(\rho''/2\rho_m\rho_n)$ for intervals of 1° of astronomical or geographical latitude.*

14. Geodetic Differences of Latitude, Longitude, and Azimuth.

a. Primary triangulation.

Denote two points on the surface of the earth's spheroid by P_1 and P_2 respectively. Let

$s =$ length of geodesic line joining P_1 and P_2,
ϕ_1, $\phi_2 =$ astronomical latitudes of P_1 and P_2,
λ_1, $\lambda_2 =$ longitudes of P_1 and P_2,
$\Delta\lambda = \lambda_2 - \lambda_1$,
$\alpha_{1.2} =$ azimuth of $P_1 P_2$ (s) at P_1,
$\alpha_{2.1} =$ azimuth of $P_2 P_1$ (s) at P_2,
$e =$ eccentricity of spheroid,
ρ_m, $\rho_n =$ principal (meridian and normal) radii of curvature at the point P_1.

Then for the longest sides of measurable triangles on the earth the following formulas will give ϕ_2, λ_2, and $\alpha_{2.1}$ in terms of ϕ_1, λ_1, $\alpha_{1.2}$, and s. The azimuths are astronomical, and are reckoned from the south by way of the west through 360°.

$$\begin{aligned} \alpha' &= 180° - \alpha_{1.2}, \quad \text{and } \alpha_{2.1} = 180° + \alpha'', \quad \text{for } \alpha_{1.2} < 180° \\ \alpha' &= \alpha_{1.2} - 180°, \quad \text{and } \alpha_{2.1} = 180° - \alpha'', \quad \text{for } \alpha_{1.2} > 180° \end{aligned} \qquad (1$$

$$\eta = \frac{s}{\rho_n} \left\{ 1 + \tfrac{1}{6} \frac{e^2}{1-e^2} \left(\frac{s}{\rho_n}\right)^2 \cos^2 \phi_1 \cos^2 \alpha' \right\} \qquad (2)$$

$$\zeta = \tfrac{1}{4} \frac{e^2\,\eta^2}{1-e^2} \cos^2 \phi_1 \sin 2\alpha' \qquad (3)$$

* For the solution of very large triangles and for a full treatment of the theory thereof, consult *Die Mathematischen und Physikalischen Theorieen der Höheren Geodäsie*, von Dr. F. R. Helmert. Leipzig, 1880, 1884.

$$\tan \tfrac{1}{2}(\alpha'' + \Delta\lambda + \zeta) = \frac{\cos \tfrac{1}{2}(90^\circ - \phi_1 - \eta)}{\cos \tfrac{1}{2}(90^\circ - \phi_1 + \eta)} \cot \tfrac{1}{2} \alpha'$$

$$\tan \tfrac{1}{2}(\alpha'' - \Delta\lambda + \zeta) = \frac{\sin \tfrac{1}{2}(90^\circ - \phi_1 - \eta)}{\sin \tfrac{1}{2}(90^\circ - \phi_1 + \eta)} \cot \tfrac{1}{2} \alpha' \qquad (4)$$

$$\phi_2 - \phi_1 = \frac{s}{\rho_m} \frac{\sin \tfrac{1}{2}(\alpha'' - \alpha' + \zeta)}{\sin \tfrac{1}{2}(\alpha'' + \alpha' + \zeta)} \{1 + \tfrac{1}{12} \eta^2 \cos^2 \tfrac{1}{2}(\alpha'' - \alpha')\}. \qquad (5)$$

To express η, ζ, and $\phi_2 - \phi_1$ in seconds of arc we must multiply the right hand sides of (2), (3), and (5) by $\rho'' = 206\,264.''8$. For logarithmic compution of η'' and ζ'', or η and ζ in seconds, we may write with an accuracy generally sufficient

$$\log \eta'' = \log (\rho'' s/\rho_n) + \tfrac{1}{6} \frac{\mu e^2}{1 - e^2} \left(\frac{s}{\rho_n}\right)^2 \cos^2 \phi_1 \cos^2 \alpha', \qquad (6)$$

$$\log \zeta'' = \log \tfrac{1}{4} \frac{e^2}{(1 - e^2) \rho''} + \log \{(\eta'')^2 \cos^2 \phi_1 \sin 2 \alpha'\}, \qquad (7)$$

where μ in (6) is the modulus of common logarithms. For units of the 7th decimal place of $\log \eta''$ we have for the adopted spheroid

$$\log \tfrac{1}{6} \frac{\mu e^2}{1 - e^2} = 3.69309.$$

Also

$$\log \tfrac{1}{4} \frac{e^2}{(1 - e^2)\rho'} = 1.91697 - 10.$$

Similarly, for the computation of the logarithm of the last factor in (5) we have

$$\log \{1 + \tfrac{1}{12} \eta^2 \cos^2 \tfrac{1}{2}(\alpha'' - \alpha')\} = \log \{1 + \frac{1}{12(\rho'')^2} (\eta'')^2 \cos^2 \tfrac{1}{2}(\alpha'' - \alpha')\}.$$

Putting for brevity

$$q = \frac{1}{12(\rho'')^2} (\eta'')^2 \cos^2 \tfrac{1}{2}(\alpha'' - \alpha')$$

the logarithm of the desired logarithm is given to terms of the second order inclusive in q by

$$\log \log (1 + q) = \log \mu q - \tfrac{1}{2} \mu q.$$

For the adopted spheroid

$$\log \frac{\mu}{12(\rho'')^2} = 4.92975 - 10$$

for units of the seventh decimal place.

For a line 200 miles (about 320 kilometres) long, the maximum value of the second term in (6) is but 12.6 units in the 7th place of $\log \eta''$. For the same length of line, the maximum value of ζ'' is 0.''895, and the maximum value of the logarithm of the last factor in (5), or $\log (1 + q)$, is less than 922 units in the seventh place of decimals.

For computing differences of latitude, longitude, and azimuth in primary triangulation whose sides are 1° (about 70 miles, or 100 kilometres) or less in length, the most convenient means are formulas giving $\phi_2 - \phi_1$, $\lambda_2 - \lambda_1$, and

$\alpha_{2.1} - (180^\circ - \alpha_{1.2})$, in series proceeding according to powers of the distance s. Formulas of this kind with convenient tables for facilitating the computations are given in the Reports of the U. S. Coast and Geodetic Survey.*

b. Secondary triangulation.

For secondary triangulation, wherein the sides are 12 miles (20 kilometres) or less in length, and wherein differences of latitude and longitude are needed to the nearest hundredth of a second only, the following formulas may suffice. Using the same notation as in the preceding section, the formulas are : —

$$\begin{aligned} \phi_2 &= \phi_1 + \Delta\phi, \\ \lambda_2 &= \lambda_1 + \Delta\lambda, \\ \alpha_{2.1} &= 180^\circ + \alpha_{1.2} + \Delta\alpha, \end{aligned} \tag{1}$$

$$\begin{aligned} \Delta\phi &= - \quad a_1\, s \cos \alpha_{1.2} - a_2\, s^2 \sin^2 \alpha_{1.2}, \\ \Delta\lambda &= + b_1 \sec \phi_1\, s \sin \alpha_{1.2} - b_2\, s^2 \sin \alpha_{1.2} \cos \alpha_{1.2}, \\ \Delta\alpha &= - c_1 \tan \phi_1\, s \sin \alpha_{1.2} + c_2\, s^2 \sin \alpha_{1.2} \cos \alpha_{1.2}. \end{aligned} \tag{2}$$

The constants entering the latter equations are defined by the following expressions, wherein ρ_m and ρ_n are the principal radii of curvature of the spheroid at the point whose latitude is ϕ_1 and $\rho'' = 206\,264.''8$:

$$a_1 = \frac{\rho''}{\rho_m}, \qquad b_1 = c_1 = \frac{\rho''}{\rho_n},$$

$$a_2 = \frac{\rho'' \tan \phi_1}{2\, \rho_m\, \rho_n}, \qquad b_2 = \frac{\rho'' \sec \phi_1 \tan \phi_1}{\rho_n^2}, \qquad c_2 = \frac{\rho''(1 + 2 \tan^2 \phi_1)}{2\, \rho_n^2}.$$

The logarithms of the factors a_1, b_1, c_1, a_2, b_2, c_2, are given in Table 15 for the English foot as unit, and in Table 16 for the metre as unit, the argument being the initial latitude ϕ_1 for all of them.

When all of the differences given by (2) are computed, they may be checked by the formula

$$\sin \tfrac{1}{2}(\phi_2 + \phi_1) = \frac{\Delta\alpha}{\Delta\lambda}. \tag{3}$$

For convenience of reference in numerical applications of the above formulas, (2) may be written thus :

$$\begin{aligned} \Delta\phi &= A_1 + A_2, \\ \Delta\lambda &= B_1 + B_2, \\ \Delta\alpha &= C_1 + C_2, \end{aligned}$$

in which, for example, A_1 and A_2 are the first and second terms respectively of $\Delta\phi$, due regard being paid to the signs of the functions of $\alpha_{1.2}$.

Numerical example. The following example will serve to illustrate the use of formulas (1) to (3). The value of log s is for s in English feet, s being in this case about 12.3 miles.

ϕ_1	38° 54′ 08.″38	λ_1	88° 03′ 24.″15	$\alpha_{1.2}$	43° 01′ 46.″29
$\Delta\phi$	−07′ 50.″21	$\Delta\lambda$	+09′ 20.″22	$\Delta\alpha$	−05′ 51.″32
ϕ_2	38° 46′ 18.″17	λ_2	88° 12′ 44.″37	$\alpha_{2.1}$	222° 55′ 54.″97
$\frac{1}{2}(\phi_2 + \phi_1)$	38° 50′ 13.″27				

* See Appendix 7, Report of 1884, for latest edition of these tables.

	log		log		log		log
s	4.81308	s	4.81308	$s \sin \alpha_{1.2}$	4.647	$s \sin \alpha_{1.2}$	4.647
$\cos \alpha_{1.2}$	9.86392	$\sin \alpha_{1.2}$	9.83402	$s \sin \alpha_{1.2}$	4.647	$s \cos \alpha_{1.2}$	4.677
a_1	7.99495	$\sec \phi_1$	0.10890	a_2	0.279	b_2	0.688
		b_1	7.99316			c_2	0.733
A_1	2.67195	B_1	2.74916	A_2	9.573	B_2	0.012
		$\sin \phi_1$	9.79795			C_2	0.057
		C_1	2.54711				

							log
A_1	$-469.''84$	B_1	$+561.''25$	C_1	$-352.''46$	$\Delta\alpha$	2.54570
A_2	$-0.''37$	B_2	$-1.''03$	C_2	$+1.''14$	$\Delta\lambda$	2.74836
$\Delta\phi$	$-470.''21$	$\Delta\lambda$	$+560.''22$	$\Delta\alpha$	$-351.''32$	$\sin \frac{1}{2}(\phi_2 + \phi_1)$	9.79734

15. Trigonometric Leveling.

a. Computation of heights from observed zenith distances.

Let s = sea level distance between two points P_1 and P_2,

H_1, H_2 = heights above sea level of P_1 and P_2,

z_1 = observed zenith distance of P_2 from P_1,

z_2 = observed zenith distance of P_1 from P_2,

ρ = radius of curvature of vertical section at P_1 through P_2, or at P_2 through P_1, the curvature being sensibly the same for both for this purpose,

C = angle at centre of curvature subtended by s,

m_1, m_2 = coefficients of refraction at P_1 and P_2,

$\Delta z_1, \Delta z_2$ = angles of refraction at P_1 and P_2.

Then, the fundamental relations are

$$C = \frac{s}{\rho}, \qquad \Delta z_1 = m_1 C, \qquad \Delta z_2 = m_2 C, \qquad (1)$$

$$z_1 + z_2 + \Delta z_1 + \Delta z_2 = 180^\circ + C,$$

$$H_2 - H_1 = s \tan \tfrac{1}{2}(z_2 + \Delta z_2 - z_1 - \Delta z_1)\left(1 + \frac{H_2 + H_1}{2\rho} + \frac{s^2}{12\rho^2} + \ldots\right). \qquad (2)$$

When the zenith distances z_1 and z_2 are simultaneous, or when Δz_1 and Δz_2 are assumed to be equal, (2) becomes

$$H_2 - H_1 = s \tan \tfrac{1}{2}(z_2 - z_1)\left(1 + \frac{H_2 + H_1}{2\rho} + \frac{s^2}{12\rho^2} + \ldots\right). \qquad (3)$$

For the case of a single observed zenith distance z_1, say, and a known or assumed value of $m = m_1 = m_2$, the following formula may be applied :

$$H_2 - H_1 = s \cot z_1 + \frac{1 - 2m}{2\rho} s^2 + \frac{1 - m}{\rho} s^2 \cot^2 z_1. \qquad (4)$$

The coefficient of refraction m varies very greatly under different atmospheric conditions. Its average value for land lines is about 0.07. The following table gives the values of $\log \frac{1}{2}(1 - 2m)$ and $\log (1 - m)$ for values of m ranging from 0.05 to 0.10. It is taken from Appendix 18, Report of U. S. Coast and Geodetic

Survey for 1876. Table 12 taken from the same source gives values of log ρ needed for use in (3) and (4).

Table of values of log $\frac{1}{2}(1 - 2m)$ and log $(1 - m)$.

m	log $\frac{1}{2}(1 - 2m)$.	log $(1 - m)$.	m	log $\frac{1}{2}(1 - 2m)$.	log $(1 - m)$.
0.050	9.65321	9.978	0.075	9.62839	9.966
51	65225	77	76	62737	66
52	65128	77	77	62634	65
53	65031	76	78	62531	65
54	64933	76	79	62428	64
0.055	9.64836	9.975	0.080	9.62325	9.964
56	64738	75	81	62221	63
57	64640	75	82	62118	63
58	64542	74	83	62014	62
59	64444	74	84	61910	62
0.060	9.64345	9.973	0.085	9.61805	9.961
61	64246	73	86	61700	61
62	64147	72	87	61595	60
63	64048	72	88	61490	60
64	63949	71	89	61384	60
0.065	9.63849	9.971	0.090	9.61278	9.959
66	63749	70	91	61172	59
67	63649	70	92	61066	58
68	63548	69	93	60959	58
69	63448	69	94	60853	57
0.070	9.63347	9.968	0.095	9.60746	9.957
71	63246	68	96	60638	56
72	63144	68	97	60531	56
73	63043	67	98	60423	55
74	62941	67	99	60315	55
			0.100	9.60206	9.954

For less precise work one may use equation (4) in the form

$$H_2 - H_1 = s \cot z_1 + c\, s^2, \qquad (5)$$

wherein, if we make $m = 0.07$ and use for ρ its average value, or $\sqrt{\rho_m \rho_n}$ for latitude 45°,

$$\log c = 2.313 - 10 \text{ for } s \text{ in feet,}$$
$$= 2.829 - 10 \text{ for } s \text{ in metres.}$$

Thus, for a distance (s) of 10 miles the value of the term $c\, s^2$ in (5) is 57.3 feet.

If altitudes a_1, say, are observed in the place of zenith distances z_1, it is most convenient to write (5) thus: —

$$H_2 - H_1 = \pm\, s \tan a_1 + c\, s^2, \qquad (6)$$

where the upper sign is used when α_1 is an angle of elevation and the lower sign when α_1 is an angle of depression.

b. Coefficients of refraction.

When z_1 and z_2 are both observed for a given line, a coefficient of refraction may be computed from the assumption of equality of coefficients at the two ends of the line. Thus, equations (1) give

$$\Delta z_1 + \Delta z_2 = 180^\circ + C - (z_1 + z_2),$$

or

$$(m_1 + m_2)\frac{s}{\rho} = 180^\circ + \frac{s}{\rho} - (z_1 + z_2),$$

whence

$$m_1 + m_2 = 1 - \frac{\rho}{s}(z_1 + z_2 - 180^\circ).$$

Assuming $m_1 = m_2 = m$, and supposing $z_1 + z_2 - 180^\circ$ expressed in seconds of arc,

$$m = \frac{1}{2}\left\{1 - \frac{\rho}{s\rho''}(z_1 + z_2 - 180^\circ)\right\}.$$

$$\rho'' = 206264.''8, \qquad \log \rho'' = 5.3144251.$$

c. Dip and distance of sea horizon.

Let

h = height of eye above sea level,
δ = dip or angle of depression of horizon,
s = distance of horizon from observer.

Then

$$\delta \text{ (in seconds)} = 58.82\sqrt{h \text{ in feet}},$$
$$= 106.54\sqrt{h \text{ in metres}}.$$

$$s \text{ (in miles)} = 1.317\sqrt{h \text{ in feet}},$$
$$s \text{ (in kilometres)} = 3.839\sqrt{h \text{ in metres}}.$$

The above formulas take account of curvature and refraction. They depend on the value 0.0784 for the coefficient of refraction, and are quite as accurate as the uncertainties in such data justify. For convenience of memory, and for an accuracy amply sufficient in most cases, the coefficients of the radicals in the last two formulas may be written $\frac{4}{3}$ and $\frac{1}{3}^{0}$ respectively.

16. Miscellaneous Formulas.

a. Correction to observed angle for eccentric position of instrument

Let C' be the eccentric position of the instrument, and C_0 the observed value of the angle at that point between two other points A and B. Let C denote the central point as well as the angle ACB desired. Call the distance CC' r and denote the angle ACC' by θ. Denote the lines BC and AC, which are assumed to be sensibly the same as BC' and AC', by a and b respectively. Then

$$C - C_0 \text{ (in seconds)} = \frac{\rho'' r \sin(\theta - C_0)}{a} - \frac{\rho'' r \sin\theta}{b},$$

$$\rho'' = 206\,264.''8, \qquad \log \rho'' = 5.3144251.$$

Attention must be paid to the signs of $\sin(\theta - C_0)$ and $\sin\theta$, and to the fact that angles are counted from A towards B through 360°. A diagram drawn in accordance with the above specifications will elucidate any special case.

b. Reduction of measured base to sea level.

Let l be the length of the bar, tape or other unit used in measuring the base. Let l_0 be the corresponding length reduced to sea level for a height h, this latter being the observed height of l. Then if ρ denote the radius of curvature of the earth's surface in the direction of the base,

$$l_0 = \frac{\rho l}{\rho + h} = \left(1 - \frac{h}{\rho} + \ldots\right) l$$

with sufficient accuracy. Hence, for the whole length of the base,

$$\Sigma l_0 = \Sigma l - \frac{1}{\rho} \Sigma lh.$$

If L denote the total measured length, L_0 the corresponding total sea level length, and H the mean value of the heights h, the above equation gives

$$L_0 = L - L\frac{H}{\rho}.$$

c. The three-point problem.

In this problem the positions of three points A, B, C, and hence the elements of the triangle they form, are given together with the two angles APC and BPC at a point P whose position is required. Denote the angles and the sides of the known triangle by A, B, C, and a, b, c, respectively. Also put

$$APC = \beta, \qquad BPC = \alpha,$$
$$PAC = x, \qquad PBC = y.$$

Then the sum of the angles in the quadrilateral $PACB$ is

$$\alpha + \beta + x + y + C = 360°,$$

whence

$$\tfrac{1}{2}(x + y) = 180° - \tfrac{1}{2}(\alpha + \beta + C). \tag{1}$$

Compute an auxiliary angle z from the equation

$$\tan z = \frac{a \sin\beta}{b \sin\alpha}; \tag{2}$$

Then

$$\tan \tfrac{1}{2}(x - y) = \tan(z - 45°) \tan \tfrac{1}{2}(x + y). \tag{3}$$

These three equations give all the data essential to a complete determination of the position of P. Any special case should be elucidated by a diagram drawn in accordance with the specifications given above.

When the positions of the points A, B, C are given on a map, the position of P on the same map may be found graphically by drawing lines making angles with each other equal to the given angles α and β from a point on a piece of tracing paper, and then placing this tracing on the map so as to meet the required conditions. This ready method of solving the problem is often sufficient.

17. Salient Facts of Physical Geodesy.

a. Area of earth's surface, areas of continents, area of oceans.*

	Square miles.
Total area of earth's surface	196 940 000
Area continent of Europe	3 820 000
" " Asia	17 230 000
" " Africa	11 480 000
" " Australia	3 406 000
" " America	15 950 000
Total area of continents	51 886 000
Total area of oceans	145 054 000

b. Average heights of continents and depths of oceans.†

	Feet.	Metres.
Average height of continent of Europe	980	300
" " " Asia	1640	500
" " " Africa	1640	500
" " " Australia . . .	820	250
" " " America	1340	410
Average height of all	1440	440

	Feet.	Metres.
Average depth of Atlantic Ocean	12 100	3680
" " Pacific Ocean	12 700	3890
" " Indian Ocean	11 000	3340
Average depth of all	11 300	3440

c. Volume, surface density, mean density, and mass of earth.

Volume of earth = 259 880 000 000 cubic miles.
= 1 083 200 000 000 cubic kilometres.
= 260×10^9 cubic miles (about).
= 108×10^{10} cubic kilometres (about).

Surface density of earth = 2.56 ± 0.16 ‡
Mean density of earth = 5.576 ± 0.016.

* Derived from relative areas given in Helmert's *Geodäsie*, Band II. p. 313.

† Helmert's *Geodäsie*, Band II. p. 313.

‡ These densities are given by Professor Wm. Harkness in his memoir on *The Solar Parallax and Related Constants*. The surface density applies to that portion of the earth's crust which lies above and within a shell ten miles thick, the lower surface of this shell being ten miles below sea level.

Assuming the mass of a cubic foot of water to be 62.28 pounds (at 62° F.),

$$\text{Mass of earth}^{*} = 13\,284 \times 10^{21} \text{ pounds.}$$
$$= 6\,642 \times 10^{18} \text{ tons (of 2000 lbs.).}$$
$$= 60\,258 \times 10^{20} \text{ kilogrammes.}$$

d. Principal moments of inertia and energy of rotation of earth.

M = mass of earth,
A = moment of inertia of earth about an axis in its equator,
C = moment of inertia about axis of rotation,
a = equatorial axis of earth,
ω = angular velocity of earth,
= $(2\,\pi/86164)$ for mean solar second as unit of time.

Then †

$$A = 0.325\ Ma^2,$$
$$C = 0.326\ Ma^2.$$

$$\text{Energy of rotation of earth} = \tfrac{1}{2}\,\omega^2 C.$$
$$= 0.163\ \omega^2 Ma^2.$$
$$= 504 \times 10^{25} \text{ foot-poundals.}$$
$$= 217 \times 10^{26} \text{ kilogramme-metres.}$$
$$= 212 \times 10^{35} \text{ ergs.}$$

References.

The most exhaustive treatise on the theory of geodesy is found in "Die Mathematischen und Physikalischen Theorieen der Höheren Geodäsie," von Dr. F. R. Helmert. Leipzig: B. G. Teubner; 8vo, 1880 (vol. i.), 1884 (vol. ii.). An excellent work on the practical as well as theoretical features of the subject is "Die geodätischen Hauptpunkte und ihre Co-ordinaten," von G. Zachariae; autorisirte deutsche Ausgabe, von E. Lamp. Berlin: Robert Oppenheim, 8vo, 1878. Of works in English the most comprehensive is "Geodesy," by A. R. Clarke. Oxford: The Clarendon Press, 8vo, 1880.

* The mass of the earth's atmosphere is about one-millionth part of the entire mass, or about 66×10^{14} tons.

† The values of A and C are those given by Harkness, *loc. cit.*, but they are here abridged to three places of decimals.

ASTRONOMY.

1. The Celestial Sphere. Planes and Circles of Reference.

The celestial sphere is a sphere to which it is convenient to refer stars and other celestial objects. Its centre is assumed to be coincident with the eye of the observer, and the objects referred to it are supposed to lie in its surface. The orientation of this sphere is defined by its equator, which is assumed to be parallel to the earth's equator. The equator is thus the principal plane of reference. Other planes of reference are the plane of the horizon, which is perpendicular to the plumb line at the place; the meridian, which is a plane through the place and the earth's axis of rotation; the prime-vertical, which is a vertical plane at the place at right angles to the meridian; and the ecliptic, which is a plane parallel to the plane of the earth's orbit. These planes cut the surface of the sphere in great circles called the equator, the horizon, the meridian, etc. The points on the sphere defined by the intersection of the meridians, or the points where the axis of the equator pierces the sphere, are called the poles. Similarly, the prolongation of the plumb line upwards pierces the sphere in the zenith, and its prolongation downwards pierces the sphere in the nadir. Great circles passing through the zenith are called vertical circles.

2. Spherical Co-ordinates.

a. Notation.

The position of a celestial body may be defined by several systems of co-ordinates. The most important of these in practical astronomy are the azimuth and altitude system and the hour angle and declination system. In the first of these the azimuth of a star or other body is the angle between the meridian plane of the place and a vertical plane through the star. It is measured, in general, from the south around by the west through 360°. The altitude of a star is its angular distance above the horizon, and its zenith distance is the complement of the altitude. In the second system the hour angle of a star is the angle between the meridian plane of the place and a meridian plane through the star. It is measured towards the west through 360°. The declination of a star is its angular distance above or below the equator; the complement of the declination is called the polar distance.

The angular distance of the pole above the horizon is equal to the zenith distance of the equator, or to the latitude of the place. Likewise, the altitude of the equator and the zenith distance of the pole are each equal to the complement of the latitude at any place.

These quantities are usually designated by the following notation : —

A = the azimuth of a star or object,
h = its altitude,
z = its zenith distance $= 90^\circ - h$,
t = its hour angle,
δ = its declination,
p = its polar distance $= 90^\circ - \delta$,
q = the parallactic angle, or angle at the star between the pole and the zenith,
ϕ = the latitude of the place of observation.

b. Altitude and azimuth in terms of declination and hour angle.

The fundamental relations for this problem are —

$$\begin{aligned} \sin h &= \sin \phi \sin \delta + \cos \phi \cos \delta \cos t, \\ \cos h \cos A &= -\cos \phi \sin \delta + \sin \phi \cos \delta \cos t, \\ \cos h \sin A &= \cos \delta \sin t. \end{aligned} \qquad (1)$$

When it is desired to compute both A and h by means of logarithms, the most convenient formulas are,

$$\begin{aligned} m \sin M &= \sin \delta, & \tan M &= \frac{\tan \delta}{\cos t}, \\ m \cos M &= \cos \delta \cos t, & & \\ \sin h &= m \cos (\phi - M), & \tan A &= \frac{\tan t \cos M}{\sin (\phi - M)}, \\ \cos h \cos A &= m \sin (\phi - M), & \tan h &= \frac{\cos A}{\tan (\phi - M)}. \\ \cos h \sin A &= \cos \delta \sin t, & & \end{aligned} \qquad (2)$$

$$A > 180^\circ \text{ when } t > 180^\circ \text{ and } A < 180^\circ \text{ when } t < 180^\circ.$$

For the computation of A and z separately, the following formulas are useful :

$$\begin{aligned} \tan A &= -\frac{\sin t}{\cos \phi \tan \delta (1 - \tan \phi \cot \delta \cos t)} \\ &= -\frac{a \sin t}{1 - b \cos t}, \end{aligned} \qquad (3)$$

where

$$a = \sec \phi \cot \delta, \qquad b = \tan \phi \cot \delta.$$

Formulas (3) are especially appropriate for the computation of a series of azimuths of close circumpolar stars, since a and b will be constant for a given place and date.

$$\begin{aligned} \cos z &= \cos (\phi \sim \delta) - 2 \cos \phi \cos \delta \sin^2 \tfrac{1}{2} t, \\ \sin^2 \tfrac{1}{2} z &= \sin^2 \tfrac{1}{2} (\phi \sim \delta) + \cos \phi \cos \delta \sin^2 \tfrac{1}{2} t, \\ (\phi \sim \delta) &= \phi - \delta, \text{ for } \phi > \delta \\ &= \delta - \phi, \text{ for } \phi < \delta. \end{aligned} \qquad (4)$$

For logarithmic application of (4) we may write

$$m^2 = \cos\phi\cos\delta, \qquad n^2 = \sin^2\tfrac{1}{2}(\phi \sim \delta),$$

$$\tan N = \frac{m}{n}\sin\tfrac{1}{2}t, \tag{5}$$

$$\sin\tfrac{1}{2}z = \frac{n}{\cos N} = \frac{m}{\sin N}\sin\tfrac{1}{2}t.$$

c. Declination and hour angle in terms of altitude and azimuth.

The fundamental relations for this case are

$$\begin{aligned} \sin\delta &= \sin\phi\sin h - \cos\phi\cos h\cos A, \\ \cos\delta\cos t &= \cos\phi\sin h + \sin\phi\cos h\cos A, \\ \cos\delta\sin t &= \cos h\sin A. \end{aligned} \tag{1}$$

For logarithmic computation by means of an auxiliary angle M one may write

$$\begin{aligned} m\sin M &= \cos h\cos A, & \tan M &= \cot h\cos A, \\ m\cos M &= \sin h, & & \\ \sin\delta &= m\sin(\phi - M), & \tan t &= \frac{\tan A\sin M}{\cos(\phi - M)}, \\ \cos\delta\cos t &= m\cos(\phi - M), & & \\ \cos\delta\sin t &= \cos h\sin A, & \tan\delta &= \tan(\phi - M)\cos t. \end{aligned} \tag{2}$$

d. Hour angle and azimuth in terms of zenith distance.

$$\cos t = \frac{\cos z - \sin\phi\sin\delta}{\cos\phi\cos\delta}.$$

$$\tan^2\tfrac{1}{2}t = \frac{\sin(\sigma - \phi)\cos(\sigma - \delta)}{\cos\sigma\cos(\sigma - z)}, \qquad \sigma = \tfrac{1}{2}(\phi + \delta + z).$$

$$\cos A = \frac{\sin\phi\cos z - \sin\delta}{\cos\phi\sin z}.$$

$$\tan^2\tfrac{1}{2}A = \frac{\sin(\sigma - \phi)\cos(\sigma - z)}{\cos\sigma\sin(\sigma - \delta)}, \qquad \sigma = \tfrac{1}{2}(\phi + \delta + z).$$

e. Formulas for parallactic angle.

$$\begin{aligned} \cos z &= \sin\delta\sin\phi + \cos\delta\cos\phi\cos t, \\ \sin z\cos q &= \cos\delta\sin\phi - \sin\delta\cos\phi\cos t, \\ \sin z\sin q &= \cos\phi\sin t, \\ \sin\delta &= \cos z\sin\phi + \sin z\cos\phi\cos t, \\ \cos\delta\cos q &= \sin z\sin\phi + \cos z\cos\phi\cos A, \\ \cos\delta\sin q &= \cos\phi\sin A. \end{aligned} \tag{1}$$

The first three of these are adapted to logarithmic computation as follows : —

$$\begin{aligned} n \sin N &= \cos \phi \cos t, \\ n \cos N &= \sin \phi, \\ \cos z &= n \sin (\delta + N), \\ \sin z \cos q &= n \cos (\delta + N), \\ \sin z \sin q &= \cos \phi \sin t ; \end{aligned}$$

whence

$$\begin{aligned} \tan N &= \cot \phi \cos t, \\ \tan z \sin q &= \frac{\tan t \sin N}{\sin (\delta + N)}, \\ \tan z \cos q &= \cot (\delta + N). \end{aligned} \qquad (2)$$

A similar adaptation results for the last three of equations (1) by interchanging δ and z. The equations (2) give both z and q in terms of ϕ, δ, and t, without ambiguity, since $\tan z$ is positive for stars above the horizon.

If A, z, and q are all required from ϕ, δ, and t, they are best given by the Gaussian relations

$$\begin{aligned} \sin \tfrac{1}{2} z \sin \tfrac{1}{2}(A + q) &= \sin \tfrac{1}{2} t \cos \tfrac{1}{2}(\phi + \delta), \\ \sin \tfrac{1}{2} z \cos \tfrac{1}{2}(A + q) &= \cos \tfrac{1}{2} t \sin \tfrac{1}{2}(\phi - \delta), \\ \cos \tfrac{1}{2} z \sin \tfrac{1}{2}(A - q) &= \sin \tfrac{1}{2} t \sin \tfrac{1}{2}(\phi + \delta), \\ \cos \tfrac{1}{2} z \cos \tfrac{1}{2}(A - q) &= \cos \tfrac{1}{2} t \cos \tfrac{1}{2}(\phi - \delta). \end{aligned} \qquad (3)$$

f. Hour angle, azimuth, and zenith distance of a star at elongation.

In this case the parallactic angle is 90° and the required quantities are given by the formulas

$$\begin{aligned} \cos t &= \frac{\tan \phi}{\tan \delta}, \\ \sin A &= \frac{\cos \delta}{\cos \phi}, \\ \cos z &= \frac{\sin \phi}{\sin \delta}. \end{aligned} \qquad (1)$$

When all of the quantities t, A, and z are to be computed the following formulas are more advantageous : —

$$K^2 = \sin (\delta + \phi) \sin (\delta - \phi),$$

$$\sin t = \frac{K}{\cos \phi \sin \delta}, \quad \cos A = \frac{K}{\cos \phi}, \quad \sin z = \frac{K}{\sin \delta}, \qquad (2)$$

$$\tan t = \frac{K}{\sin \phi \cos \delta}, \quad \tan A = \frac{\cos \delta}{K}, \quad \tan z = \frac{K}{\sin \phi}.$$

g. Hour angle, zenith distance, and parallactic angle for transit of a star across prime vertical.

In this case the azimuth angle is 90° and the required quantities are given by the formulas

$$\cos t = \frac{\tan \delta}{\tan \phi}, \quad \cos z = \frac{\sin \delta}{\sin \phi}, \quad \sin q = \frac{\cos \phi}{\cos \delta}; \qquad (1)$$

or, if all of them are to be computed, by the formulas

$$K^2 = \sin(\phi + \delta) \sin(\phi - \delta),$$

$$\sin t = \frac{K}{\sin \phi \cos \delta}, \quad \sin z = \frac{K}{\sin \phi}, \quad \cos q = \frac{K}{\cos \delta}, \qquad (2)$$

$$\tan t = \frac{K}{\cos \phi \sin \delta}, \quad \tan z = \frac{K}{\sin \delta}, \quad \tan q = \frac{\cos \phi}{K}.$$

For special accuracy the following group will be preferred:—

$$\tan^2 \tfrac{1}{2} t = \frac{\sin(\phi - \delta)}{\sin(\phi + \delta)},$$

$$\tan^2 \tfrac{1}{2} z = \frac{\tan \frac{1}{2}(\phi - \delta)}{\tan \frac{1}{2}(\phi + \delta)}, \qquad (3)$$

$$\tan^2 (45^\circ - \tfrac{1}{2} q) = \tan \tfrac{1}{2}(\phi + \delta) \tan \tfrac{1}{2}(\phi - \delta).$$

h. Hour angle and azimuth of a star when in the horizon, or at the time of rising or setting.

In this case the zenith distance of the star is 90°, and the required quantities are given by

$$\cos t = - \tan \phi \tan \delta,$$

$$\cos A = - \frac{\sin \delta}{\cos \phi};$$

or by

$$\tan^2 \tfrac{1}{2} t = \frac{\cos(\phi - \delta)}{\cos(\phi + \delta)},$$

$$\tan^2 \tfrac{1}{2} A = \frac{\tan \frac{1}{2}(90^\circ - \phi + \delta)}{\tan \frac{1}{2}(90^\circ - \phi - \delta)}.$$

On account of refraction, the values of t and A given by these formulas are subject to the following corrections, to wit:—

$$\Delta t = \frac{R}{\cos \phi \cos \delta \sin t}, \qquad \Delta A = \frac{\tan \phi}{\sin A} R,$$

where R is the refraction in the horizon. Thus the actual values of the hour angle and azimuth at the time of rising or setting of a star are

$$t + \Delta t \text{ and } A + \Delta A.$$

i. Differential formulas.

The general differential relations for the altitude and azimuth and the declination and hour angle systems of coördinates are: —

$$\begin{aligned} dz &= -\cos q\, d\delta + \sin q \cos \delta\, dt + \cos A\, d\phi, \\ \sin z\, dA &= \sin q\, d\delta + \cos q \cos \delta\, dt - \cos z \sin A\, d\phi. \end{aligned} \qquad (1)$$

$$\begin{aligned} d\delta &= -\cos q\, dz + \sin q \sin z\, dA + \cos t\, d\phi, \\ \cos \delta\, dt &= \sin q\, dz + \cos q \sin z\, dA + \sin \delta \sin t\, d\phi. \end{aligned} \qquad (2)$$

The following values derived from (1) are of interest as showing the dependence of z and A on t in special cases: —

	$\left(\frac{dz}{dt}\right)$	$\left(\frac{dA}{dt}\right)$
For a star in the meridian	$= 0,$	$= \frac{\cos \delta}{\sin z},$
For a star in the prime vertical	$= \cos \phi,$	$= \sin \phi,$
For a star at elongation	$= \cos \delta,$	$= 0.$

3. Relations of Different Kinds of Time used in Astronomy.

a. The sidereal and solar days.

The sidereal day is the interval between two successive transits of the vernal equinox over the same meridian. The sidereal time at any instant is the hour angle of the vernal equinox reckoned from the meridian towards the west from 0 to 24 hours. The sidereal time at any place is 0 when the vernal equinox is in the meridian of that place.

The solar day is the interval between two successive transits of the sun across any meridian; and the solar time at any instant is the hour angle of the sun at that instant. The solar day begins at any place when the sun is in the meridian of that place.

The mean solar day is the interval between two successive transits over the same meridian of a fictitious sun, called the mean sun, which is assumed to move uniformly in the equator at such a rate that it returns to the vernal equinox at the same instant with the actual sun.

Time reckoned with respect to the actual sun is called apparent time, while that reckoned with respect to the mean sun is called mean time. The difference between apparent and mean time, which amounts at most to about 16^m, is called the equation of time. This quantity is given for every day in the year in ephemerides.

The sidereal time when a star or other object crosses the meridian is called the right ascension of the object. The right ascension of the mean sun is also called the sidereal time of mean noon. This time is given for every day in the year in ephemerides for particular meridians, and can be found for any meridian by allowing for the difference in longitude.

The time to which ephemerides and most astronomical calculations are referred is the solar day, beginning at noon, and divided to hours numbered continuously from 0^h to 24^h. This is called astronomical time; and such a day is called the astronomical day. It begins, therefore, 12 hours later than the civil day.

b. Relation of apparent and mean time.

A = apparent time = hour angle of real sun,
M = mean time = hour angle of mean sun,
E = equation of time.

$$M = A + E.$$

In the use of this relation, E may be most conveniently derived (by interpolation for the place of observation) from an ephemeris.

c. Relation of sidereal and mean solar intervals of time.

I = interval of mean solar time,
I' = corresponding interval in sidereal time,
r = the ratio of the tropical year expressed in sidereal days to the tropical year expressed in mean solar days

$$= \frac{366.2422}{365.2422} = 1.002738.$$

$$I' = rI = I + (r - 1)\,I = I + 0.002738\,I$$
$$I = r^{-1}\,I' = I' - (1 - r^{-1})\,I' = I' - 0.002730\,I'.$$

Tables for making such calculations are usually given in ephemerides (see, for example, the American Ephemeris). Short tables for this purpose are Tables 34 and 35 of this volume.

Frequent reference is made to the relations

24^h sidereal time = $23^h\ 56^m\ 04.^s091$ solar time,
24^h mean time = $24^h\ 03^m\ 56.^s555$ sidereal time.

d. Interconversion of sidereal and mean solar time.

T_m = mean time at any place,
T_s = corresponding sidereal time,
= right ascension of meridian of the place,
A = right ascension of mean sun for place and date,
= sidereal time of mean noon for place and date.

$$T_s = A + T_m \text{ expressed in sidereal time.}$$

$$T_m = (T_s - A) \text{ expressed in mean time.}$$

The quantity A is given in the ephemerides for particular meridians, and can be found by interpolation for any meridian whose longitude with respect to the meridian of the ephemeris is known. The formulas assume that A is taken out of the ephemeris for the next preceding mean noon.

e. Relation of sidereal time to the right ascension and hour angle of a star.

T_s = sidereal time at any place,
= right ascension of the meridian of the place,
α = right ascension of a star,
t = the hour angle of the star at the time T_s.

$$T_s = \alpha + t, \qquad t = T_s - \alpha.$$

4. Determination of Time.

a. By meridian transits.

A determination of time consists in finding the correction to the clock, chronometer, or watch used to record time. If T_0 denote the true time at any place of an event, T the corresponding observed clock time, and ΔT the clock correction,

$$T_0 = T + \Delta T.$$

The simplest way to determine the clock correction is to observe the transit of a star, whose right ascension is known, across the meridian. In this case the true time $T_0 = \alpha$, the right ascension of the star; and if T is the observed clock time of the transit,

$$\Delta T = \alpha - T.$$

Meridian transits of stars may be observed by means of a theodolite or transit instrument mounted so that its telescope describes the meridian when rotated about its horizontal axis. The meridian transit instrument is specially designed for this purpose, and affords the most precise method of determining time.*

Since it is impossible to place the telescope of such an instrument exactly in the meridian, it is essential in precise work to determine certain constants, which define this defect of adjustment, along with the clock correction. These constants are the azimuth of the telescope when in the horizon, the inclination of the horizontal axis of the telescope, and the error of collimation of the telescope.†

Let

a = azimuth constant,
b = inclination or level constant,
c = collimation constant.

a is considered plus when the instrument points east of south; b is plus when the west end of the rotation axis is the higher; and c is intrinsically plus when the star observed crosses the thread (or threads) too soon from lack of collimation. (The latter constant is generally referred to the clamp or circle on the horizontal axis of the instrument.)

* The best treatise on the theory and use of this instrument is to be found in Chauvenet's *Manual of Spherical and Practical Astronomy*, which should be consulted by one desiring to go into the details of the subject.

† Other equivalent constants may be used, but those given are most commonly employed.

Also let

$$\phi = \text{latitude of the place,}$$
$$\delta = \text{declination of star observed,}$$
$$\alpha = \text{right ascension of star observed,}$$
$$T = \text{observed clock time of star's transit,}$$
$$\Delta T = \text{the clock correction at an assumed epoch } T_0,$$
$$r = \text{the rate of the clock, or other timepiece,}$$
$$A = \frac{\sin(\phi - \delta)}{\cos \delta} = \text{the ``azimuth factor,''}$$
$$B = \frac{\cos(\phi - \delta)}{\cos \delta} = \text{the ``level factor,''}$$
$$C = \frac{1}{\cos \delta} = \text{the ``collimation factor.''}$$

Then, when a, b, c are small (conveniently less than 10^s each, and in ordinary practice less than 1^s each),

$$T + \Delta T + Aa + Bb + Cc + r(T - T_0) = \alpha.$$

This is known as Mayer's formula for the computation of time from star transits.

The quantity Bb is generally observed directly with a striding level. Assuming it to be known and combined with T, the above equation gives

$$\Delta T + Aa + Cc + r(T - T_0) = \alpha - T. \qquad (1)$$

This equation involves four unknown quantities, ΔT, a, c, and r; so that in general it will be essential to observe at least four different stars in order to get the objective quantity ΔT. Where great precision is not needed, the effect of the rate, for short intervals of time, may be ignored, and the collimation c may be rendered insignificant by adjustment. Then the equation (1) is simplified in

$$\Delta T + Aa = \alpha - T. \qquad (2)$$

This shows that observations of two stars of different declinations will suffice to give ΔT. Since the factor A is plus for stars south of the zenith (in north latitude) and minus for stars north of the zenith, if stars be so chosen as to make the two values of A equal numerically but of opposite signs, ΔT will result from the mean of two equations of the form (2). With good instrumental adjustments (b and c small), this simple sort of observation with a theodolite will give ΔT to the nearest second.

A still better plan for approximate determination of time is to observe a pair of north and south stars as above, and then reverse the telescope and observe another pair similarly situated, since the remaining error of collimation will be partly if not wholly eliminated. Indeed, a well selected and well observed set of four stars will give the error of the timepiece used within a half second or less. This method is especially available to geographers who may desire such an approximate value of the timepiece correction for use in determining azimuth. It will suffice in the application of the method to set up the instrument (theodolite or transit) in the vertical plane of Polaris, which is always close enough to the meridian. The determination will then proceed according to the following programme: —

1. Observe time of transit of a star south of zenith,
2. Observe time of transit of a star north of zenith.

Reverse telescope,

3. Observe time of transit of another star south of zenith,
4. Observe time of transit of another star north of zenith.

Each star observation will give an equation of the form (1), and the mean of the four resulting equations is

$$\Delta T + a\,\frac{\Sigma A}{4} + c\,\frac{\Sigma C}{4} + r\,\frac{\Sigma(T - T_0)}{4} = \frac{\Sigma(\alpha - T)}{4}.$$

Now the coefficient of r in this equation may be always made zero by taking for the epoch T_0 the mean of the observed times T. Likewise, ΣA and ΣC may be made small by suitably selected stars, since two of the A's and C's are positive and two negative. The value $\frac{1}{4}\,\Sigma(\alpha - T)$ is thus always a close approximation to ΔT for the epoch $T_0 = \frac{1}{4}\,\Sigma T$, when ΣA and ΣC approximate to zero. But if these sums are not small, approximate values of a and c may be found from the four equations of the form (1), neglecting the rate, and these substituted in the above formula will give all needful precision.

For refined work, as in determining differences of longitude, several groups of stars are observed, half of them with the telescope in one position and half in the reverse position, and the quantities ΔT, a, c, and r are computed by the method of least squares. In such work it is always advantageous to select the stars with a view to making the sums of the azimuth and collimation coefficients approximate to zero, since this gives the highest precision and entails the simplest computations.*

b. By a single observed altitude of a star.

An approximate determination of time, often sufficient for the purposes of the geographer, may be had by observing the altitude or zenith distance of a known star. The method requires also a knowledge of the latitude of the place.

Let

z_1 = the observed zenith distance of the star,
R = the refraction,
z = the true zenith distance of the star,
$= z_1 + R$,
α, δ, = the right ascension and declination of the star,
t = hour angle of star at time of observation,
T = observed time when z_1 is measured,
ΔT = correction to timepiece,
ϕ = latitude of place.

Then the hour angle t may be computed by

$$\tan^2 \tfrac{1}{2}\,t = \frac{\sin(\sigma - \phi)\,\cos(\sigma - \delta)}{\cos\sigma\,\cos(\sigma - z)}, \quad \sigma = \tfrac{1}{2}(\phi + \delta + z).$$

* For details of theory and practice in time work done according to this plan see Bulletin 49, U. S. Geological Survey.

Having the hour angle the clock correction ΔT is given by

$$\Delta T = \alpha + t - T,$$

in which all terms must be expressed in the same unit; *i. e.*, in sidereal or in mean time.

The refraction R may be taken from Table 31.

The most advantageous position of the star observed, so far as the effect of an error in the measured quantity z_1 is concerned, is in the prime vertical, but stars near the horizon should be avoided on account of uncertainties in refraction. The least favorable position of the star is in the meridian.

Compared with the preceding method the present method is inferior in precision, but it is often available when the other cannot be applied.

c. By equal altitudes of a star.

This method is an obvious extension of the preceding method, and has the advantage of eliminating the effect of constant instrumental errors in the measured altitudes or zenith distances. Thus it is plain that the mean of the times when a (fixed) star has the same altitude east and west of the meridian, whether one can measure that altitude correctly or not, is the time of meridian transit.

This method may, therefore, give a good approximation to the timepiece correction when nothing better than an engineer's transit, whose telescope can be clamped, is available. When the instrument has a vertical circle (or when a sextant is used) a series of altitudes may be observed before meridian passage of the star, and a similar series in the reverse order with equal altitudes respectively after meridian passage. The half sums of the times of equal altitudes on the two sides of the meridian will give a series of values for the time of meridian transit from which the precision attained may be inferred.

This method is frequently applied to the sun, observations being made before and after noon. For the theory of the corrections essential in this case on account of the changing position of the sun, on account of inequalities in the observed altitudes, etc., the reader must be referred to special treatises on practical astronomy.*

5. Determination of Latitude.

a. By meridian altitudes.

The readiest method of determining the latitude of a place is to measure the meridian zenith distance or altitude of a known star. When precision is not required this process is a very simple one, since it is only essential to follow a (fixed) star near the meridian until its altitude is greatest, or zenith distance least. Thus, if the observed zenith distance is z_1, the true zenith distance z, and the refraction R,

$$z = z_1 + R;$$

* The best work of this kind is Chauvenet's *Manual of Spherical and Practical Astronomy*. It should be consulted by all persons desiring a knowledge of the details of practical astronomy.

and if the declination of the star is δ and the latitude of the place ϕ,

$$\phi = \delta \pm z$$

according as the star is south or north of the zenith.

A more accurate application of the same principle is to observe the altitudes of a circumpolar star at upper and lower culmination (above and below the pole). The mean of these altitudes, corrected for refraction, is the latitude of the place. This process, it will be observed, does not require a knowledge of the star's declination.

b. By the measured altitude of a star at a known time.

h = measured altitude corrected for refraction,
T_s = observed sidereal time,
α, δ = right ascension and declination of star,
t = hour angle of star,
ϕ = latitude of place.

Then ϕ may be computed by means of the following formulas: —

$$t = T_s - \alpha,$$

$$\tan \beta = \frac{\tan \delta}{\cos t}, \qquad \cos \gamma = \frac{\sin h \sin \beta}{\sin \delta},$$

$$\phi = \beta \pm \gamma.$$

In the application of these β may be taken numerically less than 90°, and since t may also be taken less than 90°, β may be taken with the same sign as δ. γ is indeterminate as to sign analytically, but whether it should be taken as positive or negative can be decided in general by an approximate knowledge of the latitude, which is always had except in localities near the equator.

The most advantageous position of a star in determining latitude by this method is in the meridian, and the least advantageous in the prime vertical. When a series of observations on the same star is made, they should be equally distributed about the meridian; and when more than one star is observed it is advantageous to observe equal numbers of them on the north and south of the zenith.

The application of this method to the pole star is especially well adapted to the means available to the geographer and engineer, namely, a good theodolite and a good timepiece. In this case the following simple formula for the latitude may be used: —

$$\phi = h - p \cos t + \tfrac{1}{2} p^2 \sin 1'' \sin^2 t \tan h,$$

where p is the polar distance of Polaris in seconds (about 5400″), and the other symbols have the same meaning as defined above. Tables giving the logarithms of p and $\frac{1}{2} p^2 \sin 1''$ are published in the American Ephemeris.

c. By the zenith telescope.

The zenith telescope furnishes the most precise means known for the determination of the latitude of a place. For the theory of the instrument and method when applied to refined work the reader must be referred to special treatises.* It will suffice here to state the principle of the method, which may sometimes be advantageously applied by the geographer. Let z_s be the meridian zenith distance of a star south of the zenith, and z_n the meridian zenith distance of another star north of the zenith. Let δ_s and δ_n denote the declinations of these stars respectively. Then

$$z_s = \phi - \delta_s,$$
$$z_n = \delta_n - \phi,$$

whence

$$\phi = \tfrac{1}{2}(\delta_s + \delta_n) + \tfrac{1}{2}(z_s - z_n).$$

It appears, therefore, that this method requires only that the difference $(z_s - z_n)$ be measured. Herein lies the advantage of the method, since that difference may be made small by a suitable selection of pairs of stars. With the zenith telescope the stars are so chosen that the difference $(z_s - z_n)$ may be measured by means of a micrometer in the telescope.

The essential principles and advantages of this method may be realized also with a theodolite, or other telescope, to which a vertical circle is attached, the difference $(z_s - z_n)$ being measured on the circle; and a determination of latitude within 5″ or less is thus easy with small theodolites of the best class (*i. e.*, with those whose circles read to 10″ or less by opposite verniers or microscopes).

6. Determination of Azimuth.

a. By observation of a star at a known time.

T_s = sidereal time of observation,
α, δ = right ascension and declination of star observed,
t = hour angle of star,
$= T_s - \alpha$,
ϕ = latitude of place,
A = azimuth of the star at the time T_s counted from the south around by the west through 360°.

The azimuth A may be computed by the formulas

$$a = \sec\phi \cot\delta, \qquad b = \tan\phi \cot\delta,$$

$$\tan A = -\frac{a \sin t}{1 - b\cos t}. \qquad (1)$$

The angle A will fall in the same semicircle as t, and A is thus determined by its tangent without ambiguity. The quantities a and b will be sensibly constant for

* Among which Chauvenet's *Manual of Spherical and Practical Astronomy* is the best.

a given star and date; and hence they need be computed but once for a series of observations on the same star on one date.

The effects of small errors Δt, $\Delta\phi$, and $\Delta\delta$ in the assumed time, latitude, and declination are expressed by

$$\frac{\cos\delta\cos q}{\sin z}\Delta t, \qquad -\sin A\cot z\,\Delta\phi, \qquad \frac{\sin q}{\sin z}\Delta\delta,$$

respectively, where z and q are the zenith distance and parallactic angle of the star. Hence the effect of Δt will vanish for a star at elongation; the effect of $\Delta\phi$ vanishes for a star in the meridian, and is always small (in middle latitudes) for a close circumpolar star; the effect of $\Delta\delta$ vanishes for a star in the meridian. It appears advantageous, therefore, to observe for azimuth (in middle latitudes) close circumpolar stars at elongations, since the effect of the time error is then least, and the effects of errors in the latitude and declination are small and may be eliminated entirely by observing the same star at both elongations.

The hour angle t_e, the azimuth A_e, and the altitude h_e of a star at elongation are given by the formulas (2) of section 2, *f*. Those best suited to the purpose are

$$K^2 = \sin(\delta+\phi)\sin(\delta-\phi),$$

$$\tan t_e = \frac{K}{\sin\phi\cos\delta}, \qquad \tan A_e = \frac{\cos\delta}{K}, \qquad \tan h_e = \frac{\sin\phi}{K}. \qquad (2)$$

Knowing the time of elongation of a close circumpolar star, it suffices for many purposes to observe the angle between the star and some reference terrestrial mark at or in the vicinity of that time.

For precise determinations of azimuth it is customary to observe a star near its elongation repeatedly, thus obtaining a series of results whose mean will be sensibly free from errors of observation and errors due to instrumental defects.

The computation of the azimuth A may be made accurately in all cases by the formulas (1); but when a close circumpolar star is observed near elongation, it may be more convenient to use the following formulas: —

$\Delta t = (t - t_e)$, or the interval before or after elongation at the time of observation,

$\Delta A = (A - A_e)$, or the difference in azimuths of the star at the time of elongation and at the time of observation, (3)

$$\Delta A'' = \frac{(15)^2}{2\rho''}\frac{\sin\delta\cos\delta}{\sin t_e\cos\phi}(\Delta t^s)^2 \pm \frac{(15)^3}{2(\rho'')^2}\frac{\sin\delta\cos\delta}{\sin t_e\tan t_e\cos\phi}(\Delta t^s)^3.*$$

* To the same order of approximation one may write in the first term of this expression

$$\frac{(15)^2}{2\rho''}(\Delta t^s)^2 = \rho''\,2\sin^2\tfrac{1}{2}\Delta t = \frac{2\sin^2\frac{1}{2}\Delta t}{\sin 1''},$$

which latter is the most convenient form when tables giving $\log\frac{(2\sin^2\frac{1}{2}\Delta t)}{\sin 1''}$ for the argument Δt in time are at hand. Such tables are given in Chauvenet's *Manual of Spherical and Practical Astronomy* (for full title see p. lxxxii), and in *Formeln und Hülfstafeln für Geographische Ortsbestimmungen*, von Dr. Th. Albrecht. Leipzig: Wilhelm Engelmann, 4to, 2d ed., 1879.

This last formula gives ΔA in seconds of arc when Δt is expressed in seconds of time; Δt is considered positive in all cases (in the use of the formula), and with this convention the positive sign is used when the star is between either elongation and upper culmination, and the negative sign when the star is between either elongation and lower culmination. For a given star, place, and date the coefficients of $(\Delta t^s)^2$ and $(\Delta t^s)^3$ will be sensibly constant and their logarithms will thus be constant for a series of observations of a star on any date. By reason of the large factors $(\rho'' = 206\,264.''8)^2$ and $\tan t_e$ in the denominator of the second term, it will be very small unless Δt^s is large. Hence this term may often be neglected. Using both terms, the formula will give ΔA for Polaris to the nearest $0.''01$ when $\Delta t < 40^m$ and when observations are made in middle latitudes.

By reference to formulas (2) of section 2, *f*, it is seen that

$$\frac{\sin\delta\cos\delta}{\sin t_e\cos\phi} = \frac{\sin^2\delta\cos\delta}{K},$$

$$\frac{\sin\delta\cos\delta}{\sin t_e\tan t_e\cos\phi} = \frac{\sin^2\delta\cos^2\delta\sin\phi}{K^2},$$

$$K^2 = \sin(\delta+\phi)\sin(\delta-\phi).*$$

b. By an observed altitude of a star.

h = true altitude of star observed; *i. e.*, the observed altitude less the refraction,
ϕ = latitude of place,
p = polar distance of star,
A = azimuth of star.

$$\tan^2\tfrac{1}{2}A = \frac{\sin(\sigma-\phi)\sin(\sigma-h)}{\cos\sigma\cos(\sigma-p)},$$

$$\sigma = \tfrac{1}{2}(\phi + h + p).$$

The most advantageous position of the star, on account of possible error in the observed value of h, is that in which $\sin A$ is a maximum. This position is then at elongation for stars which elongate, in the prime vertical for stars which cross this great circle, and in the horizon for a star which neither elongates nor crosses the prime vertical. A star will elongate when $p < 90° - \phi$; it will cross the prime vertical when p lies between $90° - \phi$ and $90°$; and it will neither elongate nor cross the prime vertical when $p > 90°$, or when the declination (δ) of the star is negative.

c. By equal altitudes of a star.

By this method, when a fixed star is observed first east of the meridian and then west of the meridian at the same altitude, the direction of the meridian will

* In precise work the computed azimuth requires the following correction for daily aberration, namely:—

$$\Delta A = -0.''32\,\frac{\cos\phi}{\sin z}\cos A,$$

where A is to be reckoned from the south by way of the west through 360°.

obviously be given by the mean of the azimuth circle readings for the two observed directions. This process will thus give the direction of the meridian free from the effect of any instrumental errors common to the equal altitudes observed. Neither does it require any knowledge of the star's position (right ascension and declination). It is therefore available to one provided with nothing but an instrument for measuring altitudes and azimuths, and is susceptible of considerable precision when a series of such equal altitudes is carefully referred to a terrestrial mark.

When the sun is observed, it is essential to take account of its change in declination between the first and the second observation. Let A_1 and A_2 be the true azimuths counted from the meridian toward the east and west respectively at the times t_1 and t_2 of the two observations. Also, let $\Delta\delta$ be the increase in declination of the sun in the interval $(t_2 - t_1)$. Then

$$A_2 - A_1 = \frac{\Delta\delta}{\cos\phi \sin\frac{1}{2}(t_2 - t_1)}.$$

Calling the azimuth circle readings for the east and west observations R_1 and R_2 respectively, the resulting azimuths are

$$A_1 = \tfrac{1}{2}(R_2 - R_1) - \tfrac{1}{2}(A_2 - A_1),$$
$$A_2 = \tfrac{1}{2}(R_2 - R_1) + \tfrac{1}{2}(A_2 - A_1).$$

References.

Many excellent treatises on spherical and practical astronomy are available. Among these the most complete are the following: —

"A Manual of Spherical and Practical Astronomy," by William Chauvenet. Philadelphia: J. B. Lippincott & Co., 2 vols., 8vo, 5th ed., 1887. "A Treatise on Practical Astronomy, as applied to Astronomy and Geodesy," by C. L. Doolittle. New York: John Wiley & Sons, 8vo, 2d ed., 1888. "Lehrbuch der Sphärischen Astronomie," von F. Brünnow. Berlin: Fred. Dümler, 8vo, 1851. "Spherical Astronomy," by F. Brünnow. Translated by the author from the second German edition. London: Asher & Co., 8vo, 1865.

THEORY OF ERRORS.

1. Laws of Error.

The theory of errors is that branch of mathematical science which considers the nature and extent of errors in derived quantities due to errors in the data on which such quantities depend. A law of error is a relation between the magnitude of an error and the probability of its occurrence. The simplest case of a law of error is that in which all possible errors (in the system of errors) are equally likely to occur. An example of such a case is had in the errors of tabular logarithms, natural trigonometric functions, etc.; all errors from zero to a half unit in the last tabular place being equally likely to occur.

When quantities subject to errors following simple laws are combined in any manner, the law of error of the quantity resulting from the combination is in general more complex than that of either component.

Let ϵ denote the magnitude of any error in a system of errors whose law of error is defined by $\phi(\epsilon)$. Then if ϵ vary continuously the probability of its occurrence will be expressed by $\phi(\epsilon)d\epsilon$. If ϵ vary continuously between equal positive and negative limits whose magnitude is a, the sum of all the probabilities $\phi(\epsilon)d\epsilon$ must be unity, or

$$\int_{-a}^{+a} \phi(\epsilon)\, d\epsilon = 1.$$

For the case of tabular logarithms, etc., alluded to above, $\phi(\epsilon) = c$, a constant whose value is $1/(2\,a) = 1$, since $a = 0.5$.

For the case of a logarithm interpolated between two consecutive tabular values, by the formula $v = v_1 + (v_2 - v_1)\,t = v_1\,(1 - t) + v_2\,t$, where v_1 and v_2 are the tabular values, and t the interval between v_1 and the derived value v, $\phi(\epsilon)$ has the following remarkable forms when the extra decimals (practically the first of them) in $(v_2 - v_1)\,t$ are retained: —

$$\phi(\epsilon) = \frac{\frac{1}{2} + \epsilon}{(1 - t)\,t} \text{ for values of } \epsilon \text{ between } -\tfrac{1}{2} \text{ and } -(\tfrac{1}{2} - t),$$

$$= \frac{1}{1 - t} \text{ for values of } \epsilon \text{ between } -(\tfrac{1}{2} - t) \text{ and } +(\tfrac{1}{2} - t), \qquad (1)$$

$$= \frac{\frac{1}{2} - \epsilon}{(1 - t)\,t} \text{ for values of } \epsilon \text{ between } +(\tfrac{1}{2} - t) \text{ and } +\tfrac{1}{2}.$$

It thus appears that $\phi(\epsilon)$ in this case is represented by the upper base and the two sides of a trapezoid.

When, as is usually the practice, the quantity $(v_2 - v_1)\,t$ is rounded to the nearest unit of the last tabular place, $\phi(\epsilon)$ becomes more complex, but is still represented by a series of straight lines. It is worthy of remark that the latter species of interpolated value is considerably less precise than the former, wherein an additional figure beyond the last tabular place is retained.

When an infinite number of infinitesimal errors, each subject to the law of constant probability and each as likely to be positive as negative, are combined by addition, the law of the resultant error is of remarkable simplicity and generality. It is expressed by

$$\phi(\epsilon) = \frac{h}{\sqrt{\pi}}\, e^{-h^2 \epsilon^2} \qquad (2)$$

where e is the Napierian base, $\pi = 3.14159 +$, and h is a constant dependent on the relative magnitude of the errors in the system. This is the law of error of least squares. It is the law followed more or less closely by most species of observational errors. Its general use is justified by experience rather than by mathematical deduction.

a. Probable, mean, and average errors.

For the purposes of comparison of different systems of errors following the same law, three different terms are in use. These are the *probable error*,* or that error in the system which is as likely to be exceeded as not; the *mean error*, or that error which is the square root of the mean of the squares of all errors in the system; and the *average error*, which is the average, regardless of sign, of all errors in the system. Denote these errors by ϵ_p, ϵ_m, ϵ_a, respectively. Then in all systems in which positive and negative errors of equal magnitude are equally likely to occur, and in which the limits of error are denoted by $-a$ and $+a$, the analytical definitions of the probable, mean, and average errors are : —

$$\int_{-a}^{-\epsilon_p} \phi(\epsilon)\, d\epsilon = \int_{-\epsilon_p}^{0} \phi(\epsilon)\, d\epsilon = \int_{0}^{+\epsilon_p} \phi(\epsilon)\, d\epsilon = \int_{+\epsilon_p}^{+a} \phi(\epsilon)\, d\epsilon = \tfrac{1}{4},$$

$$\epsilon^2_m = \int_{-a}^{+a} \phi(\epsilon)\, \epsilon^2\, d\epsilon, \qquad \epsilon_a = \int_{-a}^{+a} \phi(\epsilon)\, \epsilon\, d\epsilon. \qquad (3)$$

* The reader should observe that the word probable is here used in a specially technical sense. Thus, the probable error is not "the most probable error," nor "the most probable value of the actual error," etc., as commonly interpreted.

b. Probable, mean, average, and maximum actual errors of interpolated logarithms, trigonometric functions, etc.

When values of logarithms, etc., are interpolated from numerical tables by means of first differences, as explained above, the probable and other errors depend on the magnitude of the interpolating factor. Thus, the interpolated value is

$$v = v_1 + (v_2 - v_1)\, t$$

where v_1 and v_2 are consecutive tabular values and t is the interpolating factor.

For the species of interpolated value wherein the quantity $(v_2 - v_1)\, t$ is not rounded to the nearest unit of the last tabular place (or wherein the next figure beyond that place is retained) the maximum possible actual error is 0.5 of a unit of the last tabular place, and formulas (1) and (3) show that the probable, mean, and average errors are given by the following expressions: —

$$\begin{aligned} \epsilon_p &= \tfrac{1}{4}(1 - t) && \text{for } t \text{ between 0 and } \tfrac{1}{3}, \\ &= \tfrac{1}{2} - \tfrac{1}{2}\sqrt{2t\,(1-t)} && \text{for } t \text{ between } \tfrac{1}{3} \text{ and } \tfrac{2}{3}, \\ &= \tfrac{1}{4}\, t && \text{for } t \text{ between } \tfrac{2}{3} \text{ and } 1. \end{aligned}$$

$$\epsilon_m = \left\{ \frac{1 - (1 - 2\,t)^4}{96\,(1 - t)\,t} \right\}^{\frac{1}{2}}.$$

$$\begin{aligned} \epsilon_a &= \frac{1 - (1 - 2t)^3}{24\,(1 - t)\,t} && \text{for } t \text{ between 0 and } \tfrac{1}{2}, \\ &= \frac{1 - (2t - 1)^3}{24\,(1 - t)\,t} && \text{for } t \text{ between } \tfrac{1}{2} \text{ and } 1. \end{aligned}$$

It thus appears that the probable error of an interpolated value of the species under consideration decreases from 0.25 to 0.15 of a unit of the last tabular place as t increases from 0 to 0.5. Hence such interpolated values are more precise than tabular values.

For the species of interpolated values ordinarily used, wherein $(v_2 - v_1)\, t$ is rounded to the nearest unit of the last tabular place, the probable, mean, and average errors are greater than the corresponding errors for tabular values. The laws of error for this ordinary species of interpolated value are similar to but in general more complex than those defined by equations (1). It must suffice here to give the practical results which flow from these laws for special values of the interpolating factor t.* The following table gives the probable, mean, average, and maximum actual error of such interpolated values for $t = 1, \frac{1}{2}, \frac{1}{3}, \ldots \frac{1}{10}$. It will be observed that $t = 1$ corresponds to a tabular value.

* For the theory of the errors of this species of interpolated values see *Annals of Mathematics*, vol. ii. pp. 54–59.

Characteristic Errors of Interpolated Logarithms, etc.

Interpolating factor t	Probable error ϵ_p	Mean error ϵ_m	Average error ϵ_a	Maximum actual error
1	0.250	0.289	0.250	$\frac{1}{2}$
$\frac{1}{2}$	.292	.408	.333	1
$\frac{1}{3}$	.256	.347	.287	$\frac{5}{6}$
$\frac{1}{4}$	.276	.382	.313	1
$\frac{1}{5}$	.268	.370	.303	$\frac{9}{10}$
$\frac{1}{6}$	.277	.385	.315	1
$\frac{1}{7}$	.274	.380	.311	$\frac{13}{14}$
$\frac{1}{8}$	.279	.389	.318	1
$\frac{1}{9}$	.278	.386	.316	$\frac{17}{18}$
$\frac{1}{10}$	.281	.392	.320	1

2. The Method of Least Squares.

a. General statement of method.

When the errors to which observed quantities are subject follow the law expressed by

$$\phi(\epsilon) = \frac{h}{\sqrt{\pi}} e^{-h^2 \epsilon^2},$$

a unique method results for the computation of the most probable values of the observed quantities and of quantities dependent on the observed quantities. The method requires that the sum of the weighted squares of the corrections to the observed quantities shall be a minimum,* subject to whatever theoretical conditions the corrections must satisfy. These conditions are of two kinds, namely, those expressing relations between the corrections only, and those expressing relations between the corrections and other unknown quantities whose values are disposable in determining the minimum. A familiar illustration of the first class of conditions is presented by the case of a triangle each of whose angles is measured, the condition being that the sum of the corrections is a constant. An equally familiar illustration of the second class of conditions is found in the case where the sum and difference of two unknown quantities are separately observed; in this case the two unknowns are to be found along with the corrections.

Mathematically, the general problem of least squares may be stated in two

* Hence the term least squares.

equations. Thus, let $x, y, z, \ldots$ be the observed quantities with weights $p, q, r, \ldots$. Let the corrections to the observed quantities be denoted by $\Delta x, \Delta y, \Delta z, \ldots$; so that the corrected quantities are $x + \Delta x, y + \Delta y, z + \Delta z, \ldots$. Let the disposable quantities whose values are to be determined along with the corrections be denoted by $\xi, \eta, \zeta, \ldots$. Then, the theoretical conditions which must be satisfied by $x + \Delta x, y + \Delta y, z + \Delta z, \ldots$ and by $\xi, \eta, \zeta, \ldots$ may be symbolized by

$$F_n(\xi, \eta, \zeta, \ldots x + \Delta x, y + \Delta y, z + \Delta z, \ldots) = 0. \qquad (4)$$

Subject to the conditions specified by the n equations (4), we must also have

$$\begin{aligned} p(\Delta x)^2 + q(\Delta y)^2 + r(\Delta z)^2 + \ldots &= \text{a minimum} \qquad (5) \\ &= u, \text{ say.} \end{aligned}$$

Equations (4) and (5) contain the solution of every problem of adjustment by the method of least squares. Two examples may suffice to illustrate their use.

First, take the case of the observed angles of a triangle alluded to above. Calling the observed angles x, y, z, we have

$$x + \Delta x + y + \Delta y + z + \Delta z = 180° + \text{spherical excess},$$

or

$$\begin{aligned} \Delta x + \Delta y + \Delta z &= 180° + \text{spherical excess} - (x + y + z) \\ &= c, \text{ say.} \end{aligned}$$

This is the only condition of the form (4). The problem is completely stated, then, in the two equations

$$\Delta x + \Delta y + \Delta z = c$$
$$p(\Delta x)^2 + q(\Delta y)^2 + r(\Delta z)^2 = \text{a min.} = u.$$

To solve this problem the simplest mode of procedure is to eliminate one of the corrections by means of the first equation and then make u a minimum. Thus, eliminating Δz, there results

$$u = p(\Delta x)^2 + q(\Delta y)^2 + r(c - \Delta x - \Delta y)^2.$$

The conditions for a minimum of u are:—

$$\frac{\partial u}{\partial \Delta x} = (p + r)\Delta x + r\Delta y - rc = 0,$$

$$\frac{\partial u}{\partial \Delta y} = r\Delta x + (q + r)\Delta y - rc = 0;$$

and these give, in connection with the value $\Delta z = c - \Delta x - \Delta y$,

$$\Delta x = \frac{Q}{p}, \qquad \Delta y = \frac{Q}{q}, \qquad \Delta z = \frac{Q}{r}.$$

where

$$Q = \frac{c}{\frac{1}{p} + \frac{1}{q} + \frac{1}{r}}.$$

When the weights are equal, or when $p = q = r$, the corrections are—

$$\Delta x = \Delta y = \Delta z = \tfrac{1}{3}c.$$

Secondly, take the case, also alluded to above, of the observed sum and the observed difference of two numbers. Denote the numbers by ξ and η, the latter being the smaller. Let the observed values of the sum $(\xi + \eta)$ be denoted by $x_1, x_2, \ldots x_m$ and their weights $p_1, p_2, \ldots p_m$ respectively. Likewise, call the observed values of the difference $(\xi - \eta)$, $y_1, y_2, \ldots y_n$, and their weights $q_1, q_2 \ldots q_n$ respectively. Then there will be $m + n$ equations of the type (4), namely: —

$$\left.\begin{aligned}
\xi + \eta - (x_1 + \Delta x_1) &= 0,\\
\xi + \eta - (x_2 + \Delta x_2) &= 0,\\
&\ldots\ldots\\
\xi + \eta - (x_m + \Delta x_m) &= 0,\\
\xi - \eta - (y_1 + \Delta y_1) &= 0,\\
\xi - \eta - (y_2 + \Delta y_2) &= 0,\\
&\ldots\ldots\\
\xi - \eta - (y_n + \Delta y_n) &= 0;
\end{aligned}\right\} \qquad (a)$$

and the minimum equation is

$$u = p_1 (\Delta x_1)^2 + p_2 (\Delta x_2)^2 + \ldots + q_1 (\Delta y_1)^2 + q_2 (\Delta y_2)^2 + \ldots = \text{a min.} \qquad (b)$$

The equations of group (a) give

$$\left.\begin{aligned}
\Delta x_1 &= \xi + \eta - x_1,\\
\Delta x_2 &= \xi + \eta - x_2,\\
&\ldots\\
\Delta y_1 &= \xi - \eta - y_1,\\
\Delta y_2 &= \xi - \eta - y_2,\\
&\ldots;
\end{aligned}\right\} \qquad (c)$$

and these values in (b) give

$$u = p_1 (\xi + \eta - x_1)^2 + \ldots + q_1 (\xi - \eta - y_1)^2 + \ldots \qquad (d)$$

Thus it appears that all conditions will be satisfied if ξ and η are so determined as to make u in (d) a minimum. Hence, using square brackets to denote summation of like quantities, the values of ξ and η must be found from

$$\left.\begin{aligned}
\frac{\partial u}{\partial \xi} &= [p + q]\, \xi + [p - q]\, \eta - [px + qy] = 0,\\
\frac{\partial u}{\partial \eta} &= [p - q]\, \xi + [p + q]\, \eta - [px - qy] = 0.
\end{aligned}\right\} \qquad (e)$$

Equations (e) give ξ and η, and these substituted in (c) will give the corrections to the observed quantities.

b. Relation of probable, mean, and average errors.

The introduction of the law of error (2) in equations (3) furnishes the following relations, when it is assumed that the limits of possible error are $-\infty$ and $+\infty$:

$$\epsilon_p = 0.6745\, \epsilon_m = 0.8453\, \epsilon_a. \qquad (6)$$

c. Case of a single unknown quantity.

The case of a single unknown quantity whose observed values are of equal or unequal weight is comprised in the following formulas:—

$x_1, x_2, \ldots x_m =$ observed values of unknown quantity,
$p_1, p_2, \ldots p_m =$ the weights of $x_1, x_2, \ldots$
$v_1, v_2, \ldots v_m =$ most probable corrections to $x_1, x_2, \ldots$
$x =$ most probable value of the unknown quantity,
$m =$ the number of *independent* observations.

Then the conditional equations (4) are

$$x - x_1 = v_1,$$
$$x - x_2 = v_2,$$
$$\cdot \quad \cdot \quad \cdot$$
$$x - x_m = v_m;$$

the minimum equation (5) is

$$p_1v_1^2 + p_2v_2^2 + \ldots = [pv^2] = [p(x - x_i)^2] = \text{a min.},$$

where $i = 1, 2, \ldots m$, and

$$x = \frac{p_1x_1 + p_2x_2 + \ldots p_mx_m}{p_1 + p_2 + \ldots p_m} = \frac{[px]}{[p]}.$$

When the weights are equal, $p_1 = p_2 = \ldots = p_m$, and

$$x = \frac{[x]}{m},$$

or the arithmetic mean of the observed values.

Weight of $x = [p]$ when the p's are unequal,
$= m$ when the p's are equal.

Mean error of an observed value of weight unity $= \sqrt{\frac{[pvv]}{m - 1}}$ for unequal weights,

$= \sqrt{\frac{[vv]}{m - 1}}$ for equal weights.

Mean error of an observed value of weight $p = \sqrt{\frac{[pvv]}{(m - 1)\,p}}$ for unequal weights.

Mean error of $x = \sqrt{\frac{[pvv]}{(m - 1)\,[p]}}$ for unequal weights,

$= \sqrt{\frac{[vv]}{m\,(m - 1)}}$ for equal weights.

The corresponding probable errors are found by multiplying these values by 0.6745. See equation (6).

A formula for the average error sometimes useful is

$$\text{Average error} = \frac{[pv]}{\sqrt{(m-1)[p]}} \text{ for unequal weights.}$$

$$= \frac{[v]}{\sqrt{m(m-1)}} \text{ for equal weights.}$$

In these the residuals v are all taken with the same sign. A sufficient approximation in many cases of equal weights is $\frac{[v]}{m}$; but the above formulas dependent on the squares of the residuals are in general more precise.

An important check on the computation of x is $[pv] = 0$; *i. e.*, the sum of the residuals v, each multiplied by its weight, is zero if the computation is correct.

d. Case of observed function of several unknown quantities $\xi, \eta, \zeta \ldots$

A case of frequent occurrence, and one which includes the preceding case, is that in which a function of several unknown quantities is observed. Thus, for example, the observed time of passage of a star across the middle thread of a transit instrument is a function of the azimuth and collimation of the transit instrument and the error of the timepiece used. In cases of this kind the conditional equations of the type (4) assume the form

$$F(\xi, \eta, \zeta \ldots x + \Delta x) = 0;$$

that is, each of them contains but one observed quantity x along with several disposable (disposable in satisfying the minimum equation) quantities $\xi, \eta, \zeta \ldots$

The process of solution in this case consists in eliminating the corrections $\Delta x_1, \Delta x_2, \ldots$ from the above conditional equations, substituting their values in the minimum equation (5), and then placing the differential coefficients of u with respect to $\xi, \eta, \zeta \ldots$ separately equal to zero. There will thus result as many independent equations as there are unknown quantities of the class in which $\xi, \eta, \zeta \ldots$ fall, the remaining unknown quantities $\Delta x_1, \Delta x_2, \ldots$, or the corrections to the observed values, are then found from the conditional equations.

In many applications it happens that the conditional equations

$$F(\xi, \eta, \zeta, \ldots x + \Delta x) = 0,$$

are not of the linear form. But they may be rendered linear in the following manner. First, eliminate the quantities $x + \Delta x$ from the conditional equations. The result of this elimination may be written

$$f(\xi, \eta, \zeta \ldots) - x - \Delta x = 0.$$

Secondly, put

$$\xi = \xi_0 + \Delta\xi,$$
$$\eta = \eta_0 + \Delta\eta,$$
$$\cdot \quad \cdot \quad \cdot$$

where $\xi_0, \eta_0, \ldots$ are approximate values of $\xi, \eta, \ldots$, found in any manner, and $\Delta\xi, \Delta\eta, \ldots$ are corrections thereto. Then supposing the approximate values

$\xi_0, \eta_0, \ldots$ so close that we may neglect the squares, products, and higher powers of $\Delta\xi, \Delta\eta, \ldots$, Taylor's series gives

$$f(\xi_0, \eta_0, \zeta_0, \ldots) + \frac{\partial f}{\partial \xi}\Delta\xi + \frac{\partial f}{\partial \eta}\Delta\eta + \frac{\partial f}{\partial \zeta}\Delta\zeta + \ldots - x - \Delta x = 0,$$

which is linear with respect to the corrections $\Delta\xi, \Delta\eta, \ldots$. For brevity, and for the sake of conformity with notation generally used, put

$$n = x - f(\xi_0, \eta_0, \zeta_0 \ldots);$$
$$v = \Delta x,$$

$$a = \frac{\partial f}{\partial \xi}, \qquad b = \frac{\partial f}{\partial \eta}, \qquad c = \frac{\partial f}{\partial \zeta}, \ldots$$

$$x = \Delta\xi, \qquad y = \Delta\eta, \qquad z = \Delta\zeta, \ldots.$$

Then the conditional equations will assume the form

$$ax + by + cz + \ldots - n = v;$$

and if they are m in number they may be written individually thus: —

$$\begin{aligned} a_1x + b_1y + c_1z + \ldots - n_1 &= v_1, \\ a_2 \quad + b_2 \quad + c_2 \quad + \ldots - n_2 &= v_2, \\ \ldots \\ a_m \quad + b_m \quad + c_m \quad + \ldots - n_m &= v_m. \end{aligned} \qquad \text{(a)}$$

The minimum equation (5) becomes

$$u = [pv^2] = [p(ax + by + cz + \ldots - n)^2];$$

so that placing $\frac{\partial u}{\partial x}, \frac{\partial u}{\partial y}, \frac{\partial u}{\partial z}, \ldots$ separately equal to zero will give as many independent equations as there are values of $x, y, z, \ldots$. The resulting equations are in the usual (Gaussian) notation of least squares: —

$$\begin{aligned} [paa]x + [pab]y + [pac]z + \ldots - [pan] &= 0, \\ [pab] \quad + [pbb] \quad + [pbc] \quad + \ldots - [pbn] &= 0, \\ [pac] \quad + [pbc] \quad + [pcc] \quad + \ldots - [pcn] &= 0, \\ \ldots \end{aligned} \qquad \text{(b)}$$

The equations (a) are sometimes called observation-equations. The absolute term n is called the observed quantity. It is always equal to the observed quantity *minus* the computed quantity $f(\xi_0, \eta_0, \zeta \ldots)$, which latter is assumed to be free from errors of observation. The term v is called the residual. It is sometimes, though quite erroneously, replaced by zero in the equations (a).

The equations (b) are called normal equations. They are usually formed directly from equations (a) by the following process: Multiply each equation by the coefficient of x and by the weight p of the v in the same equation, and add the products. The result is the first equation of (b), or the normal equation in x. The normal equations in $y, z, \ldots$ are found in a similar manner.

A noteworthy peculiarity of the normal equations is their symmetry. Hence in forming equations (b) from (a) it is not essential to compute all the coefficients of $x, y, z, \ldots$ except in the first equation.

Checks on the computed values of the numerical terms in the normal equations are found thus: Add the coefficients $a, b, c, \ldots$ of $x, y, z, \ldots$ in (a) and put

$$
\begin{aligned}
&a_1 + b_1 + c_1 + \ldots = s_1, \\
&a_2 + b_2 + c_2 + \ldots = s_2, \\
&\ldots\ldots
\end{aligned}
$$

Multiply each of these, first, by its pa; secondly, by its pb, etc., and then add the products. The results are

$$
\begin{aligned}
&[paa] + [pab] + [pac] + \ldots = [pas] \\
&[pab] + [pbb] + [pbc] + \ldots = [pbs] \\
&\ldots\ldots
\end{aligned}
$$

These will check the coefficients of $x, y, z, \ldots$ in (b). To check the absolute terms, multiply each of the above sums by its np, and add the products. The result is

$$[pan] + [pbn] + [pcn] + \ldots = [psn],$$

which must be satisfied if the absolute terms are correct.

Checks on the computation of $x, y, z, \ldots$ from (b) and of $v_1, v_2, \ldots$ from (a) are furnished by

$$[pav] = 0, \qquad [pbv] = 0, \qquad [pcv] = 0, \qquad \ldots\ldots$$

To get the unknowns x, y, z, and their weights simultaneously, the best method of procedure is, in general, the following: For brevity replace the absolute terms in (b) by $A, B, C, \ldots$ respectively. Then the solution of (b) will be expressed by

$$
\begin{aligned}
x &= \alpha_1 A + \beta_1 B + \gamma_1 C + \ldots, \\
y &= \alpha_2 \quad + \beta_2 \quad + \gamma_2 \quad + \ldots, \\
z &= \alpha_3 \quad + \beta_3 \quad + \gamma_3 \quad + \ldots, \\
&\ldots,
\end{aligned} \qquad \text{(c)}
$$

in which $\alpha_1, \beta_1, \gamma_1, \ldots$ are numerical quantities; and

$$
\begin{aligned}
\text{weight of } x &= \frac{1}{\alpha_1}, \\
\text{weight of } y &= \frac{1}{\beta_2}, \\
\text{weight of } z &= \frac{1}{\gamma_3}, \\
&\ldots\ldots
\end{aligned} \qquad \text{(d)}
$$

To compute mean (and hence probable) errors the following formulas apply: —

m = the number of observed quantities n

= number of equations of condition,

μ = number of the quantities $x, y, z, \ldots$

ϵ_m = mean error of an observed quantity (n) of weight unity,

ϵ_p = corresponding probable error = $0.6745\ \epsilon_m$.

$$\epsilon_m = \sqrt{\frac{[pvv]}{m - \mu}} \text{ for unequal weights,}$$

$$= \sqrt{\frac{[vv]}{m - \mu}} \text{ for equal weights,}$$

Mean error of any observed quantity (n) of weight $p = \frac{\epsilon_m}{\sqrt{p}}$,

Mean error of $x = \epsilon_m \sqrt{\alpha_1}$,
Mean error of $y = \epsilon_m \sqrt{\beta_2}$,
Mean error of $z = \epsilon_m \sqrt{\gamma_3}$,
. . . ,

where $\alpha_1, \beta_2, \gamma_3, \ldots$ are defined by equations (c) and (d) above.

e. Case of functions of several observed quantities x, y, z, ...

This case is that in which the conditional equations (4) contain no disposable quantities $\xi, \eta, \zeta, \ldots$. It is the opposite extreme to that represented by the case of the preceding section.* It finds its most important and extensive application in the adjustment of triangulation, wherein the observed quantities are the angles and bases of the triangulation, and the conditions (4) arise from the geometrical relations which the observed quantities *plus* their respective corrections must satisfy.

An outline of the general method of procedure in this case is the following: —

The first step consists in stating the conditional equations and in reducing them to the linear form if they are not originally so. The form in which they present themselves is (4) with $\xi, \eta, \zeta, \ldots$ suppressed, or

$$F(x_1 + \Delta x_1, x_2 + \Delta x_2, x_3 + \Delta x_3, \ldots) = 0,$$

wherein $x, y, z, \ldots$ of (4) are replaced by $x_1, x_2, x_3 \ldots$ for the purpose of simplicity in the sequel. If this equation is not linear, Taylor's series gives

$$F(x_1, x_2, x_3 \ldots) + \frac{\partial F}{\partial x_1}\Delta x_1 + \frac{\partial F}{\partial x_2}\Delta x_2 = \ldots = 0,$$

since the method supposes that the squares, products, etc., of $\Delta x_1, \Delta x_2 \ldots$ may be neglected. The last equation is then linear with respect to the corrections $\Delta x_1, \Delta x_2 \ldots$ which it is desired to find.

For brevity put

$$F(x_1, x_2, x_3 \ldots) = q_1, \text{ a known quantity,}$$

$$\frac{\partial F}{\partial x_1} = a_1, \qquad \frac{\partial F}{\partial x_2} = a_2, \qquad \frac{\partial F}{\partial x_3} = a_3, \ldots .$$

Then the conditional equations will be of the type

$$a_1\Delta x_1 + a_2\Delta x_2 + a_3\Delta x_3 + \ldots + q_1 = 0.$$

* The middle ground between these extremes has been little explored; indeed, most practical applications fall at one or the other of the extremes.

There will be as many equations of this type as there are independent relations which the quantities $x_1 + \Delta x_1$, $x_2 + \Delta x_2$, ... must satisfy. Suppose there are k such relations, and let the differential coefficients $\partial F/\partial x_1$, $\partial F/\partial x_2$, ... for the second relation be denoted by b_1, b_2, b_3, ... ; for the third relation by c_1, c_2, c_3, ..., etc. Then all of the conditional equations may be written thus:

$$\begin{array}{llll} a_1\Delta x_1 + a_2\Delta x_2 + a_3\Delta x_3 + \ldots + q_1 = 0, \\ b_1 \qquad\; + b_2 \qquad\; + b_3 \qquad\; + \ldots + q_2 = 0, \\ c_1 \qquad\; + c_2 \qquad\; + c_3 \qquad\; + \ldots + q_3 = 0, \\ \ldots, \end{array} \qquad (a)$$

the number of these equations being k.

Call the weights of the observed quantities x_1, x_2, ... p_1, p_2, ... Then, subject to the conditions (a) we must have (in accordance with (5))

$$u = p_1(\Delta x_1)^2 + p_2(\Delta x_2)^2 + \ldots = [p(\Delta x)^2] \qquad (b)$$

a minimum.

Equations (a) and (b) contain the solution of all problems falling under the present case. Obviously, the number of conditions (a) must be less than the number of observed quantities x, or less than the number of Δx's in (b); in other words, if m denote the number of observed quantities, $m > k$, for if $m \overline{\gtrless} k$ the minimum equation (b) has no meaning.

The question presented by (a) and (b) is one of elimination only. Two methods, the one direct and the other indirect, are available. Thus, by the direct method one finds from (a) as many Δx's as there are equations (a), or k such values, and substitutes them in (b). The remaining $(m - k)$ values of Δx in (b) may then be treated as independent and the differential coefficients of u with respect to each of them placed equal to zero. Thus all of the corrections Δx become known.

By the indirect process, one multiplies the first of equations (a) by a factor Q_1, the second by Q_2, the third by Q_3, ... and subtracts the differential (with respect to the Δx's) of the sum of these products from half the differential of (b). The result of these operations is

$$\begin{aligned} \tfrac{1}{2}\,du = &\{p_1\Delta x_1 - (a_1Q_1 + b_1Q_2 + c_1Q_3 + \ldots)\}\, d\Delta x_1 \\ &+ \{p_2\Delta x_2 - (a_2Q_1 + b_2Q_2 + c_2Q_3 + \ldots)\}\, d\Delta x_2 \\ &+ \ldots \\ &+ \{p_m\Delta x_m - (a_mQ_1 + b_mQ_2 + c_mQ_3 + \ldots)\}\, d\Delta x_m \end{aligned}$$

Now we may choose the factors Q_1, Q_2, ... Q_k in such a way as to make k of the coefficients of the differentials in this equation disappear; and after thus eliminating k of these differentials we are at liberty to place the coefficients of the remaining $(m - k)$ differentials equal to zero. Thus all conditions are satisfied by making

$$\begin{array}{l} a_1Q_1 + b_1Q_2 + c_1Q_3 + \ldots - p_1\Delta x_1 = 0, \\ a_2 \quad\; + b_2 \quad\; + c_2 \quad\; + \ldots - p_2\Delta x_2 = 0, \\ \ldots \\ a_m \quad + b_m \quad + c_m \quad + \ldots - p_m\Delta x_m = 0; \end{array} \qquad (c)$$

and the values of the corrections will be given by these equations when the factors Q_1, Q_2, ... are known. To find the latter it suffices to substitute the values of Δx, Δx_2, . . . from (c) in (a), whereby there will result k equations containing the Q_1, Q_2 . . . Q_k alone as unknowns. The result of this substitution is

$$\begin{aligned} \left[\frac{aa}{p}\right] Q_1 + \left[\frac{ab}{p}\right] Q_2 + \left[\frac{ac}{p}\right] Q_3 + \ldots + q_1 &= 0, \\ \left[\frac{ab}{p}\right] \quad + \left[\frac{bb}{p}\right] \quad + \left[\frac{bc}{p}\right] \quad + \ldots + q_2 &= 0, \qquad (d) \\ \left[\frac{ac}{p}\right] \quad + \left[\frac{bc}{p}\right] \quad + \left[\frac{cc}{p}\right] \quad + \ldots + q_3 &= 0, \\ \ldots\ldots \end{aligned}$$

These equations (d) are derived directly from (c) in the following manner: multiply the first of (c) by $\frac{a_1}{p_1}$, the second by $\frac{a_2}{p_2}$, etc., sum the products, and compare the sum with the first of (a). The first of (d) is then evident; the others are obtained in a similar way.

The mean error of an observed quantity of weight unity is in this case given by the formula

$$\epsilon_m = \sqrt{\frac{[p(\Delta x)^2]}{k}},$$

where k is the number of conditions (a); and the mean error of any observed value of weight p is

$$\frac{\epsilon_m}{\sqrt{p}}.$$

f. Computation of mean and probable errors of functions of observed quantities.

Let V denote any function of one or more independently observed quantities $x, y, z, \ldots$; that is, let

$$V = f(x, y, z \ldots).$$

A question of frequent occurrence with respect to such functions is, What is the mean* error of V in terms of the mean errors of $x, y, z, \ldots$? The answer to this question given by the method of least squares assumes that the actual errors (whatever they may be) of $x, y, z, \ldots$ are so small that the actual error of V is a linear function of the errors of x, y, z. In other words, if $e_x, e_y, e_z, \ldots$ denote the actual errors of $x, y, z, \ldots$, and ΔV denote the corresponding actual error of V, the method assumes that

$$\Delta V = \frac{\partial V}{\partial x} e_x + \frac{\partial V}{\partial y} e_y + \frac{\partial V}{\partial z} e_z + \ldots, \qquad (a)$$

wherein the squares, products, etc., of $e_x, e_y, e_z, \ldots$ are omitted.

This condition being fulfilled, let ϵ denote the mean error of V, and $\epsilon_x, \epsilon_y, \epsilon_z \ldots$ denote those of $x, y, z, \ldots$ respectively. Then the law of error of least squares requires that

$$\epsilon^2 = \left(\frac{\partial V}{\partial x}\right)^2 \epsilon_x^2 + \left(\frac{\partial V}{\partial y}\right)^2 \epsilon_y^2 + \left(\frac{\partial V}{\partial z}\right)^2 \epsilon_z^2 + \ldots \qquad (b)$$

* Since the probable error is 0.6745 times the mean error the latter only need be considered.

This equation includes all cases. Its analogy with (a) should be noted, since the step from (a) to (b) is clear when the correct form of (a) is known. Mistakes in the application of (b) are most likely to arise from a lack of knowledge of the *independently observed* quantities $x, y, z, \ldots$ or from a lack of knowledge of the true form of (a). Hence,* in deriving probable errors of functions of observed quantities attention should be given first to the construction of the expression for the actual error (a).

A few examples may serve to illustrate the use of (a) and (b).

(1.) Suppose

$$V = f(x, y, z, \ldots) = a(x - y) + b(y + z) + c(z - 1).$$

Then

$$\frac{\partial V}{\partial x} = a, \qquad \frac{\partial V}{\partial y} = b - a, \qquad \frac{\partial V}{\partial z} = b + c,$$

$$\Delta V = ae_x + (b - a)e_y + (b + c)e_z,$$

$$\epsilon^2 = a^2\epsilon_x^2 + (b - a)^2\epsilon_y^2 + (b + c)^2\epsilon_z^2.$$

(2.) Suppose

$$V = f(x, y, z \ldots) = \frac{a}{x} + b\frac{y}{z^2}.$$

Then

$$\frac{\partial V}{\partial x} = -\frac{a}{x^2}, \qquad \frac{\partial V}{\partial y} = \frac{b}{z^2}, \qquad \frac{\partial V}{\partial z} = -\frac{2\,by}{z^3},$$

$$\Delta V = -\frac{a}{x^2}e_x + \frac{b}{z^2}e_y - \frac{2\,by}{z^3}e_z,$$

$$\epsilon^2 = \frac{a^2}{x^4}\epsilon_x^2 + \frac{b^2}{z^4}\epsilon_y^2 + \frac{4\,b^2y^2}{z^6}\epsilon_z^2.$$

(3.) Suppose

$$V = a \log x + b \sin y + c \log \tan z.$$

Then

$$\frac{\partial V}{\partial x} = \frac{a\mu}{x}\dagger, \qquad \frac{\partial V}{\partial y} = b \cos y, \qquad \frac{\partial V}{\partial z} = \frac{c\mu}{\sin z \cos z},$$

and

$$\epsilon^2 = \left(\frac{a\mu}{x}\right)^2\epsilon_x^2 + (b \cos y)^2\epsilon_y^2 + \left(\frac{2\,c\mu}{\sin 2z}\right)^2\epsilon_z^2.$$

(4.) Suppose the case of a single triangle all of whose angles are observed. What is the mean error, 1st, of an observed angle; 2d, of the correction to an observed angle; and 3d, of the corrected or adjusted angle?

Let x, y, z denote the observed angles, p, q, r their weights, and $\Delta x, \Delta y, \Delta z$ the corresponding corrections.

Then, as shown on p. lxxxvii,

$$\Delta x + \Delta y + \Delta z = c = 180^\circ + \text{sph. excess} - (x + y + z)$$
$$= \text{error of closure of triangle,}$$

$$Q = \frac{c}{\frac{1}{p} + \frac{1}{q} + \frac{1}{r}},$$

$$\Delta x = \frac{Q}{p}, \qquad \Delta y = \frac{Q}{q}, \qquad \Delta z = \frac{Q}{r}.$$

* As remarked by Sir George Airy in his *Theory of Errors.*

† μ = modulus of common logarithms.

For brevity, put

$$g = 180^\circ + \text{spherical excess}, \qquad h = \frac{1}{\frac{1}{p} + \frac{1}{q} + \frac{1}{r}}.$$

Then

$$Q = h\,(g - x - y - z) = hc,$$

$$\Delta x = \frac{h}{p}(g - x - y - z),$$

$$x + \Delta x = \frac{h}{p}(g - x - y - z) + x,$$

with similar expressions for the other two angles.

Now by the formula on p. xcv the square of the mean error of an observed angle of weight unity is (since there is but one condition to which Δx, Δy, Δz are subject),

$$p(\Delta x)^2 + q(\Delta y)^2 + r(\Delta z)^2 = \frac{Q^2}{h} = hc^2.$$

Hence, the squares of the mean errors of the *observed* angles x, y, z, their weights being p, q, r respectively, are

$$\frac{hc^2}{p}, \qquad \frac{hc^2}{q}, \qquad \frac{hc^2}{r},$$

respectively.

To get the mean error of a correction, Δx for example, formula (a) gives

$$\Delta V = \Delta(\Delta x) = -\frac{h}{p}(e_x + e_y + e_z),$$

and the corresponding expressions for the actual errors of Δy and Δz are found from this by replacing p by q and r respectively. Thus by (b), observing that the mean errors of x, y, z are given above, there result

Square of mean error of $\Delta x = (hc/p)^2$,
" " " $\Delta y = (hc/q)^2$,
" " " $\Delta z = (hc/r)^2$.

Likewise, the formula for the actual error of $x + \Delta x$ is

$$\Delta V = \Delta(x + \Delta x) = \left(1 - \frac{h}{p}\right)e_x - \frac{h}{p}e_y - \frac{h}{p}e_z,$$

and the corresponding expressions for the actual errors of $y + \Delta y$ and $z + \Delta z$ are found by interchange of q and r with p. Thus the squares of the mean errors of the *adjusted* angles are : —

for $(x + \Delta x)$, $\quad \dfrac{hc^2}{p}\left(1 - \dfrac{h}{p}\right)$,

for $(y + \Delta y)$, $\quad \dfrac{hc^2}{q}\left(1 - \dfrac{h}{q}\right)$,

for $(z + \Delta z)$, $\quad \dfrac{hc^2}{r}\left(1 - \dfrac{h}{r}\right)$.

In case the weights are equal, or in case $p = q = r$, $h = \frac{1}{3}$, and there result, —

Square of mean error of observed angle	$= \frac{1}{3} c^2$,
" " " " " correction to observed angle	$= \frac{1}{9} c^2$,
" " " " " adjusted angle	$= \frac{2}{9} c^2$,

where c is the error of closure of the triangle; so that in this case of equal weights the three mean errors are to one another as $\frac{1}{3}\sqrt{3}$, $\frac{1}{3}$, and $\frac{1}{3}\sqrt{2}$.

References.

The literature of the theory of errors, especially as exemplified by the method of least squares, is very extensive. Amongst the best treatises the following are worthy of special mention: Method of Least Squares, Appendix to vol. ii. of Chauvenet's "Spherical and Practical Astronomy." Philadelphia: J. B. Lippincott & Co., 8vo, 5th ed., 1887. "A Treatise on the Adjustment of Observations, with Applications to Geodetic Work and Other Measures of Precision," by T. W. Wright. New York: D. Van Nostrand, 8vo, 1884. "On the Algebraical and Numerical Theory of Errors of Observation and on the Combination of Observations," by Sir George Biddle Airy. London: Macmillan & Co., 12mo, 2d ed., 1875. "Die Ausgleichungsrechnung nach der Methode der Kleinsten Quadrate, mit Anwendungen auf die Geodäsie und die Theorie der Messinstrumente," von F. R. Helmert. Leipzig: B. G. Teubner, 8vo, 1872.

EXPLANATION OF SOURCE AND USE OF THE TABLES.

TABLES 1 and 2 are copies of tables issued by the Office of Standard Weights and Measures of the United States, edition of November, 1891.

Table 3 is derived from standard tables giving such data. The arrangement is that given in "Des Ingenieurs Taschenbuch, herausgegeben von dem Verein 'Hütte'"* (11th edition, 1877). The numbers have been compared with those given in the latter work, and also with those in Barlow's "Tables." The logarithms have been checked by comparison with Vega's 7-place tables.

Table 4 is abridged from a similar table in the Taschenbuch just referred to.

Tables 5 and 6 are copies of standard forms for such table. They have been checked by comparison with standard higher-place tables. The mode of using these tables will be evident from the following examples: —

(1.) To find the logarithm of any number, as 0.06944, we look in **Table 5** in the column headed N for the first two significant figures of the number, which are in this case 69. In the same horizontal line with 69 we now look for the number in the column headed with the next figure of the given number, which is in the present case 4. We thus find .8414 for the mantissa of the logarithm of the number 694. To get the increase due to the additional figure 4, we look in the same horizontal line under Prop. Parts in the column headed 4 and find the number 2, which is the amount in units of the fourth place to be added to the part of the mantissa previously found. Thus the mantissa of log (0.06944) is .8416. The characteristic for the logarithm in question is $-2 = 8 - 10$. Hence $\log (0.06944) = 8.8416 - 10$.

(2.) To find the number corresponding to any logarithm, as $8.8416 - 10$, we look in **Table 6** in the column headed L for the first two figures of the mantissa, which are in this case 84. In the same horizontal line with 84 we now look for the number in the column headed by the next figure of the mantissa, which is in this case 1. We thus find 6394 for the number corresponding to the mantissa 8410. To get the increase due to the additional figure 6, we look in the same horizontal line under Prop. Parts in the column headed 6 and find 10, which is the amount in units of the fourth place to be added to the number previously found. Thus the significant figures of the number are 6944, and since the characteristic of the logarithm is $8 - 10 = -2$, the required number is 0.06944.

* Berlin: Verlag von Ernst & Korn. This work is an invaluable one to the engineer, architect, geographer, etc.

Tables 7 and 8 are taken from "Smithsonian Meteorological Tables" (the first volume of this series). Their mode of use will be apparent from the following example: Required the sine and tangent for 28° 17′.

sine 28° 10′, Table 7	0.4720.	Tabular difference = 26.
Proportional part for 7′ (7 × 2.6) . .	18.	
sine 28° 17′	0.4738.	

tangent 28° 10′, Table 8	0.5354.	Difference for 1′ = 3.8.
Increase for 7′ (7 × 3.8)	27.	
tangent 28° 17′	0.5381.	

Table 9 is a copy of a similar table published in "Professional Papers, Corps Engineers," U. S. A., No. 12. It has been checked by comparison with other tables in general use. This table is useful in computing latitudes and departures in traverse surveys wherein the bearings of the lines are observed to the nearest quarter of a degree, and in other work where multiples of sines and cosines are required. Thus, if L denote the length and B the bearing from the meridian of any line, the latitude and departure of the line are given by

$$L\cos B \quad \text{and} \quad L\sin B$$

respectively; the "latitude" being the distance approximately between the parallels of latitude at the ends of the line, and the "departure" being the distance approximately between the meridians at the ends of the line. As an example, let it be required to compute the latitude and departure for $L = 4837$, in any unit, and $B = 36° 15′$. The computation runs thus: —

	Latitude.	Departure.
For 4000	3225.77	2365.23
800	645.16	473.05
30	24.19	17.74
7	5.63	4.14
4837	$L\cos B = 3900.77$	$L\sin B = 2860.16$

Tables 10 and 11 give the logarithms of the principal radii of curvature of the earth's spheroid. They were computed by Mr. B. C. Washington, Jr., and carefully checked by differences. They depend on the elements of Clarke's spheroid of 1866. The use of these tables is sufficiently explained on p. xlv–xlix.

Table 12 gives logarithms of radii of curvature of the earth's spheroid in sections inclined to the meridian sections. It is abridged to 5 places from a 6-place table published in the "Report of the U. S. Coast and Geodetic Survey for 1876." Its use is explained on pp. lxi–lxiv.

Tables 13 and 14 give logarithms of factors needed to compute the spheroidal excess of triangles on the earth's spheroid. No. 13 is constructed for the English foot as unit, and No. 14 for the metre. These tables were computed by Mr.

Charles H. Kummell. Their use is explained on p. lviii. The following example will illustrate their use: —

Latitude of vertex A of triangle		48° 08′
" " B "		47 52
" " C "		47 04
Mean latitude		47 41

Angle $C = 51° 22' 55''$ log sin C	9.89283 — 10
log a (feet)	5.64401
log b (feet)	5.58681
log factor, **Table 13**, for 47° 41′	0.37176
Spheroidal excess = 31.″290, log	1.49541

Tables 15 and 16 give logarithms of factors for computing differences of latitude, longitude, and azimuth in secondary triangulation whose lines are 12 miles (20 kilometres) or less in length. These tables were computed by Mr. Charles H. Kummell. **Table 15** gives factors for the English foot as unit, and **Table 16** for the metre as unit. The use of these tables is illustrated by a numerical example given on pp. lx and lxi. For lines not exceeding the length mentioned, the tables will give differences of latitude and longitude to the nearest hundredth of a second of arc, using 5-place logarithms of the lengths of the lines.

Table 17 gives lengths of terrestrial arcs of meridians corresponding to latitude intervals of 10″, 20″, . . . 60″, and 10′, 20′, . . . 60′, or lengths corresponding to arcs less than 1°. The unit of length is the English foot. The table was computed by Mr. B. C. Washington, Jr.

The length corresponding to any latitude interval is the distance along the meridian between parallels whose latitudes are less and greater respectively than the given latitude by half the interval. Thus, for example, the length corresponding to the interval 30′ and latitude 37° (182047.3 feet) is the distance along the meridian from latitude 36° 45′ to latitude 37° 15′.

By interpolation, we may get from this table the meridional distance corresponding to any interval. The following example illustrates this use: Required the distance between latitude 41° 28′ 17.″8 and latitude 41° 39′ 53.″4. The difference of these latitudes is 11′ 35.″6, and their mean is 41° 34′ 05.″6. The computation runs thus: —

	Latitude 41°.	Tabular difference.
10′	60724.60 feet	10.70 feet
1′	6072.46 "	1.07 "
30″	3036.23 "	.54 "
5″	506.04 "	.09 "
0.″6	60.72 "	.01 "
$\frac{34.09}{60} \times 12.41$	7.05 "	sum, 12.41 "
Distance =	70407.10 "	

When the degree of precision required is as great as that of the example just given, it will be more convenient to use formulas (2) on p. xlvi. Thus, in this example, —

		log.
$\Delta\phi = 695.''6$		2.8423596
$\phi = 41^\circ\ 34'\ 05.''6$, ρ_m	(Table 10)	7.3196820
	cons't	4.6855749
Length $= 70407.10$ feet		4.8476165

Table 18 gives lengths of terrestrial arcs of parallels corresponding to longitude intervals of 10″, 20″, . . . 60″, and 10′, 20′, . . . 60′, or lengths corresponding to arcs less than 1°. The unit is the English foot. This table was computed by Mr. B. C. Washington, Jr.

The method of using this table is similar to that applicable to Table 17 explained above. For the computation of long arcs it will in general be less laborious to use the formulas (1) on p. xlix than to resort to interpolation from Table 18.

Tables 19–24 give the rectangular co-ordinates for the projection of maps, in accordance with the polyconic system explained on pp. liii–lvi, for the following scales respectively : —

Table 19, scale	$\frac{1}{250000}$		unit = English inch.
" 20, "	$\frac{1}{125000}$		unit = English inch.
" 21, "	$\frac{1}{126720}$	(2 miles to 1 inch)	unit = English inch.
" 22, "	$\frac{1}{63360}$	(1 mile to 1 inch)	unit = English inch.
" 23, "	$\frac{1}{200000}$		unit = millimetre.
" 24, "	$\frac{1}{80000}$		unit = millimetre.

These tables were computed by Mr. B. C. Washington, Jr.

The use of these tables and their application in the construction of maps may be best explained by an example. Suppose it is required to draw meridians and parallels for a map of an area of 1° extent in longitude, lying between the parallels of 34° and 35°. Let the scale of the map be one mile to the inch, or 1/63360, and let the meridians and parallels be 10′ apart respectively. Draw on the projection paper an indefinite straight line *AB*, Fig. 4, to represent the middle meridian of the map. Take any convenient point, as *C*, on this line for the latitude 34°, and lay off from this point the meridional distances *CD*, *CE*, *CF*, . . . *CI*, given in the second column of Table 22, p. 114.* Through the points *D*, *E*, *F*, . . . I, thus found, draw indefinite straight lines perpendicular to *AB*. By means of these lines and the tabular co-ordinates, points on the developed parallels and meridians are readily found. Thus, for example, the abscissas for points ten minutes apart on the parallel 34° 20′ are 9.53, 19.06, and 28.59 inches. These distances are to be laid off on *NN′* in both directions from *AB*. At the points *L*, *M*, *N*, *L′*, *M′*, *N′*, so determined, erect perpendiculars to *NN′* equal in length, respectively, to the ordinates corresponding to the longitude intervals

* The meridional distances and the abscissas of the points on the developed parallels in Fig. 4 are one twentieth of the true or tabular values. The ordinates of points on the developed parallels are the tabular values.

10′, 20′, 30′. The curved line joining the extremities of these perpendiculars is the parallel required. It may be drawn by means of a flexible ruler. The other parallels are constructed in the same manner. They are all concave towards the north or south according as the map shows a portion of the northern or southern hemisphere. The meridians are drawn in a similar manner through the points (*e. g.*, *P*, *Q*, *M*, *R*, *S*, *T*, *U* in Fig. 4) having the same longitude relative to the middle meridian. All meridians are concave towards the middle meridian.

A test of the graphical work which should always be applied is the approximation to equality of corresponding diagonals in the various quadrilaterals formed. Thus in Fig. 4, *VX* should be equal to *WY*, *CN* to *CN′*, *EV* to *EW*, etc.*

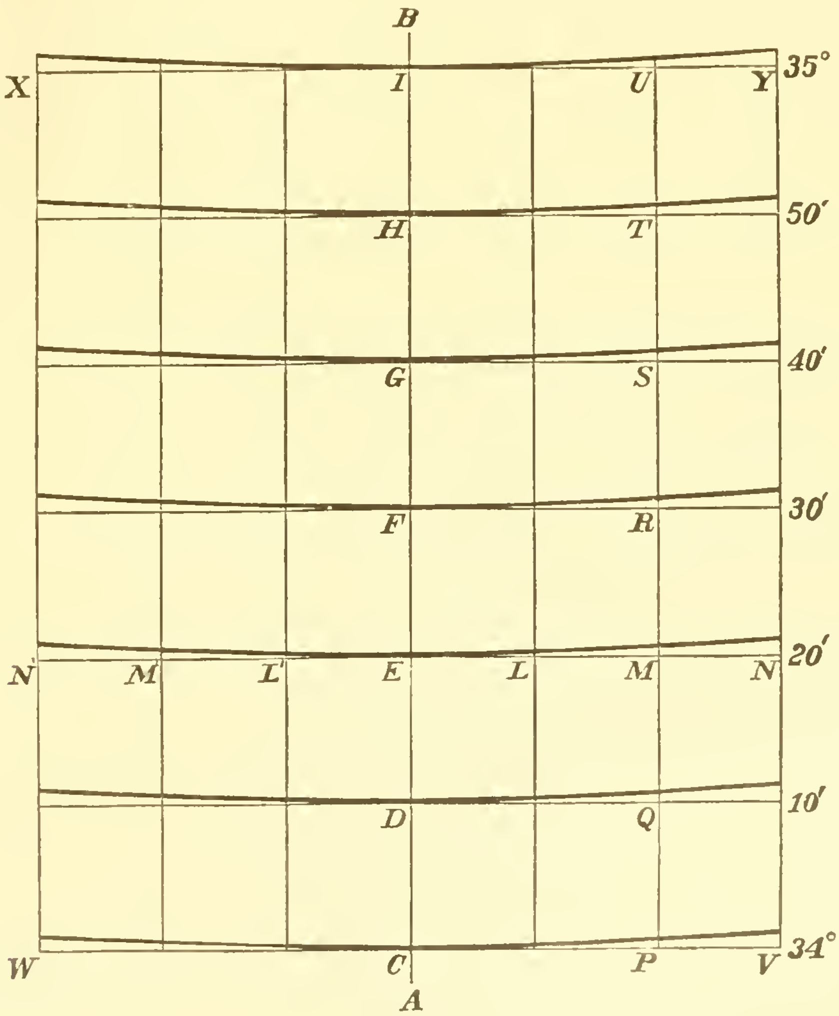


Fig. 4.

Tables 25–29 give areas of quadrilaterals, bounded by meridians and parallels, of the earth's surface. They are taken from "Bulletin 50, U. S. Geological Survey." The unit of length used is the English mile, and the areas are thus given in square miles. The method of using these tables is obvious.

Table 30 gives data for the computation of heights, from barometric measures, in accordance with the formula of Babinet.† This table is taken from the "Smithsonian Meteorological Tables" (the first volume of this series). The manner of using it is explained in connection with the table.

* It should be noted that *CN* is not equal to *EV*, *N* and *V* referring here to points on the developed parallels.

† *Comptes Rendus*, Paris, 1850, vol. xxv. p. 309.

Table 31 gives the mean astronomical refraction in terms of the apparent altitude of a star or other object outside the earth's atmosphere. It is taken from Vega's 7-place table of logarithms. Its use will be evident from the following example: —

Apparent altitude of star	$= 34^\circ$	$17'$	$12.''7$
Refraction $= 1' \; 24.''3 - \frac{3}{20} \times 1.''1 =$		1	24.1
True altitude of star	$= 34$	15	48.6

Tables 32 and 33 facilitate the interconversion of arc and time. They are taken from the "Smithsonian Meteorological Tables" (the first volume of this series). The following examples illustrate their use: —

(1.) To convert $68^\circ \; 29' \; 48.''8$ into time we have from **Table 32** —

$68^\circ =$	4^h	32^m	00^s
$29' =$		1	56
$48'' =$			3.20
$0.''8 =$			.05
Equivalent in time $=$	4	33	59.25

(2.) To convert $5^h \; 43^m \; 28.^s8$ into arc we have from **Table 33** —

$5^h =$	75°	$00'$	$00''$
$43^m =$	10	45	00
$28^s =$		7	00
$0.^s8 =$			12
Equivalent in arc $=$	85	52	12

Tables 34 and 35 facilitate the interconversion of mean solar and sidereal time intervals. They are taken from Vega's 7-place table of logarithms. The mode of using them is explained in the tables themselves.

Tables 36 and 37 give the lengths of degrees of terrestrial arcs of meridians and parallels expressed in metres,* statute miles (English), and geographic miles (distance corresponding to 1′ on the earth's equator). These tables are taken from the "Smithsonian Meteorological Tables" (the first volume of this series).

Table 38 facilitates the interconversion of statute (English) miles and nautical miles. The nautical mile used is that defined by the U. S. Coast and Geodetic Survey, namely: the length of a minute of arc of a great circle of the sphere whose surface equals that of the earth (Clarke's spheroid of 1866). For formula for radius of such sphere see p. lii. This table is taken from the "Smithsonian Meteorological Tables" (the first volume of this series).

Table 39 gives the English and metric equivalents of other standards of length still in use or obsolescent. It is taken from the "Smithsonian Meteorological Tables" (the first volume of this series).

Table 40 gives values of the acceleration (g) of gravity, $\log g$, $\log (1/2g)$, $\log \sqrt{2g}$,

* It should be observed that the metric values given in these tables depend on Clarke's value of the ratio of the yard to the metre, which is now known to be erroneous by about the 1/100000th part.

and (g/π^2) or the length of a seconds pendulum, for intervals of 5° of geographical latitude. It was computed by the editor, and is based on the formula for g given by Professor William Harkness in his memoir "On the Solar Parallax and its Related Constants." *

Table 41 gives the linear expansions of the principal metals. It was compiled by the editor from various sources. The values given for the expansion per degree Centigrade have been rounded (with one exception) to the nearest unit in the millionths place, or to the nearest micron, since different specimens of the same metal vary more or less in the ten-millionths place.

Table 42 gives the fractional changes in numbers corresponding to changes in the 4th, 5th, . . . 7th place of their logarithms. These fractions are often convenient in showing the approximate error in a number due to a given error in its logarithm, or the converse. Thus, for example, referring to the remark in a foot-note under explanation of Tables 36 and 37 above, the error in the logarithm of Clarke's ratio of the yard to the metre is about 4 units in the sixth place of decimals; the Table 42 shows, then, that the metric equivalents in Tables 36 and 37 are erroneous by about 1/100 000th part.

* Washington, Government Printing Office, 1891.

GEOGRAPHICAL TABLES

TABLE 1.

FOR CONVERTING U. S. WEIGHTS AND MEASURES.*

CUSTOMARY TO METRIC.

LINEAR.

	Inches to millimetres.	Feet to metres.	Yards to metres.	Miles to kilometres.
1 =	25·4001	0·304801	0·914402	1·60935
2 =	50·8001	0·609601	1·828804	3·21869
3 =	76·2002	0·914402	2·743205	4·82804
4 =	101·6002	1·219202	3·657607	6·43739
5 =	127·0003	1·524003	4·572009	8·04674
6 =	152·4003	1·828804	5·486411	9·65608
7 =	177·8004	2·133604	6·400813	11·26543
8 =	203·2004	2·438405	7·315215	12·87478
9 =	228·6005	2·743205	8·229616	14·48412

CAPACITY.

	Fluid drams to millilitres or cubic centimetres.	Fluid ounces to millilitres.	Quarts to litres.	Gallons to litres.
1 =	3·70	29·57	0·94636	3·78543
2 =	7·39	59·15	1·89272	7·57087
3 =	11·09	88·72	2·83908	11·35630
4 =	14·79	118·29	3·78543	15·14174
5 =	18·48	147·87	4·73179	18·92717
6 =	22·18	177·44	5·67815	22·71261
7 =	25·88	207·02	6·62451	26·49804
8 =	29·57	236·59	7·57087	30·28348
9 =	33·27	266·16	8·51723	34·06891

SQUARE.

	Square inches to square centimetres.	Square feet to square decimetres.	Square yards to square metres.	Acres to hectares.
1 =	6·452	9·290	0·836	0·4047
2 =	12·903	18·581	1·672	0·8094
3 =	19·355	27·871	2·508	1·2141
4 =	25·807	37·161	3·344	1·6187
5 =	32·258	46·452	4·181	2·0234
6 =	38·710	55·742	5·017	2·4281
7 =	45·161	65·032	5·853	2·8328
8 =	51·613	74·323	6·689	3·2375
9 =	58·065	83·613	7·525	3·6422

WEIGHT.

	Grains to milligrammes.	Avoirdupois ounces to grammes.	Avoirdupois pounds to kilogrammes.	Troy ounces to grammes.
1 =	64.7989	28·3495	0·45359	31·10348
2 =	129·5978	56·6991	0·90719	62·20696
3 =	194·3968	85·0486	1·36078	93·31044
4 =	259·1957	113·3981	1·81437	124·41392
5 =	323·9946	141·7476	2·26796	155·51740
6 =	388·7935	170·0972	2·72156	186·62088
7 =	453·5924	198·4467	3·17515	217·72437
8 =	518·3914	226·7962	3·62874	248·82785
9 =	583·1903	255·1457	4·08233	279·93133

CUBIC.

	Cubic inches to cubic centimetres.	Cubic feet to cubic metres.	Cubic yards to cubic metres.	Bushels to hectolitres.
1 =	16·387	0·02832	0·765	0·35239
2 =	32·774	0·05663	1·529	0·70479
3 =	49·161	0·08495	2·294	1·05718
4 =	65·549	0·11327	3·058	1·40957
5 =	81·936	0·14158	3·823	1·76196
6 =	98·323	0·16990	4·587	2·11436
7 =	114·710	0·19822	5·352	2·46675
8 =	131·097	0·22654	6·116	2·81914
9 =	147·484	0·25485	6·881	3·17154

1 Gunter's chain = 20·1168 metres.
1 sq. statute mile = 259·000 hectares.
1 fathom = 1·829 metres.
1 nautical mile = 1853·25 metres.
1 foot = 0.304801 metre, 9·4840158 log.
1 avoir. pound = 453·5924277 gram.
15432·35639 grains = 1 kilogramme.

The only authorized material standard of customary length is the Troughton scale belonging to this office, whose length at 59°.62 Fahr. conforms to the British standard. The yard in use in the United States is therefore equal to the British yard.

The only authorized material standard of customary weight is the Troy pound of the Mint. It is of brass of unknown density, and therefore not suitable for a standard of mass. It was derived from the British standard Troy pound of 1758 by direct comparison. The British Avoirdupois pound was also derived from the latter, and contains 7,000 grains Troy.

The grain Troy is therefore the same as the grain Avoirdupois, and the pound Avoirdupois in use in the United States is equal to the British pound Avoirdupois.

The British gallon = 4.54346 litres. The British bushel = 36.3477 litres.

The length of the nautical mile given above and adopted by the U. S. Coast and Geodetic Survey many years ago is defined as that of a minute of arc of a great circle of a sphere whose surface equals that of the earth (Clarke's Spheroid of 1866).

* Issued by U. S. Office of Standard Weights and Measures, and republished here by permission of Superintendent of Coast and Geodetic Survey.

FOR CONVERTING U. S. WEIGHTS AND MEASURES.

METRIC TO CUSTOMARY.

LINEAR.

	Metres to inches.	Metres to feet.	Metres to yards.	Kilometres to miles.
1 =	39·3700	3.28083	1·093611	0·62137
2 =	78·7400	6·56167	2·187222	1·24274
3 =	118·1100	9·84250	3·280833	1·86411
4 =	157·4800	13·12333	4·374444	2·48548
5 =	196·8500	16·40417	5·468056	3·10685
6 =	236·2200	19·68500	6·561667	3·72822
7 =	275·5900	22·96583	7·655278	4·34959
8 =	314·9600	26·24667	8·748889	4·97096
9 =	354·3300	29·52750	9.842500	5·59233

CAPACITY.

	Millilitres or cubic centimetres to fluid drams.	Centilitres to fluid ounces.	Litres to quarts.	Decalitres to gallons.	Hectolitres to bushels.
1 =	0·27	0·338	1·0567	2·6417	2·8377
2 =	0·54	0·676	2·1134	5·2834	5·6755
3 =	0·81	1·014	3·1700	7·9251	8·5132
4 =	1·08	1·353	4·2267	10·5668	11·3510
5 =	1·35	1·691	5·2834	13·2085	14·1887
6 =	1·62	2·029	6·3401	15·8502	17·0265
7 =	1·89	2·367	7·3968	18·4919	19·8642
8 =	2·16	2·705	8·4535	21·1336	22·7019
9 =	2·43	3·043	9·5101	23·7753	25·5397

SQUARE.

	Square centimetres to square inches.	Square metres to square feet.	Square metres to square yards.	Hectares to acres.
1 =	0·1550	10·764	1·196	2·471
2 =	0·3100	21·528	2·392	4·942
3 =	0·4650	32·292	3·588	7·413
4 =	0.6200	43·055	4·784	9·884
5 =	0·7750	53·819	5·980	12·355
6 =	0.9300	64·583	7·176	14·826
7 =	1·0850	75·347	8·372	17·297
8 =	1·2400	86·111	9·568	19·768
9 =	1·3950	96·875	10·764	22·239

WEIGHT.

	Milligrammes to grains.	Kilogrammes to grains.	Hectogrammes to ounces avoirdupois.	Kilogrammes to pounds avoirdupois.
1 =	0·01543	15432·36	3·5274	2·20462
2 =	0·03086	30864·71	7·0548	4·40924
3 =	0·04630	46297·07	10·5822	6·61387
4 =	0·06173	61729·43	14·1096	8·81849
5 =	0·07716	77161·78	17·6370	11·02311
6 =	0·09259	92594·14	21·1644	13·22773
7 =	0·10803	108026·49	24·6918	15·43236
8 =	0·12346	123458·85	28·2192	17·63698
9 =	0·13889	138891·21	31·7466	19·84160

CUBIC.

	Cubic centimetres to cubic inches.	Cubic decimetres to cubic inches.	Cubic metres to cubic feet.	Cubic metres to cubic yards.
1 =	0·0610	61·023	35·314	1·308
2 =	0·1220	122·047	70·629	2·616
3 =	0·1831	183·070	105·943	3·924
4 =	0·2441	244·004	141·258	5·232
5 =	0·3051	305·117	176·572	6·540
6 =	0·3661	366·140	211·887	7·848
7 =	0·4272	427·164	247·201	9·156
8 =	0·4882	488·187	282·516	10·464
9 =	0·5492	549·210	317·830	11·771

WEIGHT — (*continued*).

	Quintals to pounds av.	Milliers or tonnes to pounds av.	Kilogrammes to ounces Troy.
1 =	220·46	2204·6	32·1507
2 =	440·92	4409·2	64·3015
3 =	661·39	6613·9	96·4522
4 =	881·85	8818·5	128·6030
5 =	1102·31	11023·1	160·7537
6 =	1322·77	13227·7	192·9044
7 =	1543·24	15432·4	225·0552
8 =	1763·70	17637·0	257·2059
9 =	1984·16	19841·6	289·3567

By the concurrent action of the principal governments of the world an International Bureau of Weights and Measures has been established near Paris. Under the direction of the International Committee, two ingots were cast of pure platinum-iridium in the proportion of 9 parts of the former to 1 of the latter metal. From one of these a certain number of kilogrammes were prepared, from the other a definite number of metre bars. These standards of weight and length were intercompared, without preference, and certain ones were selected as International prototype standards. The others were distributed by lot, in September, 1889, to the different governments and are called National prototype standards. Those apportioned to the United States were received in 1890 and are in the keeping of this office.

The metric system was legalized in the United States in 1866.

The International Standard Metre is derived from the Mètre des Archives, and its length is defined by the distance between two lines at 0° Centigrade, on a platinum-iridium bar deposited at the International Bureau of Weights and Measures.

The International Standard Kilogramme is a mass of platinum-iridium deposited at the same place, and its weight in vacuo is the same as that of the Kilogramme des Archives.

The litre is equal to a cubic decimetre, and it is measured by the quantity of distilled water which, at its maximum density, will counterpoise the standard kilogramme in a vacuum, the volume of such a quantity of water being, as nearly as has been ascertained, equal to a cubic decimetre.

TABLE 3.

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
1	1000.000	1	1	1.0000	1.0000	0.00000
2	500.000	4	8	1.4142	1.2599	0.30103
3	333.333	9	27	1.7321	1.4422	0.47712
4	250.000	16	64	2.0000	1.5874	0.60206
5	200.000	25	125	2.2361	1.7100	0.69897
6	166.667	36	216	2.4495	1.8171	0.77815
7	142.857	49	343	2.6458	1.9129	0.84510
8	125.000	64	512	2.8284	2.0000	0.90309
9	111.111	81	729	3.0000	2.0801	0.95424
10	100.000	100	1000	3.1623	2.1544	1.00000
11	90.9091	121	1331	3.3166	2.2240	1.04139
12	83.3333	144	1728	3.4641	2.2894	1.07918
13	76.9231	169	2197	3.6056	2.3513	1.11394
14	71.4286	196	2744	3.7417	2.4101	1.14613
15	66.6667	225	3375	3.8730	2.4662	1.17609
16	62.5000	256	4096	4.0000	2.5198	1.20412
17	58.8235	289	4913	4.1231	2.5713	1.23045
18	55.5556	324	5832	4.2426	2.6207	1.25527
19	52.6316	361	6859	4.3589	2.6684	1.27875
20	50.0000	400	8000	4.4721	2.7144	1.30103
21	47.6190	441	9261	4.5826	2.7589	1.32222
22	45.4545	484	10648	4.6904	2.8020	1.34242
23	43.4783	529	12167	4.7958	2.8439	1.36173
24	41.6667	576	13824	4.8990	2.8845	1.38021
25	40.0000	625	15625	5.0000	2.9240	1.39794
26	38.4615	676	17576	5.0990	2.9625	1.41497
27	37.0370	729	19683	5.1962	3.0000	1.43136
28	35.7143	784	21952	5.2915	3.0366	1.44716
29	34.4828	841	24389	5.3852	3.0723	1.46240
30	33.3333	900	27000	5.4772	3.1072	1.47712
31	32.2581	961	29791	5.5678	3.1414	1.49136
32	31.2500	1024	32768	5.6569	3.1748	1.50515
33	30.3030	1089	35937	5.7446	3.2075	1.51851
34	29.4118	1156	39304	5.8310	3.2396	1.53148
35	28.5714	1225	42875	5.9161	3.2711	1.54407
36	27.7778	1296	46656	6.0000	3.3019	1.55630
37	27.0270	1369	50653	6.0828	3.3322	1.56820
38	26.3158	1444	54872	6.1644	3.3620	1.57978
39	25.6410	1521	59319	6.2450	3.3912	1.59106
40	25.0000	1600	64000	6.3246	3.4200	1.60206
41	24.3902	1681	68921	6.4031	3.4482	1.61278
42	23.8095	1764	74088	6.4807	3.4760	1.62325
43	23.2558	1849	79507	6.5574	3.5034	1.63347
44	22.7273	1936	85184	6.6332	3.5303	1.64345
45	22.2222	2025	91125	6.7082	3.5569	1.65321
46	21.7391	2116	97336	6.7823	3.5830	1.66276
47	21.2766	2209	103823	6.8557	3.6088	1.67210
48	20.8333	2304	110592	6.9282	3.6342	1.68124
49	20.4082	2401	117649	7.0000	3.6593	1.69020
50	20.0000	2500	125000	7.0711	3.6840	1.69897
51	19.6078	2601	132651	7.1414	3.7084	1.70757
52	19.2308	2704	140608	7.2111	3.7325	1.71600
53	18.8679	2809	148877	7.2801	3.7563	1.72428
54	18.5185	2916	157464	7.3485	3.7798	1.73239

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
55	18.1818	3025	166375	7.4162	3.8030	1.74036
56	17.8571	3136	175616	7.4833	3.8259	1.74819
57	17.5439	3249	185193	7.5498	3.8485	1.75587
58	17.2414	3364	195112	7.6158	3.8709	1.76343
59	16.9492	3481	205379	7.6811	3.8930	1.77085
60	16.6667	3600	216000	7.7460	3.9149	1.77815
61	16.3934	3721	226981	7.8102	3.9365	1.78533
62	16.1290	3844	238328	7.8740	3.9579	1.79239
63	15.8730	3969	250047	7.9373	3.9791	1.79934
64	15.6250	4096	262144	8.0000	4.0000	1.80618
65	15.3846	4225	274625	8.0623	4.0207	1.81291
66	15.1515	4356	287496	8.1240	4.0412	1.81954
67	14.9254	4489	300763	8.1854	4.0615	1.82607
68	14.7059	4624	314432	8.2462	4.0817	1.83251
69	14.4928	4761	328509	8.3066	4.1016	1.83885
70	14.2857	4900	343000	8.3666	4.1213	1.84510
71	14.0845	5041	357911	8.4261	4.1408	1.85126
72	13.8889	5184	373248	8.4853	4.1602	1.85733
73	13.6986	5329	389017	8.5440	4.1793	1.86332
74	13.5135	5476	405224	8.6023	4.1983	1.86923
75	13.3333	5625	421875	8.6603	4.2172	1.87506
76	13.1579	5776	438976	8.7178	4.2358	1.88081
77	12.9870	5929	456533	8.7750	4.2543	1.88649
78	12.8205	6084	474552	8.8318	4.2727	1.89209
79	12.6582	6241	493039	8.8882	4.2908	1.89763
80	12.5000	6400	512000	8.9443	4.3089	1.90309
81	12.3457	6561	531441	9.0000	4.3267	1.90849
82	12.1951	6724	551368	9.0554	4.3445	1.91381
83	12.0482	6889	571787	9.1104	4.3621	1.91908
84	11.9048	7056	592704	9.1652	4.3795	1.92428
85	11.7647	7225	614125	9.2195	4.3968	1.92942
86	11.6279	7396	636056	9.2736	4.4140	1.93450
87	11.4943	7569	658503	9.3274	4.4310	1.93952
88	11.3636	7744	681472	9.3808	4.4480	1.94448
89	11.2360	7921	704969	9.4340	4.4647	1.94939
90	11.1111	8100	729000	9.4868	4.4814	1.95424
91	10.9890	8281	753571	9.5394	4.4979	1.95904
92	10.8696	8464	778688	9.5917	4.5144	1.96379
93	10.7527	8649	804357	9.6437	4.5307	1.96848
94	10.6383	8836	830584	9.6954	4.5468	1.97313
95	10.5263	9025	857375	9.7468	4.5629	1.97772
96	10.4167	9216	884736	9.7980	4.5789	1.98227
97	10.3093	9409	912673	9.8489	4.5947	1.98677
98	10.2041	9604	941192	9.8995	4.6104	1.99123
99	10.1010	9801	970299	9.9499	4.6261	1.99564
100	10.0000	10000	1000000	10.0000	4.6416	2.00000
101	9.90099	10201	1030301	10.0499	4.6570	2.00432
102	9.80392	10404	1061208	10.0995	4.6723	2.00860
103	9.70874	10609	1092727	10.1489	4.6875	2.01284
104	9.61538	10816	1124864	10.1980	4.7027	2.01703
105	9.52381	11025	1157625	10.2470	4.7177	2.02119
106	9.43396	11236	1191016	10.2956	4.7326	2.02531
107	9.34579	11449	1225043	10.3441	4.7475	2.02938
108	9.25926	11664	1259712	10.3923	4.7622	2.03342
109	9.17431	11881	1295029	10.4403	4.7769	2.03743

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
110	9.09091	12100	1331000	10.4881	4.7914	2.04139
111	9.00901	12321	1367631	10.5357	4.8059	2.04532
112	8.92857	12544	1404928	10.5830	4.8203	2.04922
113	8.84956	12769	1442897	10.6301	4.8346	2.05308
114	8.77193	12996	1481544	10.6771	4.8488	2.05690
115	8.69565	13225	1520875	10.7238	4.8629	2.06070
116	8.62069	13456	1560896	10.7703	4.8770	2.06446
117	8.54701	13689	1601613	10.8167	4.8910	2.06819
118	8.47458	13924	1643032	10.8628	4.9049	2.07188
119	8.40336	14161	1685159	10.9087	4.9187	2.07555
120	8.33333	14400	1728000	10.9545	4.9324	2.07918
121	8.26446	14641	1771561	11.0000	4.9461	2.08279
122	8.19672	14884	1815848	11.0454	4.9597	2.08636
123	8.13008	15129	1860867	11.0905	4.9732	2.08991
124	8.06452	15376	1906624	11.1355	4.9866	2.09342
125	8.00000	15625	1953125	11.1803	5.0000	2.09691
126	7.93651	15876	2000376	11.2250	5.0133	2.10037
127	7.87402	16129	2048383	11.2694	5.0265	2.10380
128	7.81250	16384	2097152	11.3137	5.0397	2.10721
129	7.75194	16641	2146689	11.3578	5.0528	2.11059
130	7.69231	16900	2197000	11.4018	5.0658	2.11394
131	7.63359	17161	2248091	11.4455	5.0788	2.11727
132	7.57576	17424	2299968	11.4891	5.0916	2.12057
133	7.51880	17689	2352637	11.5326	5.1045	2.12385
134	7.46269	17956	2406104	11.5758	5.1172	2.12710
135	7.40741	18225	2460375	11.6190	5.1299	2.13033
136	7.35294	18496	2515456	11.6619	5.1426	2.13354
137	7.29927	18769	2571353	11.7047	5.1551	2.13672
138	7.24638	19044	2628072	11.7473	5.1676	2.13988
139	7.19424	19321	2685619	11.7898	5.1801	2.14301
140	7.14286	19600	2744000	11.8322	5.1925	2.14613
141	7.09220	19881	2803221	11.8743	5.2048	2.14922
142	7.04225	20164	2863288	11.9164	5.2171	2.15229
143	6.99301	20449	2924207	11.9583	5.2293	2.15534
144	6.94444	20736	2985984	12.0000	5.2415	2.15836
145	6.89655	21025	3048625	12.0416	5.2536	2.16137
146	6.84932	21316	3112136	12.0830	5.2656	2.16435
147	6.80272	21609	3176523	12.1244	5.2776	2.16732
148	6.75676	21904	3241792	12.1655	5.2896	2.17026
149	6.71141	22201	3307949	12.2066	5.3015	2.17319
150	6.66667	22500	3375000	12.2474	5.3133	2.17609
151	6.62252	22801	3442951	12.2882	5.3251	2.17898
152	6.57893	23104	3511808	12.3288	5.3368	2.18184
153	6.53595	23409	3581577	12.3693	5.3485	2.18469
154	6.49351	23716	3652264	12.4097	5.3601	2.18752
155	6.45161	24025	3723875	12.4499	5.3717	2.19033
156	6.41026	24336	3796416	12.4900	5.3832	2.19312
157	6.36943	24649	3869893	12.5300	5.3947	2.19590
158	6.32911	24964	3944312	12.5698	5.4061	2.19866
159	6.28931	25281	4019679	12.6095	5.4175	2.20140
160	6.25000	25600	4096000	12.6491	5.4288	2.20412
161	6.21118	25921	4173281	12.6886	5.4401	2.20683
162	6.17284	26244	4251528	12.7279	5.4514	2.20952
163	6.13497	26569	4330747	12.7671	5.4626	2.21219
164	6.09756	26896	4410944	12.8062	5.4737	2.21484

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000 \cdot \frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
165	6.06061	27225	4492125	12.8452	5.4848	2.21748
166	6.02410	27556	4574296	12.8841	5.4959	2.22011
167	5.98802	27889	4657463	12.9228	5.5069	2.22272
168	5.95238	28224	4741632	12.9615	5.5178	2.22531
169	5.91716	28561	4826809	13.0000	5.5288	2.22789
170	5.88235	28900	4913000	13.0384	5.5397	2.23045
171	5.84795	29241	5000211	13.0767	5.5505	2.23300
172	5.81395	29584	5088448	13.1149	5.5613	2.23553
173	5.78035	29929	5177717	13.1529	5.5721	2.23805
174	5.74713	30276	5268024	13.1909	5.5828	2.24055
175	5.71429	30625	5359375	13.2288	5.5934	2.24304
176	5.68182	30976	5451776	13.2665	5.6041	2.24551
177	5.64972	31329	5545233	13.3041	5.6147	2.24797
178	5.61798	31684	5639752	13.3417	5.6252	2.25042
179	5.58659	32041	5735339	13.3791	5.6357	2.25285
180	5.55556	32400	5832000	13.4164	5.6462	2.25527
181	5.52486	32761	5929741	13.4536	5.6567	2.25768
182	5.49451	33124	6028568	13.4907	5.6671	2.26007
183	5.46448	33489	6128487	13.5277	5.6774	2.26245
184	5.43478	33856	6229504	13.5647	5.6877	2.26482
185	5.40541	34225	6331625	13.6015	5.6980	2.26717
186	5.37634	34596	6434856	13.6382	5.7083	2.26951
187	5.34759	34969	6539203	13.6748	5.7185	2.27184
188	5.31915	35344	6644672	13.7113	5.7287	2.27416
189	5.29101	35721	6751269	13.7477	5.7388	2.27646
190	5.26316	36100	6859000	13.7840	5.7489	2.27875
191	5.23560	36481	6967871	13.8203	5.7590	2.28103
192	5.20833	36864	7077888	13.8564	5.7690	2.28330
193	5.18135	37249	7189057	13.8924	5.7790	2.28556
194	5.15464	37636	7301384	13.9284	5.7890	2.28780
195	5.12821	38025	7414875	13.9642	5.7989	2.29003
196	5.10204	38416	7529536	14.0000	5.8088	2.29226
197	5.07614	38809	7645373	14.0357	5.8186	2.29447
198	5.05051	39204	7762392	14.0712	5.8285	2.29667
199	5.02513	39601	7880599	14.1067	5.8383	2.29885
200	5.00000	40000	8000000	14.1421	5.8480	2.30103
201	4.97512	40401	8120601	14.1774	5.8578	2.30320
202	4.95050	40804	8242408	14.2127	5.8675	2.30535
203	4.92611	41209	8365427	14.2478	5.8771	2.30750
204	4.90196	41616	8489664	14.2829	5.8868	2.30963
205	4.87805	42025	8615125	14.3178	5.8964	2.31175
206	4.85437	42436	8741816	14.3527	5.9059	2.31387
207	4.83092	42849	8869743	14.3875	5.9155	2.31597
208	4.80769	43264	8998912	14.4222	5.9250	2.31806
209	4.78469	43681	9129329	14.4568	5.9345	2.32015
210	4.76190	44100	9261000	14.4914	5.9439	2.32222
211	4.73934	44521	9393931	14.5258	5.9533	2.32428
212	4.71698	44944	9528128	14.5602	5.9627	2.32634
213	4.69484	45369	9663597	14.5945	5.9721	2.32838
214	4.67290	45796	9800344	14.6287	5.9814	2.33041
215	4.65116	46225	9938375	14.6629	5.9907	2.33244
216	4.62963	46656	10077696	14.6969	6.0000	2.33445
217	4.60829	47089	10218313	14.7309	6.0092	2.33646
218	4.58716	47524	10360232	14.7648	6.0185	2.33846
219	4.56621	47961	10503459	14.7986	6.0277	2.34044

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
220	4.54545	48400	10648000	14.8324	6.0368	2.34242
221	4.52489	48841	10793861	14.8661	6.0459	2.34439
222	4.50450	49284	10941048	14.8997	6.0550	2.34635
223	4.48431	49729	11089567	14.9332	6.0641	2.34830
224	4.46429	50176	11239424	14.9666	6.0732	2.35025
225	4.44444	50625	11390625	15.0000	6.0822	2.35218
226	4.42478	51076	11543176	15.0333	6.0912	2.35411
227	4.40529	51529	11697083	15.0665	6.1002	2.35603
228	4.38596	51984	11852352	15.0997	6.1091	2.35793
229	4.36681	52441	12008989	15.1327	6.1180	2.35984
230	4.34783	52900	12167000	15.1658	6.1269	2.36173
231	4.32900	53361	12326391	15.1987	6.1358	2.36361
232	4.31034	53824	12487168	15.2315	6.1446	2.36549
233	4.29185	54289	12649337	15.2643	6.1534	2.36736
234	4.27350	54756	12812904	15.2971	6.1622	2.36922
235	4.25532	55225	12977875	15.3297	6.1710	2.37107
236	4.23729	55696	13144256	15.3623	6.1797	2.37291
237	4.21941	56169	13312053	15.3948	6.1885	2.37475
238	4 20168	56644	13481272	15.4272	6.1972	2.37658
239	4.18410	57121	13651919	15.4596	6.2058	2.37840
240	4.16667	57600	13824000	15.4919	6.2145	2.38021
241	4.14938	58081	13997521	15.5242	6.2231	2.38202
242	4.13223	58564	14172488	15.5563	6.2317	2.38382
243	4.11523	59049	14348907	15.5885	6.2403	2.38561
244	4.09836	59536	14526784	15.6205	6.2488	2.38739
245	4.08163	60025	14706125	15.6525	6.2573	2.38917
246	4.06504	60516	14886936	15.6844	6.2658	2.39094
247	4.04858	61009	15069223	15.7162	6.2743	2.39270
248	4.03226	61504	15252992	15.7480	6.2828	2.39445
249	4.01606	62001	15438249	15.7797	6.2912	2.39620
250	4.00000	62500	15625000	15.8114	6.2996	2.39794
251	3.98406	63001	15813251	15.8430	6.3080	2.39967
252	3.96825	63504	16003008	15.8745	6.3164	2.40140
253	3.95257	64009	16194277	15.9060	6.3247	2.40312
254	3.93701	64516	16387064	15.9374	6.3330	2.40483
255	3.92157	65025	16581375	15.9687	6.3413	2.40654
256	3.90625	65536	16777216	16.0000	6.3496	2.40824
257	3.89105	66049	16974593	16.0312	6.3579	2.40993
258	3.87597	66564	17173512	16.0624	6.3661	2.41162
259	3.86100	67081	17373979	16.0935	6.3743	2.41330
260	3.84615	67600	17576000	16.1245	6.3825	2.41497
261	3.83142	68121	17779581	16.1555	6.3907	2.41664
262	3.81679	68644	17984728	16.1864	6.3988	2.41830
263	3.80228	69169	18191447	16.2173	6.4070	2.41996
264	3.78788	69696	18399744	16.2481	6.4151	2.42160
265	3.77358	70225	18609625	16.2788	6.4232	2.42325
266	3.75940	70756	18821096	16.3095	6.4312	2.42488
267	3.74532	71289	19034163	16.3401	6.4393	2.42651
268	3.73134	71824	19248832	16.3707	6.4473	2.42813
269	3.71747	72361	19465109	16.4012	6.4553	2.42975
270	3.70370	72900	19683000	16.4317	6.4633	2.43136
271	3.69004	73441	19902511	16.4621	6.4713	2.43297
272	3.67647	73984	20123648	16.4924	6.4792	2.43457
273	3.66300	74529	20346417	16.5227	6.4872	2.43616
274	3.64964	75076	20570824	16.5529	6.4951	2.43775

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
275	3.63636	75625	20796875	16.5831	6.5030	2.43933
276	3.62319	76176	21024576	16.6132	6.5108	2.44091
277	3.61011	76729	21253933	16.6433	6.5187	2.44248
278	3.59712	77284	21484952	16.6733	6.5265	2.44404
279	3.58423	77841	21717639	16.7033	6.5343	2.44560
280	3.57143	78400	21952000	16.7332	6.5421	2.44716
281	3.55872	78961	22188041	16.7631	6.5499	2.44871
282	3.54610	79524	22425768	16.7929	6.5577	2.45025
283	3.53357	80089	22665187	16.8226	6.5654	2.45179
284	3.52113	80656	22906304	16.8523	6.5731	2.45332
285	3.50877	81225	23149125	16.8819	6.5808	2.45484
286	3.49650	81796	23393656	16.9115	6.5885	2.45637
287	3.48432	82369	23639903	16.9411	6.5962	2.45788
288	3.47222	82944	23887872	16.9706	6.6039	2.45939
289	3.46021	83521	24137569	17.0000	6.6115	2.46090
290	3.44828	84100	24389000	17.0294	6.6191	2.46240
291	3.43643	84681	24642171	17.0587	6.6267	2.46389
292	3.42466	85264	24897088	17.0880	6.6343	2.46538
293	3.41297	85849	25153757	17.1172	6.6419	2.46687
294	3.40136	86436	25412184	17.1464	6.6494	2.46835
295	3.38983	87025	25672375	17.1756	6.6569	2.46982
296	3.37838	87616	25934336	17.2047	6.6644	2.47129
297	3.36700	88209	26198073	17.2337	6.6719	2.47276
298	3.35570	88804	26463592	17.2627	6.6794	2.47422
299	3.34448	89401	26730899	17.2916	6.6869	2.47567
300	3.33333	90000	27000000	17.3205	6.6943	2.47712
301	3.32226	90601	27270901	17.3494	6.7018	2.47857
302	3.31126	91204	27543608	17.3781	6.7092	2.48001
303	3.30033	91809	27818127	17.4069	6.7166	2.48144
304	3.28947	92416	28094464	17.4356	6.7240	2.48287
305	3.27869	93025	28372625	17.4642	6.7313	2.48430
306	3.26797	93636	28652616	17.4929	6.7387	2.48572
307	3.25733	94249	28934443	17.5214	6.7460	2.48714
308	3.24675	94864	29218112	17.5499	6.7533	2.48855
309	3.23625	95481	29503629	17.5784	6.7606	2.48996
310	3.22581	96100	29791000	17.6068	6.7679	2.49136
311	3.21543	96721	30080231	17.6352	6.7752	2.49276
312	3.20513	97344	30371328	17.6635	6.7824	2.49415
313	3.19489	97969	30664297	17.6918	6.7897	2.49554
314	3.18471	98596	30959144	17.7200	6.7969	2.49693
315	3.17460	99225	31255875	17.7482	6.8041	2.49831
316	3.16456	99856	31554496	17.7764	6.8113	2.49969
317	3.15457	100489	31855013	17.8045	6.8185	2.50106
318	3.14465	101124	32157432	17.8326	6.8256	2.50243
319	3.13480	101761	32461759	17.8606	6.8328	2.50379
320	3.12500	102400	32768000	17.8885	6.8399	2.50515
321	3.11527	103041	33076161	17.9165	6.8470	2.50651
322	3.10559	103684	33386248	17.9444	6.8541	2.50786
323	3.09598	104329	33698267	17.9722	6.8612	2.50920
324	3.08642	104976	34012224	18.0000	6.8683	2.51055
325	3.07692	105625	34328125	18.0278	6.8753	2.51188
326	3.06748	106276	34645976	18.0555	6.8824	2.51322
327	3.05810	106929	34965783	18.0831	6.8894	2.51455
328	3.04878	107584	35287552	18.1108	6.8964	2.51587
329	3.03951	108241	35611289	18.1384	6.9034	2.51720

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
330	3.03030	108900	35937000	18.1659	6.9104	2.51851
331	3.02115	109561	36264691	18.1934	6.9174	2.51983
332	3.01205	110224	36594368	18.2209	6.9244	2.52114
333	3.00300	110889	36926037	18.2483	6.9313	2.52244
334	2.99401	111556	37259704	18.2757	6.9382	2.52375
335	2.98507	112225	37595375	18.3030	6.9451	2.52504
336	2.97619	112896	37933056	18.3303	6.9521	2.52634
337	2.96736	113569	38272753	18.3576	6.9589	2.52763
338	2.95858	114244	38614472	18.3848	6.9658	2.52892
339	2.94985	114921	38958219	18.4120	6.9727	2.53020
340	2.94118	115600	39304000	18.4391	6.9795	2.53148
341	2.93255	116281	39651821	18.4662	6.9864	2.53275
342	2.92398	116964	40001688	18.4932	6.9932	2.53403
343	2.91545	117649	40353607	18.5203	7.0000	2.53529
344	2.90698	118336	40707584	18.5472	7.0068	2.53656
345	2.89855	119025	41063625	18.5742	7.0136	2.53782
346	2.89017	119716	41421736	18.6011	7.0203	2.53908
347	2.88184	120409	41781923	18.6279	7.0271	2.54033
348	2.87356	121104	42144192	18.6548	7.0338	2.54158
349	2.86533	121801	42508549	18.6815	7.0406	2.54283
350	2.85714	122500	42875000	18.7083	7.0473	2.54407
351	2.84900	123201	43243551	18.7350	7.0540	2.54531
352	2.84091	123904	43614208	18.7617	7.0607	2.54654
353	2.83286	124609	43986977	18.7883	7.0674	2.54777
354	2.82486	125316	44361864	18.8149	7.0740	2.54900
355	2.81690	126025	44738875	18.8414	7.0807	2.55023
356	2.80899	126736	45118016	18.8680	7.0873	2.55145
357	2.80112	127449	45499293	18.8944	7.0940	2.55267
358	2.79330	128164	45882712	18.9209	7.1006	2.55388
359	2.78552	128881	46268279	18.9473	7.1072	2.55509
360	2.77778	129600	46656000	18.9737	7.1138	2.55630
361	2.77008	130321	47045881	19.0000	7.1204	2.55751
362	2.76243	131044	47437928	19.0263	7.1269	2.55871
363	2.75482	131769	47832147	19.0526	7.1335	2.55991
364	2.74725	132496	48228544	19.0788	7.1400	2.56110
365	2.73973	133225	48627125	19.1050	7.1466	2.56229
366	2.73224	133956	49027896	19.1311	7.1531	2.56348
367	2.72480	134689	49430863	19.1572	7.1596	2.56467
368	2.71739	135424	49836032	19.1833	7.1661	2.56585
369	2.71003	136161	50243409	19.2094	7.1726	2.56703
370	2.70270	136900	50653000	19.2354	7.1791	2.56820
371	2.69542	137641	51064811	19.2614	7.1855	2.56937
372	2.68817	138384	51478848	19.2873	7.1920	2.57054
373	2.68097	139129	51895117	19.3132	7.1984	2.57171
374	2.67380	139876	52313624	19.3391	7.2048	2.57287
375	2.66667	140625	52734375	19.3649	7.2112	2.57403
376	2.65957	141376	53157376	19.3907	7.2177	2.57519
377	2.65252	142129	53582633	19.4165	7.2240	2.57634
378	2.64550	142884	54010152	19.4422	7.2304	2.57749
379	2.63852	143641	54439939	19.4679	7.2368	2.57864
380	2.63158	144400	54872000	19.4936	7.2432	2.57978
381	2.62467	145161	55306341	19.5192	7.2495	2.58092
382	2.61780	145924	55742968	19.5448	7.2558	2.58206
383	2.61097	146689	56181887	19.5704	7.2622	2.58320
384	2.60417	147456	56623104	19.5959	7.2685	2.58433

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
385	2.59740	148225	57066625	19.6214	7.2748	2.58546
386	2.59067	148996	57512456	19.6469	7.2811	2.58659
387	2.58398	149769	57960603	19.6723	7.2874	2.58771
388	2.57732	150544	58411072	19.6977	7.2936	2.58883
389	2.57069	151321	58863869	19.7231	7.2999	2.58995
390	2.56410	152100	59319000	19.7484	7.3061	2.59106
391	2.55754	152881	59776471	19.7737	7.3124	2.59218
392	2.55102	153664	60236288	19.7990	7.3186	2.59329
393	2.54453	154449	60698457	19.8242	7.3248	2.59439
394	2.53807	155236	61162984	19.8494	7.3310	2.59550
395	2.53165	156025	61629875	19.8746	7.3372	2.59660
396	2.52525	156816	62099136	19.8997	7.3434	2.59770
397	2.51889	157609	62570773	19.9249	7.3496	2.59879
398	2.51256	158404	63044792	19.9499	7.3558	2.59988
399	2.50627	159201	63521199	19.9750	7.3619	2.60097
400	2.50000	160000	64000000	20.0000	7.3681	2.60206
401	2.49377	160801	64481201	20.0250	7.3742	2.60314
402	2.48756	161604	64964808	20.0499	7.3803	2.60423
403	2.48139	162409	65450827	20.0749	7.3864	2.60531
404	2.47525	163216	65939264	20.0998	7.3925	2.60638
405	2.46914	164025	66430125	20.1246	7.3986	2.60746
406	2.46305	164836	66923416	20.1494	7.4047	2.60853
407	2.45700	165649	67419143	20.1742	7.4108	2.60959
408	2.45098	166464	67917312	20.1990	7.4169	2.61066
409	2.44499	167281	68417929	20.2237	7.4229	2.61172
410	2.43902	168100	68921000	20.2485	7.4290	2.61278
411	2.43309	168921	69426531	20.2731	7.4350	2.61384
412	2.42718	169744	69934528	20.2978	7.4410	2.61490
413	2.42131	170569	70444997	20.3224	7.4470	2.61595
414	2.41546	171396	70957944	20.3470	7.4530	2.61700
415	2.40964	172225	71473375	20.3715	7.4590	2.61805
416	2.40385	173056	71991296	20.3961	7.4650	2.61909
417	2.39808	173889	72511713	20.4206	7.4710	2.62014
418	2.39234	174724	73034632	20.4450	7.4770	2.62118
419	2.38663	175561	73560059	20.4695	7.4829	2.62221
420	2.38095	176400	74088000	20.4939	7.4889	2.62325
421	2.37530	177241	74618461	20.5183	7.4948	2.62428
422	2.36967	178084	75151448	20.5426	7.5007	2.62531
423	2.36407	178929	75686967	20.5670	7.5067	2.62634
424	2.35849	179776	76225024	20.5913	7.5126	2.62737
425	2.35294	180625	76765625	20.6155	7.5185	2.62839
426	2.34742	181476	77308776	20.6398	7.5244	2.62941
427	2.34192	182329	77854483	20.6640	7.5302	2.63043
428	2.33645	183184	78402752	20.6882	7.5361	2.63144
429	2.33100	184041	78953589	20.7123	7.5420	2.63246
430	2.32558	184900	79507000	20.7364	7.5478	2.63347
431	2.32019	185761	80062991	20.7605	7.5537	2.63448
432	2.31481	186624	80621568	20.7846	7.5595	2.63548
433	2.30947	187489	81182737	20.8087	7.5654	2.63649
434	2.30415	188356	81746504	20.8327	7.5712	2.63749
435	2.29885	189225	82312875	20.8567	7.5770	2.63849
436	2.29358	190096	82881856	20.8806	7.5828	2.63949
437	2.28833	190969	83453453	20.9045	7.5886	2.64048
438	2.28311	191844	84027672	20.9284	7.5944	2.64147
439	2.27790	192721	84604519	20.9523	7.6001	2.64246

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
440	2.27273	193600	85184000	20.9762	7.6059	2.64345
441	2.26757	194481	85766121	21.0000	7.6117	2.64444
442	2.26244	195364	86350888	21.0238	7.6174	2.64542
443	2.25734	196249	86938307	21.0476	7.6232	2.64640
444	2.25225	197136	87528384	21.0713	7.6289	2.64738
445	2.24719	198025	88121125	21.0950	7.6346	2.64836
446	2.24215	198916	88716536	21.1187	7.6403	2.64933
447	2.23714	199809	89314623	21.1424	7.6460	2.65031
448	2.23214	200704	89915392	21.1660	7.6517	2.65128
449	2.22717	201601	90518849	21.1896	7.6574	2.65225
450	2.22222	202500	91125000	21.2132	7.6631	2.65321
451	2.21730	203401	91733851	21.2368	7.6688	2.65418
452	2.21239	204304	92345408	21.2603	7.6744	2.65514
453	2.20751	205209	92959677	21.2838	7.6801	2.65610
454	2.20264	206116	93576664	21.3073	7.6857	2.65706
455	2.19780	207025	94196375	21.3307	7.6914	2.65801
456	2.19298	207936	94818816	21.3542	7.6970	2.65896
457	2.18818	208849	95443993	21.3776	7.7026	2.65992
458	2.18341	209764	96071912	21.4009	7.7082	2.66087
459	2.17865	210681	96702579	21.4243	7.7138	2.66181
460	2.17391	211600	97336000	21.4476	7.7194	2.66276
461	2.16920	212521	97972181	21.4709	7.7250	2.66370
462	2.16450	213444	98611128	21.4942	7.7306	2.66464
463	2.15983	214369	99252847	21.5174	7.7362	2.66558
464	2.15517	215296	99897344	21.5407	7.7418	2.66652
465	2.15054	216225	100544625	21.5639	7.7473	2.66745
466	2.14592	217156	101194696	21.5870	7.7529	2.66839
467	2.14133	218089	101847563	21.6102	7.7584	2.66932
468	2.13675	219024	102503232	21.6333	7.7639	2.67025
469	2.13220	219961	103161709	21.6564	7.7695	2.67117
470	2.12766	220900	103823000	21.6795	7.7750	2.67210
471	2.12314	221841	104487111	21.7025	7.7805	2.67302
472	2.11864	222784	105154048	21.7256	7.7860	2.67394
473	2.11416	223729	105823817	21.7486	7.7915	2.67486
474	2.10970	224677	106496424	21.7715	7.7970	2.67578
475	2.10526	225625	107171875	21.7945	7.8025	2.67669
476	2.10084	226576	107850176	21.8174	7.8079	2.67761
477	2.09644	227529	108531333	21.8403	7.8134	2.67852
478	2.09205	228484	109215352	21.8632	7.8188	2.67943
479	2.08768	229441	109902239	21.8861	7.8243	2.68034
480	2.08333	230400	110592000	21.9089	7.8297	2.68124
481	2.07900	231361	111284641	21.9317	7.8352	2.68215
482	2.07469	232324	111980168	21.9545	7.8406	2.68305
483	2.07039	233289	112678587	21.9773	7.8460	2.68395
484	2.06612	234256	113379904	22.0000	7.8514	2.68485
485	2.06186	235225	114084125	22.0227	7.8568	2.68574
486	2.05761	236196	114791256	22.0454	7.8622	2.68664
487	2.05339	237169	115501303	22.0681	7.8676	2.68753
488	2.04918	238144	116214272	22.0907	7.8730	2.68842
489	2.04499	239121	116930169	22.1133	7.8784	2.68931
490	2.04082	240100	117649000	22.1359	7.8837	2.69020
491	2.03666	241081	118370771	22.1585	7.8891	2.69108
492	2.03252	242064	119095488	22.1811	7.8944	2.69197
493	2.02840	243049	119823157	22.2036	7.8998	2.69285
494	2.02429	244036	120553784	22.2261	7.9051	2.69373

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
495	2.02020	245025	121287375	22.2486	7.9105	2.69461
496	2.01613	246016	122023936	22.2711	7.9158	2.69548
497	2.01207	247009	122763473	22.2935	7.9211	2.69636
498	2.00803	248004	123505992	22.3159	7.9264	2.69723
499	2.00401	249001	124251499	22.3383	7.9317	2.69810
500	2.00000	250000	125000000	22.3607	7.9370	2.69897
501	1.99601	251001	125751501	22.3830	7.9420	2.69984
502	1.99203	252004	126506008	22.4054	7.9476	2.70070
503	1.98807	253009	127263527	22.4277	7.9528	2.70157
504	1.98413	254016	128024064	22.4499	7.9581	2.70243
505	1.98020	255025	128787625	22.4722	7.9634	2.70329
506	1.97628	256036	129554216	22.4944	7.9686	2.70415
507	1.97239	257049	130323843	22.5167	7.9739	2.70501
508	1.96850	258064	131096512	22.5389	7.9791	2.70586
509	1.96464	259081	131872229	22.5610	7.9843	2.70672
510	1.96078	260100	132651000	22.5832	7.9896	2.70757
511	1.95695	261121	133432831	22.6053	7.9948	2.70842
512	1.95312	262144	134217728	22.6274	8.0000	2.70927
513	1.94932	263169	135005697	22.6495	8.0052	2.71012
514	1.94553	264196	135796744	22.6716	8.0104	2.71096
515	1.94175	265225	136590875	22.6936	8.0156	2.71181
516	1.93798	266256	137388096	22.7156	8.0208	2.71265
517	1.93424	267289	138188413	22.7376	8.0260	2.71349
518	1.93050	268324	138991832	22.7596	8.0311	2.71433
519	1.92678	269361	139798359	22.7816	8.0363	2.71517
520	1.92308	270400	140608000	22.8035	8.0415	2.71600
521	1.91939	271441	141420761	22.8254	8.0466	2.71684
522	1.91571	272484	142236648	22.8473	8.0517	2.71767
523	1.91205	273529	143055667	22.8692	8.0569	2.71850
524	1.90840	274576	143877824	22.8910	8.0620	2.71933
525	1.90476	275625	144703125	22.9129	8.0671	2.72016
526	1.90114	276676	145531576	22.9347	8.0723	2.72099
527	1.89753	277729	146363183	22.9565	8.0774	2.72181
528	1.89394	278784	147197952	22.9783	8.0825	2.72263
529	1.89036	279841	148035889	23.0000	8.0876	2.72346
530	1.88679	280900	148877000	23.0217	8.0927	2.72428
531	1.88324	281961	149721291	23.0434	8.0978	2.72509
532	1.87970	283024	150568768	23.0651	8.1028	2.72591
533	1.87617	284089	151419437	23.0868	8.1079	2.72673
534	1.87266	285156	152273304	23.1084	8.1130	2.72754
535	1.86916	286225	153130375	23.1301	8.1180	2.72835
536	1.86567	287296	153990656	23.1517	8.1231	2.72916
537	1.86220	288369	154854153	23.1733	8.1281	2.72997
538	1.85874	289444	155720872	23.1948	8.1332	2.73078
539	1.85529	290521	156590819	23.2164	8.1382	2.73159
540	1.85185	291600	157464000	23.2379	8.1433	2.73239
541	1.84843	292681	158340421	23.2594	8.1483	2.73320
542	1.84502	293764	159220088	23.2809	8.1533	2.73400
543	1.84162	294849	160103007	23.3024	8.1583	2.73480
544	1.83824	295936	160989184	23.3238	8.1633	2.73560
545	1.83486	297025	161878625	23.3452	8.1683	2.73640
546	1.83150	298116	162771336	23.3666	8.1733	2.73719
547	1.82815	299209	163667323	23.3880	8.1783	2.73799
548	1.82482	300304	164566592	23.4094	8.1833	2.73878
549	1.82149	301401	165469149	23.4307	8.1882	2.73957

Table 3.

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
550	1.81818	302500	166375000	23.4521	8.1932	2.74036
551	1.81488	303601	167284151	23.4734	8.1982	2.74115
552	1.81159	304704	168196608	23.4947	8.2031	2.74194
553	1.80832	305809	169112377	23.5160	8.2081	2.74273
554	1.80505	306916	170031464	23.5372	8.2130	2.74351
555	1.80180	308025	170953875	23.5584	8.2180	2.74429
556	1.79856	309136	171879616	23.5797	8.2229	2.74507
557	1.79533	310249	172808693	23.6008	8.2278	2.74586
558	1.79211	311364	173741112	23.6220	8.2327	2.74663
559	1.78891	312481	174676879	23.6432	8.2377	2.74741
560	1.78571	313600	175616000	23.6643	8.2426	2.74819
561	1.78253	314721	176558481	23.6854	8.2475	2.74896
562	1.77936	315844	177504328	23.7065	8.2524	2.74974
563	1.77620	316969	178453547	23.7276	8.2573	2.75051
564	1.77305	318096	179406144	23.7487	8.2621	2.75128
565	1.76991	319225	180362125	23.7697	8.2670	2.75205
566	1.76678	320356	181321496	23.7908	8.2719	2.75282
567	1.76367	321489	182284263	23.8118	8.2768	2.75358
568	1.76056	322624	183250432	23.8328	8.2816	2.75435
569	1.75747	323761	184220009	23.8537	8.2865	2.75511
570	1.75439	324900	185193000	23.8747	8.2913	2.75587
571	1.75131	326041	186169411	23.8956	8.2962	2.75664
572	1.74825	327184	187149248	23.9165	8.3010	2.75740
573	1.74520	328329	188132517	23.9374	8.3059	2.75815
574	1.74216	329476	189119224	23.9583	8.3107	2.75891
575	1.73913	330625	190109375	23.9792	8.3155	2.75967
576	1.73611	331776	191102976	24.0000	8.3203	2.76042
577	1.73310	332929	192100033	24.0208	8.3251	2.76118
578	1.73010	334084	193100552	24.0416	8.3300	2.76193
579	1.72712	335241	194104539	24.0624	8.3348	2.76268
580	1.72414	336400	195112000	24.0832	8.3396	2.76343
581	1.72117	337561	196122941	24.1039	8.3443	2.76418
582	1.71821	338724	197137368	24.1247	8.3491	2.76492
583	1.71527	339889	198155287	24.1454	8.3539	2.76567
584	1.71233	341056	199176704	24.1661	8.3587	2.76641
585	1.70940	342225	200201625	24.1868	8.3634	2.76716
586	1.70648	343396	201230056	24.2074	8.3682	2.76790
587	1.70358	344569	202262003	24.2281	8.3730	2.76864
588	1.70068	345744	203297472	24.2487	8.3777	2.76938
589	1.69779	346921	204336469	24.2693	8.3825	2.77012
590	1.69492	348100	205379000	24.2899	8.3872	2.77085
591	1.69205	349281	206425071	24.3105	8.3919	2.77159
592	1.68919	350464	207474688	24.3311	8.3967	2.77232
593	1.68634	351649	208527857	24.3516	8.4014	2.77305
594	1.68350	352836	209584584	24.3721	8.4061	2.77379
595	1.68067	354025	210644875	24.3926	8.4108	2.77452
596	1.67785	355216	211708736	24.4131	8.4155	2.77525
597	1.67504	356409	212776173	24.4336	8.4202	2.77597
598	1.67224	357604	213847192	24.4540	8.4249	2.77670
599	1.66945	358801	214921799	24.4745	8.4296	2.77743
600	1.66667	360000	216000000	24.4949	8.4343	2.77815
601	1.66389	361201	217081801	24.5153	8.4390	2.77887
602	1.66113	362404	218167208	24.5357	8.4437	2.77960
603	1.65837	363609	219256227	24.5561	8.4484	2.78032
604	1.65563	364816	220348864	24.5764	8.4530	2.78104

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000 \cdot \frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
605	1.65289	366025	221445125	24.5967	8.4577	2.78176
606	1.65017	367236	222545016	24.6171	8.4623	2.78247
607	1.64745	368449	223648543	24.6374	8.4670	2.78319
608	1.64474	369664	224755712	24.6577	8.4716	2.78390
609	1.64204	370881	225866529	24.6779	8.4763	2.78462
610	1.63934	372100	226981000	24.6982	8.4809	2.78533
611	1.63666	373321	228099131	24.7184	8.4856	2.78604
612	1.63399	374544	229220928	24.7386	8.4902	2.78675
613	1.63132	375769	230346397	24.7588	8.4948	2.78746
614	1.62866	376996	231475544	24.7790	8.4994	2.78817
615	1.62602	378225	232608375	24.7992	8.5040	2.78888
616	1.62338	379456	233744896	24.8193	8.5086	2.78958
617	1.62075	380689	234885113	24.8395	8.5132	2.79029
618	1.61812	381924	236029032	24.8596	8.5178	2.79099
619	1.61551	383161	237176659	24.8797	8.5224	2.79169
620	1.61290	384400	238328000	24.8998	8.5270	2.79239
621	1.61031	385641	239483061	24.9199	8.5316	2.79309
622	1.60772	386884	240641848	24.9399	8.5362	2.79379
623	1.60514	388129	241804367	24.9600	8.5408	2.79449
624	1.60256	389376	242970624	24.9800	8.5453	2.79518
625	1.60000	390625	244140625	25.0000	8.5499	2.79934
626	1.59744	391876	245314376	25.0200	8.5544	2.79657
627	1.59490	393129	246491883	25.0400	8.5590	2.79727
628	1.59236	394384	247673152	25.0599	8.5635	2.79796
629	1.58983	395641	248858189	25.0799	8.5681	2.79865
630	1.58730	396900	250047000	25.0998	8.5726	2.79934
631	1.58479	398161	251239591	25.1197	8.5772	2.80003
632	1.58228	399424	252435968	25.1396	8.5817	2.80072
633	1.57978	400689	253636137	25.1595	8.5862	2.80140
634	1.57729	401956	254840104	25.1794	8.5907	2.80209
635	1.57480	403225	256047875	25.1992	8.5952	2.80277
636	1.57233	404496	257259456	25.2190	8.5997	2.80346
637	1.56986	405769	258474853	25.2389	8.6043	2.80414
638	1.56740	407044	259694072	25.2587	8.6088	2.80482
639	1.56495	408321	260917119	25.2784	8.6132	2.80550
640	1.56250	409600	262144000	25.2982	8.6177	2.80618
641	1.56006	410881	263374721	25.3180	8.6222	2.80686
642	1.55763	412164	264609288	25.3377	8.6267	2.80754
643	1.55521	413449	265847707	25.3574	8.6312	2.80821
644	1.55280	414736	267089984	25.3772	8.6357	2.80889
645	1.55039	416025	268336125	25.3969	8.6401	2.80956
646	1.54799	417316	269586136	25.4165	8.6446	2.81023
647	1.54560	418609	270840023	25.4362	8.6490	2.81090
648	1.54321	419904	272097792	25.4558	8.6535	2.81158
649	1.54083	421201	273359449	25.4755	8.6579	2.81224
650	1.53846	422500	274625000	25.4951	8.6624	2.81291
651	1.53610	423801	275894451	25.5147	8.6668	2.81358
652	1.53374	425104	277167808	25.5343	8.6713	2.81425
653	1.53139	426409	278445077	25.5539	8.6757	2.81491
654	1.52905	427716	279726264	25.5734	8.6801	2.81558
655	1.52672	429025	281011375	25.5930	8.6845	2.81624
656	1.52439	430336	282300416	25.6125	8.6890	2.81690
657	1.52207	431649	283593393	25.6320	8.6934	2.81757
658	1.51976	432964	284890312	25.6515	8.6978	2.81823
659	1.51745	434281	286191179	25.6710	8.7022	2.81889

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
660	1.51515	435600	287496000	25.6905	8.7066	2.81954
661	1.51286	436921	288804781	25.7099	8.7110	2.82020
662	1.51057	438244	290117528	25.7294	8.7154	2.82086
663	1.50830	439569	291434247	25.7488	8.7198	2.82151
664	1.50602	440896	292754944	25.7682	8.7241	2.82217
665	1.50376	442225	294079625	25.7876	8.7285	2.82282
666	1.50150	443556	295408296	25.8070	8.7329	2.82347
667	1.49925	444889	296740963	25.8263	8.7373	2.82413
668	1.49701	446224	298077632	25.8457	8.7416	2.82478
669	1.49477	447561	299418309	25.8650	8.7460	2.82543
670	1.49254	448900	300763000	25.8844	8.7503	2.82607
671	1.49031	450241	302111711	25.9037	8.7547	2.82672
672	1.48810	451584	303464448	25.9230	8.7590	2.82737
673	1.48588	452929	304821217	25.9422	8.7634	2.82802
674	1.48368	454276	306182024	25.9615	8.7677	2.82866
675	1.48148	455625	307546875	25.9808	8.7721	2.82930
676	1.47929	456976	308915776	26.0000	8.7764	2.82995
677	1.47710	458329	310288733	26.0192	8.7807	2.83059
678	1.47493	459684	311665752	26.0384	8.7850	2.83123
679	1.47275	461041	313046839	26.0576	8.7893	2.83187
680	1.47059	462400	314432000	26.0768	8.7937	2.83251
681	1.46843	463761	315821241	26.0960	8.7980	2.83315
682	1.46628	465124	317214568	26.1151	8.8023	2.83378
683	1.46413	466489	318611987	26.1343	8.8066	2.83442
684	1.46199	467856	320013504	26.1534	8.8108	2.83506
685	1.45985	469225	321419125	26.1725	8.8152	2.83569
686	1.45773	470596	322828856	26.1916	8.8194	2.83632
687	1.45560	471969	324242703	26.2107	8.8237	2.83696
688	1.45349	473344	325660672	26.2298	8.8280	2.83759
689	1.45138	474721	327082769	26.2488	8.8323	2.83822
690	1.44928	476100	328509000	26.2679	8.8366	2.83885
691	1.44718	477481	329939371	26.2869	8.8408	2.83948
692	1.44509	478864	331373888	26.3059	8.8451	2.84011
693	1.44300	480249	332812557	26.3249	8.8493	2.84073
694	1.44092	481636	334255384	26.3439	8.8536	2.84136
695	1.43885	483025	335702375	26.3629	8.8578	2.84198
696	1.43678	484416	337153536	26.3818	8.8621	2.84261
697	1.43472	485809	338608873	26.4008	8.8663	2.84323
698	1.43266	487204	340068392	26.4197	8.8706	2.84386
699	1.43062	488601	341532099	26.4386	8.8748	2.84448
700	1.42857	490000	343000000	26.4575	8.8790	2.84510
701	1.42653	491401	344472101	26.4764	8.8833	2.84572
702	1.42450	492804	345948408	26.4953	8.8875	2.84634
703	1.42248	494209	347428927	26.5141	8.8917	2.84696
704	1.42045	495616	348913664	26.5330	8.8959	2.84757
705	1.41844	497025	350402625	26.5518	8.9001	2.84819
706	1.41643	498436	351895816	26.5707	8.9043	2.84880
707	1.41443	499849	353393243	26.5895	8.9085	2.84942
708	1.41243	501264	354894912	26.6083	8.9127	2.85003
709	1.41044	502681	356400829	26.6271	8.9169	2.85065
710	1.40845	504100	357911000	26.6458	8.9211	2.85126
711	1.40647	505521	359425431	26.6646	8.9253	2.85187
712	1.40449	506944	360944128	26.6833	8.9295	2.85248
713	1.40252	508369	362467097	26.7021	8.9337	2.85309
714	1.40056	509796	363994344	26.7208	8.9378	2.85370

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000 \cdot \frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
715	1.39860	511225	365525875	26.7395	8.9420	2.85431
716	1.39665	512656	367061696	26.7582	8.9462	2.85491
717	1.39470	514089	368601813	26.7769	8.9503	2.85552
718	1.39276	515524	370146232	26.7955	8.9545	2.85612
719	1.39082	516961	371694959	26.8142	8.9587	2.85673
720	1.38889	518400	373248000	26.8328	8.9628	2.85733
721	1.38696	519841	374805361	26.8514	8.9670	2.85794
722	1.38504	521284	376367048	26.8701	8.9711	2.85854
723	1.38313	522729	377933067	26.8887	8.9752	2.85914
724	1.38122	524176	379503424	26.9072	8.9794	2.85974
725	1.37931	525625	381078125	26.9258	8.9835	2.86034
726	1.37741	527076	382657176	26.9444	8.9876	2.86094
727	1.37552	528529	384240583	26.9629	8.9918	2.86153
728	1.37363	529984	385828352	26.9815	8.9959	2.86213
729	1.37174	531441	387420489	27.0000	9.0000	2.86273
730	1.36986	532900	389017000	27.0185	9.0041	2.86332
731	1.36799	534361	390617891	27.0370	9.0082	2.86392
732	1.36612	535824	392223168	27.0555	9.0123	2.86451
733	1.36426	537289	393832837	27.0740	9.0164	2.86510
734	1.36240	538756	395446904	27.0924	9.0205	2.86570
735	1.36054	540225	397065375	27.1109	9.0246	2.86629
736	1.35870	541696	398688256	27.1293	9.0287	2.86688
737	1.35685	543169	400315553	27.1477	9.0328	2.86747
738	1.35501	544644	401947272	27.1662	9.0369	2.86806
739	1.35318	546121	403583419	27.1846	9.0410	2.86864
740	1.35135	547600	405224000	27.2029	9.0450	2.86923
741	1.34953	549081	406869021	27.2213	9.0491	2.86982
742	1.34771	550564	408518488	27.2397	9.0532	2.87040
743	1.34590	552049	410172407	27.2580	9.0572	2.87099
744	1.34409	553536	411830784	27.2764	9.0613	2.87157
745	1.34228	555025	413493625	27.2947	9.0654	2.87216
746	1.34048	556516	415160936	27.3130	9.0694	2.87274
747	1.33869	558009	416832723	27.3313	9.0735	2.87332
748	1.33690	559504	418508992	27.3496	9.0775	2.87390
749	1.33511	561001	420189749	27.3679	9.0816	2.87448
750	1.33333	562500	421875000	27.3861	9.0856	2.87506
751	1.33156	564001	423564751	27.4044	9.0896	2.87564
752	1.32979	565504	425259008	27.4226	9.0937	2.87622
753	1.32802	567009	426957777	27.4408	9.0977	2.87679
754	1.32626	568516	428661064	27.4591	9.1017	2.87737
755	1.32450	570025	430368875	27.4773	9.1057	2.87795
756	1.32275	571536	432081216	27.4955	9.1098	2.87852
757	1.32100	573049	433798093	27.5136	9.1138	2.87910
758	1.31926	574564	435519512	27.5318	9.1178	2.87967
759	1.31752	576081	437245479	27.5500	9.1218	2.88024
760	1.31579	577600	438976000	27.5681	9.1258	2.88081
761	1.31406	579121	440711081	27.5862	9.1298	2.88138
762	1.31234	580644	442450728	27.6043	9.1338	2.88195
763	1.31062	582169	444194947	27.6225	9.1378	2.88252
764	1.30890	583696	445943744	27.6405	9.1418	2.88309
765	1.30719	585225	447697125	27.6586	9.1458	2.88366
766	1.30548	586756	449455096	27.6767	9.1498	2.88423
767	1.30378	588289	451217663	27.6948	9.1537	2.88480
768	1.30208	589824	452984832	27.7128	9.1577	2.88536
769	1.30039	591361	454756609	27.7308	9.1617	2.88593

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000 \cdot \frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
770	1.29870	592900	456533000	27.7489	9.1657	2.88649
771	1.29702	594441	458314011	27.7669	9.1696	2.88705
772	1.29534	595984	460099648	27.7849	9.1736	2.88762
773	1.29366	597529	461889917	27.8029	9.1775	2.88818
774	1.29199	599076	463684824	27.8209	9.1815	2.88874
775	1.29032	600625	465484375	27.8388	9.1855	2.88930
776	1.28866	602176	467288576	27.8568	9.1894	2.88986
777	1.28700	603729	469097433	27.8747	9.1933	2.89042
778	1.28535	605284	470910952	27.8927	9.1973	2.89098
779	1.28370	606841	472729139	27.9106	9.2012	2.89154
780	1.28205	608400	474552000	27.9285	9.2052	2.89209
781	1.28041	609961	476379541	27.9464	9.2091	2.89265
782	1.27877	611524	478211768	27.9643	9.2130	2.89321
783	1.27714	613089	480048687	27.9821	9.2170	2.89376
784	1.27551	614656	481890304	28.0000	9.2209	2.89432
785	1.27389	616225	483736625	28.0179	9.2248	2.89487
786	1.27226	617796	485587656	28.0357	9.2287	2.89542
787	1.27065	619369	487443403	28.0535	9.2326	2.89597
788	1.26904	620944	489303872	28.0713	9.2365	2.89653
789	1.26743	622521	491169069	28.0891	9.2404	2.89708
790	1.26582	624100	493039000	28.1069	9.2443	2.89763
791	1.26422	625681	494913671	28.1247	9.2482	2.89818
792	1.26263	627264	496793088	28.1425	9.2521	2.89873
793	1.26103	628849	498677257	28.1603	9.2560	2.89927
794	1.25945	630436	500566184	28.1780	9.2599	2.89982
795	1.25786	632025	502459875	28.1957	9.2638	2.90037
796	1.25628	633616	504358336	28.2135	9.2677	2.90091
797	1.25471	635209	506261573	28.2312	9.2716	2.90146
798	1.25313	636804	508169592	28.2489	9.2754	2.90200
799	1.25156	638401	510082399	28.2666	9.2793	2.90255
800	1.25000	640000	512000000	28.2843	9.2832	2.90309
801	1.24844	641601	513922401	28.3019	9.2870	2.90363
802	1.24688	643204	515849608	28.3196	9.2909	2.90417
803	1.24533	644809	517781627	28.3373	9.2948	2.90472
804	1.24378	646416	519718464	28.3549	9.2986	2.90526
805	1.24224	648025	521660125	28.3725	9.3025	2.90580
806	1.24069	649636	523606616	28.3901	9.3063	2.90634
807	1.23916	651249	525557943	28.4077	9.3102	2.90687
808	1.23762	652864	527514112	28.4253	9.3140	2.90741
809	1.23609	654481	529475129	28.4429	9.3179	2.90795
810	1.23457	656100	531441000	28.4605	9.3217	2.90849
811	1.23305	657721	533411731	28.4781	9.3255	2.90902
812	1.23153	659344	535387328	28.4956	9.3294	2.90956
813	1.23001	660969	537367797	28.5132	9.3332	2.91009
814	1.22850	662596	539353144	28.5307	9.3370	2.91062
815	1.22699	664225	541343375	28.5482	9.3408	2.91116
816	1.22549	665856	543338496	28.5657	9.3447	2.91169
817	1.22399	667489	545338513	28.5832	9.3485	2.91222
818	1.22249	669124	547343432	28.6007	9.3523	2.91275
819	1.22100	670761	549353259	28.6182	9.3561	2.91328
820	1.21951	672400	551368000	28.6356	9.3599	2.91381
821	1.21803	674041	553387661	28.6531	9.3637	2.91434
822	1.21655	675684	555412248	28.6705	9.3675	2.91487
823	1.21507	677329	557441767	28.6880	9.3713	2.91540
824	1.21359	678976	559476224	28.7054	9.3751	2.91593

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
825	1.21212	680625	561515625	28.7228	9.3789	2.91645
826	1.21065	682276	563559976	28.7402	9.3827	2.91698
827	1.20919	683929	565609283	28.7576	9.3865	2.91751
828	1.20773	685584	567663552	28.7750	9.3902	2.91803
829	1.20627	687241	569722789	28.7924	9.3940	2.91855
830	1.20482	688900	571787000	28.8097	9.3978	2.91908
831	1.20337	690561	573856191	28.8271	9.4016	2.91960
832	1.20192	692224	575930368	28.8444	9.4053	2.92012
833	1.20048	693889	578009537	28.8617	9.4091	2.92065
834	1.19904	695556	580093704	28.8791	9.4129	2.92117
835	1.19760	697225	582182875	28.8964	9.4166	2.92169
836	1.19617	698896	584277056	28.9137	9.4204	2.92221
837	1.19474	700569	586376253	28.9310	9.4241	2.92273
838	1.19332	702244	588480472	28.9482	9.4279	2.92324
839	1.19190	703921	590589719	28.9655	9.4316	2.92376
840	1.19048	705600	592704000	28.9828	9.4354	2.92428
841	1.18906	707281	594823321	29.0000	9.4391	2.92480
842	1.18765	708964	596947688	29.0172	9.4429	2.92531
843	1.18624	710649	599077107	29.0345	9.4466	2.92583
844	1.18483	712336	601211584	29.0517	9.4503	2.92634
845	1.18343	714025	603351125	29.0689	9.4541	2.92686
846	1.18203	715716	605495736	29.0861	9.4578	2.92737
847	1.18064	717409	607645423	29.1033	9.4615	2.92788
848	1.17925	719104	609800192	29.1204	9.4652	2.92840
849	1.17786	720801	611960049	29.1376	9.4690	2.92891
850	1.17647	722500	614125000	29.1548	9.4727	2.92942
851	1.17509	724201	616295051	29.1719	9.4764	2.92993
852	1.17371	725904	618470208	29.1890	9.4801	2.93044
853	1.17233	727609	620650477	29.2062	9.4838	2.93095
854	1.17096	729316	622835864	29.2233	9.4875	2.93146
855	1.16959	731025	625026375	29.2404	9.4912	2.93197
856	1.16822	732736	627222016	29.2575	9.4949	2.93247
857	1.16686	734449	629422793	29.2746	9.4986	2.93298
858	1.16550	736164	631628712	29.2916	9.5023	2.93349
859	1.16414	737881	633839779	29.3087	9.5060	2.93399
860	1.16279	739600	636056000	29.3258	9.5097	2.93450
861	1.16144	741321	638277381	29.3428	9.5134	2.93500
862	1.16009	743044	640503928	29.3598	9.5171	2.93551
863	1.15875	744769	642735647	29.3769	9.5207	2.93601
864	1.15741	746496	644972544	29.3939	9.5244	2.93651
865	1.15607	748225	647214625	29.4109	9.5281	2.93702
866	1.15473	749956	649461896	29.4279	9.5317	2.93752
867	1.15340	751689	651714363	29.4449	9.5354	2.93802
868	1.15207	753424	653972032	29.4618	9.5391	2.93852
869	1.15075	755161	656234909	29.4788	9.5427	2.93902
870	1.14943	756900	658503000	29.4958	9.5464	2.93952
871	1.14811	758641	660776311	29.5127	9.5501	2.94002
872	1.14679	760384	663054848	29.5296	9.5537	2.94052
873	1.14548	762129	665338617	29.5466	9.5574	2.94101
874	1.14416	763876	667627624	29.5635	9.5610	2.94151
875	1.14286	765625	669921875	29.5804	9.5647	2.94201
876	1.14155	767376	672221376	29.5973	9.5683	2.94250
877	1.14025	769129	674526133	29.6142	9.5719	2.94300
878	1.13895	770884	676836152	29.6311	9.5756	2.94349
879	1.13766	772641	679151439	29.6479	9.5792	2.94399

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000 \cdot \frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
880	1.13636	774400	681472000	29.6648	9.5828	2.94448
881	1.13507	776161	683797841	29.6816	9.5865	2.94498
882	1.13379	777924	686128968	29.6985	9.5901	2.94547
883	1.13250	779689	688465387	29.7153	9.5937	2.94596
884	1.13122	781456	690807104	29.7321	9.5973	2.94645
885	1.12994	783225	693154125	29.7489	9.6010	2.94694
886	1.12867	784996	695506456	29.7658	9.6046	2.94743
887	1.12740	786769	697864103	29.7825	9.6082	2.94792
888	1.12613	788544	700227072	29.7993	9.6118	2.94841
889	1.12486	790321	702595369	29.8161	9.6154	2.94890
890	1.12360	792100	704969000	29.8329	9.6190	2.94939
891	1.12233	793881	707347971	29.8496	9.6226	2.94988
892	1.12108	795664	709732288	29.8664	9.6262	2.95036
893	1.11982	797449	712121957	29.8831	9.6298	2.95085
894	1.11857	799236	714516984	29.8998	9.6334	2.95134
895	1.11732	801025	716917375	29.9166	9.6370	2.95182
896	1.11607	802816	719323136	29.9333	9.6406	2.95231
897	1.11483	804609	721734273	29.9500	9.6442	2.95279
898	1.11359	806404	724150792	29.9666	9.6477	2.95328
899	1.11235	808201	726572699	29.9833	9.6513	2.95376
900	1.11111	810000	729000000	30.0000	9.6549	2.95424
901	1.10988	811801	731432701	30.0167	9.6585	2.95472
902	1.10865	813604	733870808	30.0333	9.6620	2.95521
903	1.10742	815409	736314327	30.0500	9.6656	2.95569
904	1.10619	817216	738763264	30.0666	9.6692	2.95617
905	1.10497	819025	741217625	30.0832	9.6727	2.95665
906	1.10375	820836	743677416	30.0998	9.6763	2.95713
907	1.10254	822649	746142643	30.1164	9.6799	2.95761
908	1.10132	824464	748613312	30.1330	9.6834	2.95809
909	1.10011	826281	751089429	30.1496	9.6870	2.95856
910	1.09890	828100	753571000	30.1662	9.6905	2.95904
911	1.09769	829921	756058031	30.1828	9.6941	2.95952
912	1.09649	831744	758550528	30.1993	9.6976	2.95999
913	1.09529	833569	761048497	30.2159	9.7012	2.96047
914	1.09409	835396	763551944	30.2324	9.7047	2.96095
915	1.09290	837225	766060875	30.2490	9.7082	2.96142
916	1.09170	839056	768575296	30.2655	9.7118	2.96190
917	1.09051	840889	771095213	30.2820	9.7153	2.96237
918	1.08932	842724	773620632	30.2985	9.7188	2.96284
919	1.08814	844561	776151559	30.3150	9.7224	2.96332
920	1.08696	846400	778688000	30.3315	9.7259	2.96379
921	1.08578	848241	781229961	30.3480	9.7294	2.96426
922	1.08460	850084	783777448	30.3645	9.7329	2.96473
923	1.08342	851929	786330467	30.3809	9.7364	2.96520
924	1.08225	853776	788889024	30.3974	9.7400	2.96567
925	1.08108	855625	791453125	30.4138	9.7435	2.96614
926	1.07991	857476	794022776	30.4302	9.7470	2.96661
927	1.07875	859329	796597983	30.4467	9.7505	2.96708
928	1.07759	861184	799178752	30.4631	9.7540	2.96755
929	1.07643	863041	801765089	30.4795	9.7575	2.96802
930	1.07527	864900	804357000	30.4959	9.7610	2.96848
931	1.07411	866761	806954491	30.5123	9.7645	2.96895
932	1.07296	868624	809557568	30.5287	9.7680	2.96942
933	1.07181	870489	812166237	30.5450	9.7715	2.96988
934	1.07066	872356	814780504	30.5614	9.7750	2.97035

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
935	1.06952	874225	817400375	30.5778	9.7785	2.97081
936	1.06838	876096	820025856	30.5941	9.7819	2.97128
937	1.06724	877969	822656953	30.6105	9.7854	2.97174
938	1.06610	879844	825293672	30.6268	9.7889	2.97220
939	1.06496	881721	827936019	30.6431	9.7924	2.97267
940	1.06383	883600	830584000	30.6594	9.7959	2.97313
941	1.06270	885481	833237621	30.6757	9.7993	2.97359
942	1.06157	887364	835896888	30.6920	9.8028	2.97405
943	1.06045	889249	838561807	30.7083	9.8063	2.97451
944	1.05932	891136	841232384	30.7246	9.8097	2.97497
945	1.05820	893025	843908625	30.7409	9.8132	2.97543
946	1.05708	894916	846590536	30.7571	9.8167	2.97589
947	1.05597	896809	849278123	30.7734	9.8201	2.97635
948	1.05485	898704	851971392	30.7896	9.8236	2.97681
949	1.05374	900601	854670349	30.8058	9.8270	2.97727
950	1.05263	902500	857375000	30.8221	9.8305	2.97772
951	1.05152	904401	860085351	30.8383	9.8339	2.97818
952	1.05042	906304	862801408	30.8545	9.8374	2.97864
953	1.04932	908209	865523177	30.8707	9.8408	2.97909
954	1.04822	910116	868250664	30.8869	9.8443	2.97955
955	1.04712	912025	870983875	30.9031	9.8477	2.98000
956	1.04603	913936	873722816	30.9192	9.8511	2.98046
957	1.04493	915849	876467493	30.9354	9.8546	2.98091
958	1.04384	917764	879217912	30.9516	9.8580	2.98137
959	1.04275	919681	881974079	30.9677	9.8614	2.98182
960	1.04167	921600	884736000	30.9839	9.8648	2.98227
961	1.04058	923521	887503681	31.0000	9.8683	2.98272
962	1.03950	925444	890277128	31.0161	9.8717	2.98318
963	1.03842	927369	893056347	31.0322	9.8751	2.98363
964	1.03734	929296	895841344	31.0483	9.8785	2.98408
965	1.03627	931225	898632125	31.0644	9.8819	2.98453
966	1.03520	933156	901428696	31.0805	9.8854	2.98498
967	1.03413	935089	904231063	31.0966	9.8888	2.98543
968	1.03306	937024	907039232	31.1127	9.8922	2.98588
969	1.03199	938961	909853209	31.1288	9.8956	2.98632
970	1.03093	940900	912673000	31.1448	9.8990	2.98677
971	1.02987	942841	915498611	31.1609	9.9024	2.98722
972	1.02881	944784	918330048	31.1769	9.9058	2.98767
973	1.02775	946729	921167317	31.1929	9.9092	2.98811
974	1.02669	948676	924010424	31.2090	9.9126	2.98856
975	1.02564	950625	926859375	31.2250	9.9160	2.98900
976	1.02459	952576	929714176	31.2410	9.9194	2.98945
977	1.02354	954529	932574833	31.2570	9.9227	2.98989
978	1.02249	956484	935441352	31.2730	9.9261	2.99034
979	1.02145	958441	938313739	31.2890	9.9295	2.99078
980	1.02041	960400	941192000	31.3050	9.9329	2.99123
981	1.01937	962361	944076141	31.3209	9.9363	2.99167
982	1.01833	964324	946966168	31.3369	9.9396	2.99211
983	1.01729	966289	949862087	31.3528	9.9430	2.99255
984	1.01626	968256	952763904	31.3688	9.9464	2.99300
985	1.01523	970225	955671625	31.3847	9.9497	2.99344
986	1.01420	972196	958585256	31.4006	9.9531	2.99388
987	1.01317	974169	961504803	31.4166	9.9565	2.99432
988	1.01215	976144	964430272	31.4325	9.9598	2.99476
989	1.01112	978121	967361669	31.4484	9.9632	2.99520

VALUES OF RECIPROCALS, SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND COMMON LOGARITHMS OF NATURAL NUMBERS.

n	$1000.\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	log. n
990	1.01010	980100	970299000	31.4643	9.9666	2.99564
991	1.00908	982081	973242271	31.4802	9.9699	2.99607
992	1.00806	984064	976191488	31.4960	9.9733	2.99651
993	1.00705	986049	979146657	31.5119	9.9766	2.99695
994	1.00604	988036	982107784	31.5278	9.9800	2.99739
995	1.00503	990025	985074875	31.5436	9.9833	2.99782
996	1.00402	992016	988047936	31.5595	9.9866	2.99826
997	1.00301	994009	991026973	31.5753	9.9900	2.99870
998	1.00200	996004	994011992	31.5911	9.9933	2.99913
999	1.00100	998001	997002999	31.6070	9.9967	2.99957
1000	1.00000	1000000	1000000000	31.6228	10.0000	3.00000

CIRCUMFERENCE AND AREA OF CIRCLE IN TERMS OF DIAMETER *d*.

d	πd	$\frac{1}{4}\pi d^2$	d	πd	$\frac{1}{4}\pi d^2$	d	πd	$\frac{1}{4}\pi d^2$
10	31.416	78.5398	40	125.66	1256.64	70	219.91	3848.45
11	34.558	95.0332	41	128.81	1320.25	71	223.05	3959.19
12	37.699	113.097	42	131.95	1385.44	72	226.19	4071.50
13	40.841	132.732	43	135.09	1452.20	73	229.34	4185.39
14	43.982	153.938	44	138.23	1520.53	74	232.48	4300.84
15	47.124	176.715	45	141.37	1590.43	75	235.62	4417.86
16	50.265	201.062	46	144.51	1661.90	76	238.76	4536.46
17	53.407	226.980	47	147.65	1734.94	77	241.90	4656.63
18	56.549	254.469	48	150.80	1809.56	78	245.04	4778.36
19	59.690	283.529	49	153.94	1885.74	79	248.19	4901.67
20	62.832	314.159	50	157.08	1963.50	80	251.33	5026.55
21	65.973	346.361	51	160.22	2042.82	81	254.47	5153.00
22	69.115	380.133	52	163.36	2123.72	82	257.61	5281.02
23	72.257	415.476	53	166.50	2206.18	83	260.75	5410.61
24	75.398	452.389	54	169.65	2290.22	84	263.89	5541.77
25	78.540	490.874	55	172.79	2375.83	85	267.04	5674.50
26	81.681	530.929	56	175.93	2463.01	86	270.18	5808.80
27	84.823	572.555	57	179.07	2551.76	87	273.32	5944.68
28	87.965	615.752	58	182.21	2642.08	88	276.46	6082.12
29	91.106	660.520	59	185.35	2733.97	89	279.60	6221.14
30	94.248	706.858	60	188.50	2827.43	90	282.74	6361.73
31	97.389	754.768	61	191.64	2922.47	91	285.88	6503.88
32	100.53	804.248	62	194.78	3019.07	92	289.03	6647.61
33	103.67	855.299	63	197.92	3117.25	93	292.17	6792.91
34	106.81	907.920	64	201.06	3216.99	94	295.31	6939.78
35	109.96	962.113	65	204.20	3318.31	95	298.45	7088.22
36	113.10	1017.88	66	207.35	3421.19	96	301.59	7238.23
37	116.24	1075.21	67	210.49	3525.65	97	304.73	7389.81
38	119.38	1134.11	68	213.63	3631.68	98	307.88	7542.96
39	122.52	1194.59	69	216.77	3739.28	99	311.02	7697.69

LOGARITHMS OF NUMBERS.

N.	0	1	2	3	4	5	6	7	8	9	Prop. Parts.								
											1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7
N.	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

LOGARITHMS OF NUMBERS.

N.	0	1	2	3	4	5	6	7	8	9	Prop. Parts. 1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4
N.	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

ANTILOGARITHMS.

L.	0	1	2	3	4	5	6	7	8	9	Prop. Parts. 1	2	3	4	5	6	7	8	9
.00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
.01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
.02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
.03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
.04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
.05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
.06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
.07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
.08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
.09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
.10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
.11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
.12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
.13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
.14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
.15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
.16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
.17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
.18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
.19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
.20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
.21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
.22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
.23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
.24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
.25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
.26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
.27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
.28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
.29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
.30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
.31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
.32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
.33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
.34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
.35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
.36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
.37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
.38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
.39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
.40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
.41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
.42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
.43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
.44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
.45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
.46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
.47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
.48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
.49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6
L.	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

ANTILOGARITHMS.

L.	0	1	2	3	4	5	6	7	8	9	Prop. Parts 1	2	3	4	5	6	7	8	9
.50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
.51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
.52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
.53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
.54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
.55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
.56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
.57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
.58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
.59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
.60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
.61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
.62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
.63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
.64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
.65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
.66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
.67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
.68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
.69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
.70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
.71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
.72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
.73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
.74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
.75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
.76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
.77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
.78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
.80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
.81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
.82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
.83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
.84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
.85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
.86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
.87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
.88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
.89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
.90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
.91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
.92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
.93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
.94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
.95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
.96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
.97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
.98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
.99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20
L.	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

NATURAL SINES AND COSINES.

Natural Sines.

Angle.	0′	10′	20′	30′	40′	50′	60′	Angle.	Prop. Parts for 1′.
0°	.0000 00	.0029 09	.0058 18	.0087 27	.0116 35	.0145 44	.0174 52	89°	2.9
1	.0174 52	.0203 6	.0232 7	.0261 8	.0290 8	.0319 9	.0349 0	88	2.9
2	.0349 0	.0378 1	.0407 1	.0436 2	.0465 3	.0494 3	.0523 4	87	2.9
3	.0523 4	.0552 4	.0581 4	.0610 5	.0639 5	.0668 5	.0697 6	86	2.9
4	.0697 6	.0726 6	.0755 6	.0784 6	.0813 6	.0842 6	.0871 6	85	2.9
5	.0871 6	.0900 5	.0929 5	.0958 5	.0987 4	.1016 4	.1045 3	84	2.9
6	.1045 3	.1074 2	.1103 1	.1132 0	.1160 9	.1189 8	.1218 7	83	2.9
7	.1218 7	.1247 6	.1276 4	.1305 3	.1334	.1363	.1392	82	2.9
8	.1392	.1421	.1449	.1478	.1507	.1536	.1564	81	2.9
9	.1564	.1593	.1622	.1650	.1679	.1708	.1736	80	2.9
10	.1736	.1765	.1794	.1822	.1851	.1880	.1908	79	2.9
11	.1908	.1937	.1965	.1994	.2022	.2051	.2079	78	2.9
12	.2079	.2108	.2136	.2164	.2193	.2221	.2250	77	2.8
13	.2250	.2278	.2306	.2334	.2363	.2391	.2419	76	2.8
14	.2419	.2447	.2476	.2504	.2532	.2560	.2588	75	2.8
15	.2588	.2616	.2644	.2672	.2700	.2728	.2756	74	2.8
16	.2756	.2784	.2812	.2840	.2868	.2896	.2924	73	2.8
17	.2924	.2952	.2979	.3007	.3035	.3062	.3090	72	2.8
18	.3090	.3118	.3145	.3173	.3201	.3228	.3256	71	2.8
19	.3256	.3283	.3311	.3338	.3365	.3393	.3420	70	2.7
20	.3420	.3448	.3475	.3502	.3529	.3557	.3584	69	2.7
21	.3584	.3611	.3638	.3665	.3692	.3719	.3746	68	2.7
22	.3746	.3773	.3800	.3827	.3854	.3881	.3907	67	2.7
23	.3907	.3934	.3961	.3987	.4014	.4041	.4067	66	2.7
24	.4067	.4094	.4120	.4147	.4173	.4200	.4226	65	2.7
25	.4226	.4253	.4279	.4305	.4331	.4358	.4384	64	2.6
26	.4384	.4410	.4436	.4462	.4488	.4514	.4540	63	2.6
27	.4540	.4566	.4592	.4617	.4643	.4669	.4695	62	2.6
28	.4695	.4720	.4746	.4772	.4797	.4823	.4848	61	2.6
29	.4848	.4874	.4899	.4924	.4950	.4975	.5000	60	2.5
30	.5000	.5025	.5050	.5075	.5100	.5125	.5150	59	2.5
31	.5150	.5175	.5200	.5225	.5250	.5275	.5299	58	2.5
32	.5299	.5324	.5348	.5373	.5398	.5422	.5446	57	2.5
33	.5446	.5471	.5495	.5519	.5544	.5568	.5592	56	2.4
34	.5592	.5616	.5640	.5664	.5688	.5712	.5736	55	2.4
35	.5736	.5760	.5783	.5807	.5831	.5854	.5878	54	2.4
36	.5878	.5901	.5925	.5948	.5972	.5995	.6018	53	2.3
37	.6018	.6041	.6065	.6088	.6111	.6134	.6157	52	2.3
38	.6157	.6180	.6202	.6225	.6248	.6271	.6293	51	2.3
39	.6293	.6316	.6338	.6361	.6383	.6406	.6428	50	2.3
40	.6428	.6450	.6472	.6494	.6517	.6539	.6561	49	2.2
41	.6561	.6583	.6604	.6626	.6648	.6670	.6691	48	2.2
42	.6691	.6713	.6734	.6756	.6777	.6799	.6820	47	2.2
43	.6820	.6841	.6862	.6884	.6905	.6926	.6947	46	2.1
44	.6947	.6967	.6988	.7009	.7030	.7050	.7071	45	2.1
	60′	50′	40′	30′	20′	10′	0′	Angle.	

Natural Cosines.

NATURAL SINES AND COSINES.

Natural Sines.

Angle.	0′	10′	20′	30′	40′	50′	60′	Angle.	Prop. Parts for 1′.
45°	.7071	.7092	.7112	.7133	.7153	.7173	.7193	44°	2.0
46	.7193	.7214	.7234	.7254	.7274	.7294	.7314	43	2.0
47	.7314	.7333	.7353	.7373	.7392	.7412	.7431	42	2.0
48	.7431	.7451	.7470	.7490	.7509	.7528	.7547	41	1.9
49	.7547	.7566	.7585	.7604	.7623	.7642	.7660	40	1.9
50	.7660	.7679	.7698	.7716	.7735	.7753	.7771	39	1.9
51	.7771	.7790	.7808	.7826	.7844	.7862	.7880	38	1.8
52	.7880	.7898	.7916	.7934	.7951	.7969	.7986	37	1.8
53	.7986	.8004	.8021	.8039	.8056	.8073	.8090	36	1.7
54	.8090	.8107	.8124	.8141	.8158	.8175	.8192	35	1.7
55	.8192	.8208	.8225	.8241	.8258	.8274	.8290	34	1.6
56	.8290	.8307	.8323	.8339	.8355	.8371	.8387	33	1.6
57	.8387	.8403	.8418	.8434	.8450	.8465	.8480	32	1.6
58	.8480	.8496	.8511	.8526	.8542	.8557	.8572	31	1.5
59	.8572	.8587	.8601	.8616	.8631	.8646	.8660	30	1.5
60	.8660	.8675	.8689	.8704	.8718	.8732	.8746	29	1.4
61	.8746	.8760	.8774	.8788	.8802	.8816	.8829	28	1.4
62	.8829	.8843	.8857	.8870	.8884	.8897	.8910	27	1.4
63	.8910	.8923	.8936	.8949	.8962	.8975	.8988	26	1.3
64	.8988	.9001	.9013	.9026	.9038	.9051	.9063	25	1.3
65	.9063	.9075	.9088	.9100	.9112	.9124	.9135	24	1.2
66	.9135	.9147	.9159	.9171	.9182	.9194	.9205	23	1.2
67	.9205	.9216	.9228	.9239	.9250	.9261	.9272	22	1.1
68	.9272	.9283	.9293	.9304	.9315	.9325	.9336	21	1.1
69	.9336	.9346	.9356	.9367	.9377	.9387	.9397	20	1.0
70	.9397	.9407	.9417	.9426	.9436	.9446	.9455	19	1.0
71	.9455	.9465	.9474	.9483	.9492	.9502	.9511	18	0.9
72	.9511	.9520	.9528	.9537	.9546	.9555	.9563	17	0.9
73	.9563	.9572	.9580	.9588	.9596	.9605	.9613	16	0.8
74	.9613	.9621	.9628	.9636	.9644	.9652	.9659	15	0.8
75	.9659	.9667	.9674	.9681	.9689	.9696	.9703	14	0.7
76	.9703	.9710	.9717	.9724	.9730	.9737	.9744	13	0.7
77	.9744	.9750	.9757	.9763	.9769	.9775	.9781	12	0.6
78	.9781	.9787	.9793	.9799	.9805	.9811	.9816	11	0.6
79	.9816	.9822	.9827	.9833	.9838	.9843	.9848	10	0.5
80	.9848	.9853	.9858	.9863	.9868	.9872	.9877	9	0.5
81	.9877	.9881	.9886	.9890	.9894	.9899	.9903	8	0.4
82	.9903	.9907	.9911	.9914	.9918	.9922	.9925	7	0.4
83	.9925	.9929	.9932	.9936	.9939	.9942	.9945	6	0.3
84	.9945	.9948	.9951	.9954	.9957	.9959	.9962	5	0.3
85	.9962	.9964	.9967	.9969	.9971	.9974	.9976	4	0.2
86	.9976	.9978	.9980	.9981	.9983	.9985	.9986	3	0.2
87	.9986	.9988	.9989	.9990	.9992	.9993	.9994	2	0.1
88	.9994	.9995	.9996	.9997	.9997	.9998	.9998	1	0.1
89	.9998	.9999	.9999	1.0000	1.0000	1.0000	1.0000	0	0.0
	60′	50′	40′	30′	20′	10′	0′	Angle.	

Natural Cosines.

NATURAL TANGENTS AND COTANGENTS.

Natural Tangents.

Angle.	0′	10′	20′	30′	40′	50′	60′	Angle.	Prop. Parts for 1′.
0°	.0000 0	.0029 1	.0058 2	.0087 3	.0116 4	.0145 5	.0174 6	89°	2.9
1	.0174 6	.0203 6	.0232 8	.0261 9	.0291 0	.0320 1	.0349 2	88	2.9
2	.0349 2	.0378 3	.0407 5	.0436 6	.0465 8	.0494 9	.0524 1	87	2.9
3	.0524 1	.0553 3	.0582 4	.0611 6	.0640 8	.0670 0	.0699 3	86	2.9
4	.0699 3	.0728 5	.0757 8	.0787 0	.0816 3	.0845 6	.0874 9	85	2.9
5	.0874 9	.0904 2	.0933 5	.0962 9	.0992 3	.1021 6	.1051 0	84	2.9
6	.1051 0	.1080 5	.1109 9	.1139 4	.1168 8	.1198 3	.1227 8	83	2.9
7	.1227 8	.1257 4	.1286 9	.1316 5	.1346	.1376	.1405	82	3.0
8	.1405	.1435	.1465	.1495	.1524	.1554	.1584	81	3.0
9	.1584	.1614	.1644	.1673	.1703	.1733	.1763	80	3.0
10	.1763	.1793	.1823	.1853	.1883	.1914	.1944	79	3.0
11	.1944	.1974	.2004	.2035	.2065	.2095	.2126	78	3.0
12	.2126	.2156	.2186	.2217	.2247	.2278	.2309	77	3.1
13	.2309	.2339	.2370	.2401	.2432	.2462	.2493	76	3.1
14	.2493	.2524	.2555	.2586	.2617	.2648	.2679	75	3.1
15	.2679	.2711	.2742	.2773	.2805	.2836	.2867	74	3.1
16	.2867	.2899	.2931	.2962	.2994	.3026	.3057	73	3.2
17	.3057	.3089	.3121	.3153	.3185	.3217	.3249	72	3.2
18	.3249	.3281	.3314	.3346	.3378	.3411	.3443	71	3.2
19	.3443	.3476	.3508	.3541	.3574	.3607	.3640	70	3.3
20	.3640	.3673	.3706	.3739	.3772	.3805	.3839	69	3.3
21	.3839	.3872	.3906	.3939	.3973	.4006	.4040	68	3.4
22	.4040	.4074	.4108	.4142	.4176	.4210	.4245	67	3.4
23	.4245	.4279	.4314	.4348	.4383	.4417	.4452	66	3.5
24	.4452	.4487	.4522	.4557	.4592	.4628	.4663	65	3.5
25	.4663	.4699	.4734	.4770	.4806	.4841	.4877	64	3.6
26	.4877	.4913	.4950	.4986	.5022	.5059	.5095	63	3.6
27	.5095	.5132	.5169	.5206	.5243	.5280	.5317	62	3.7
28	.5317	.5354	.5392	.5430	.5467	.5505	.5543	61	3.8
29	.5543	.5581	.5619	.5658	.5696	.5735	.5774	60	3.8
30	.5774	.5812	.5851	.5890	.5930	.5969	.6009	59	3.9
31	.6009	.6048	.6088	.6128	.6168	.6208	.6249	58	4.0
32	.6249	.6289	.6330	.6371	.6412	.6453	.6494	57	4.1
33	.6494	.6536	.6577	.6619	.6661	.6703	.6745	56	4.2
34	.6745	.6787	.6830	.6873	.6916	.6959	.7002	55	4.3
35	.7002	.7046	.7089	.7133	.7177	.7221	.7265	54	4.4
36	.7265	.7310	.7355	.7400	.7445	.7490	.7536	53	4.5
37	.7536	.7581	.7627	.7673	.7720	.7766	.7813	52	4.6
38	.7813	.7860	.7907	.7954	.8002	.8050	.8098	51	4.7
39	.8098	.8146	.8195	.8243	.8292	.8342	.8391	50	4.9
40	.8391	.8441	.8491	.8541	.8591	.8642	.8693	49	5.0
41	.8693	.8744	.8796	.8847	.8899	.8952	.9004	48	5.2
42	.9004	.9057	.9110	.9163	.9217	.9271	.9325	47	5.4
43	.9325	.9380	.9435	.9490	.9545	.9601	.9657	46	5.5
44	.9657	.9713	.9770	.9827	.9884	.9942	1.0000	45	5.7
	60′	50′	40′	30′	20′	10′	0′	Angle.	

Natural Cotangents.

NATURAL TANGENTS AND COTANGENTS.

Natural Tangents.

Angle.	0′	10′	20′	30′	40′	50′	60′	Angle.	Prop. Parts for 1′.
45°	1.0000	1.0058	1.0117	1.0176	1.0235	1.0295	1.0355	44°	5.9
46	1.0355	1.0416	1.0477	1.0538	1.0599	1.0661	1.0724	43	6.1
47	1.0724	1.0786	1.0850	1.0913	1.0977	1.1041	1.1106	42	6.4
48	1.1106	1.1171	1.1237	1.1303	1.1369	1.1436	1.1504	41	6.6
49	1.1504	1.1571	1.1640	1.1708	1.1778	1.1847	1.1918	40	6.9
50	1.1918	1.1988	1.2059	1.2131	1.2203	1.2276	1.2349	39	7.2
51	1.2349	1.2423	1.2497	1.2572	1.2647	1.2723	1.2799	38	7.5
52	1.2799	1.2876	1.2954	1.3032	1.3111	1.3190	1.3270	37	7.9
53	1.3270	1.3351	1.3432	1.3514	1.3597	1.3680	1.3764	36	8.2
54	1.3764	1.3848	1.3934	1.4019	1.4106	1.4193	1.4281	35	8.6
55	1.4281	1.4370	1.4460	1.4550	1.4641	1.4733	1.4826	34	9.1
56	1.4826	1.4919	1.5013	1.5108	1.5204	1.5301	1.5399	33	9.6
57	1.5399	1.5497	1.5597	1.5697	1.5798	1.5900	1.6003	32	10.1
58	1.6003	1.6107	1.6212	1.6319	1.6426	1.6534	1.6643	31	10.7
59	1.6643	1.6753	1.6864	1.6977	1.7090	1.7205	1.7321	30	11.3
60	1.7321	1.7437	1.7556	1.7675	1.7796	1.7917	1.8040	29	12.0
61	1.8040	1.8165	1.8291	1.8418	1.8546	1.8676	1.8807	28	12.8
62	1.8807	1.8940	1.9074	1.9210	1.9347	1.9486	1.9626	27	13.6
63	1.9626	1.9768	1.9912	2.0057	2.0204	2.0353	2.0503	26	14.6
64	2.0503	2.0655	2.0809	2.0965	2.1123	2.1283	2.1445	25	15.7
65	2.1445	2.1609	2.1775	2.1943	2.2113	2.2286	2.2460	24	16.9
66	2.2460	2.2637	2.2817	2.2998	2.3183	2.3369	2.3559	23	18.3
67	2.3559	2.3750	2.3945	2.4142	2.4342	2.4545	2.4751	22	19.9
68	2.4751	2.4960	2.5172	2.5386	2.5605	2.5826	2.6051	21	21.7
69	2.6051	2.6279	2.6511	2.6746	2.6985	2.7228	2.7475	20	23.7
70	2.7475	2.7725	2.7980	2.8239	2.8502	2.8770	2.9042	19	
71	2.9042	2.9319	2.9600	2.9887	3.0178	3.0475	3.0777	18	
72	3.0777	3.1084	3.1397	3.1716	3.2041	3.2371	3.2709	17	
73	3.2709	3.3052	3.3402	3.3759	3.4124	3.4495	3.4874	16	
74	3.4874	3.5261	3.5656	3.6059	3.6470	3.6891	3.7321	15	
75	3.7321	3.7760	3.8208	3.8667	3.9136	3.9617	4.0108	14	
76	4.0108	4.0611	4.1126	4.1653	4.2193	4.2747	4.3315	13	
77	4.3315	4.3897	4.4494	4.5107	4.5736	4.6382	4.7046	12	
78	4.7046	4.7729	4.8430	4.9152	4.9894	5.0658	5.1446	11	
79	5.1446	5.2257	5.3093	5.3955	5.4845	5.5764	5.6713	10	
80	5.6713	5.7694	5.8708	5.9758	6.0844	6.1970	6.3138	9	
81	6.3138	6.4348	6.5606	6.6912	6.8269	6.9682	7.1154	8	
82	7.1154	7.2687	7.4287	7.5958	7.7704	7.9530	8.1443	7	
83	8.1443	8.3450	8.5555	8.7769	9.0098	9.2553	9.5144	6	
84	9.5144	9.7882	10.0780	10.3854	10.7119	11.0594	11.4301	5	
85	11.4301	11.8262	12.2505	12.7062	13.1969	13.7267	14.3007	4	
86	14.3007	14.9244	15.6048	16.3499	17.1693	18.0750	19.0811	3	
87	19.0811	20.2056	21.4704	22.9038	24.5418	26.4316	28.6363	2	
88	28.6363	31.2416	34.3678	38.1885	42.9641	49.1039	57.2900	1	
89	57.2900	68.7501	85.9398	114.5887	171.8854	343.7737	∞	0	
	60′	50′	40′	30′	20′	10′	0′	Angle.	

Natural Cotangents.

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.

Minutes.	Distance.	0°		1°		2°		Distance.	Minutes.
		Lat.	Dep.	Lat.	Dep.	Lat.	Dep.		
	1	1.00000	0.00000	0.99984	0.01745	0.99939	0.03490	1	
	2	2.00000	0.00000	1.99969	0.03490	1.99878	0.06980	2	
	3	3.00000	0.00000	2.99954	0.05235	2.99817	0.10470	3	
	4	4.00000	0.00000	3.99939	0.06980	3.99756	0.13960	4	
0	5	5.00000	0.00000	4.99923	0.08726	4.99695	0.17450	5	60
	6	6.00000	0.00000	5.99908	0.10471	5.99634	0.20940	6	
	7	7.00000	0.00000	6.99893	0.12216	6.99573	0.24430	7	
	8	8.00000	0.00000	7.99878	0.13961	7.99512	0.27920	8	
	9	9.00000	0.00000	8.99862	0.15707	8.99451	0.31410	9	
	1	0.99999	0.00436	0.99976	0.02181	0.99922	0.03925	1	
	2	1.99998	0.00872	1.99952	0.04363	1.99845	0.07851	2	
	3	2.99997	0.01308	2.99928	0.06544	2.99768	0.11777	3	
	4	3.99996	0.01745	3.99904	0.08725	3.99691	0.15703	4	
15	5	4.99995	0.02181	4.99881	0.10907	4.99614	0.19629	5	45
	6	5.99994	0.02617	5.99857	0.13089	5.99537	0.23555	6	
	7	6.99993	0.03054	6.99833	0.15270	6.99460	0.27481	7	
	8	7.99992	0.03490	7.99809	0.17452	7.99383	0.31407	8	
	9	8.99991	0.03926	8.99785	0.19633	8.99306	0.35333	9	
	1	0.99996	0.00872	0.99965	0.02617	0.99904	0.04361	1	
	2	1.99992	0.01745	1.99931	0.05235	1.99809	0.08723	2	
	3	2.99988	0.02617	2.99897	0.07853	2.99714	0.13085	3	
	4	3.99984	0.03490	3.99862	0.10470	3.99619	0.17447	4	
30	5	4.99981	0.04363	4.99828	0.13088	4.99524	0.21809	5	30
	6	5.99977	0.05235	5.99794	0.15706	5.99428	0.26171	6	
	7	6.99973	0.06108	6.99760	0.18323	6.99333	0.30533	7	
	8	7.99969	0.06981	7.99725	0.20941	7.99238	0.34895	8	
	9	8.99965	0.07853	8.99691	0.23559	8.99143	0.39257	9	
	1	0.99991	0.01308	0.99953	0.03053	0.99884	0.04797	1	
	2	1.99982	0.02617	1.99906	0.06107	1.99769	0.09595	2	
	3	2.99974	0 03926	2.99860	0.09161	2.99654	0.14393	3	
	4	3.99965	0.05235	3.99813	0.12215	3.99539	0.19191	4	
45	5	4.99957	0.06544	4.99766	0.15269	4.99424	0.23989	5	15
	6	5.99948	0.07853	5.99720	0.18323	5.99309	0.28786	6	
	7	6.99940	0.09162	6.99673	0.21376	6.99193	0.33584	7	
	8	7.99931	0.10471	7.99626	0.24430	7.99078	0.38382	8	
	9	8.99922	0.11780	8.99580	0.27484	8.98963	0.43180	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		89°		88°		87°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	3° Lat.	3° Dep.	4° Lat.	4° Dep.	5° Lat.	5° Dep.	Distance.	Minutes.
	1	0.99863	0.05233	0.99756	0.06975	0.99619	0.08715	1	
	2	1.99726	0.10467	1.99512	0.13951	1.99238	0.17431	2	
	3	2.99589	0.15700	2.99269	0.20926	2.98858	0.26146	3	
	4	3.99452	0.20934	3.99025	0.27902	3.98477	0.34862	4	
0	5	4.99315	0.26168	4.98782	0.34878	4.98097	0.43577	5	60
	6	5.99178	0.31401	5.98538	0.41853	5.97716	0.52293	6	
	7	6.99041	0.36635	6.98294	0.48829	6.97336	0.61008	7	
	8	7.98904	0.41868	7.98051	0.55805	7.96955	0.69724	8	
	9	8.98767	0.47102	8.97807	0.62780	8.96575	0.78440	9	
	1	0.99839	0.05669	0.99725	0.07410	0.99580	0.09150	1	
	2	1.99678	0.11338	1.99450	0.14821	1.99160	0.18300	2	
	3	2.99517	0.17007	2.99175	0.22232	2.98741	0.27450	3	
	4	3.99356	0.22677	3.98900	0.29643	3.98321	0.36600	4	
15	5	4.99195	0.28346	4.98625	0.37054	4.97902	0.45750	5	45
	6	5.99035	0.34015	5.98350	0.44465	5.97482	0.54900	6	
	7	6.98874	0.39684	6.98075	0.51875	6.97063	0.64051	7	
	8	7.98713	0.45354	7.97800	0.59286	7.96643	0.73201	8	
	9	8.98552	0.51023	8.97525	0.66697	8.96224	0.82351	9	
	1	0.99813	0.06104	0.99691	0.07845	0.99539	0.09584	1	
	2	1.99626	0.12209	1.99383	0.15691	1.99079	0.19169	2	
	3	2.99440	0.18314	2.99075	0.23537	2.98618	0.28753	3	
	4	3.99253	0.24419	3.98766	0.31383	3.98158	0.38338	4	
30	5	4.99067	0.30524	4.98458	0.39229	4.97698	0.47922	5	30
	6	5.98880	0.36629	5.98150	0.47075	5.97237	0.57507	6	
	7	6.98694	0.42733	6.97842	0.54921	6.96777	0.67092	7	
	8	7.98507	0.48838	7.97533	0.62767	7.96316	0.76676	8	
	9	8.98321	0.54943	8.97225	0.70613	8.95856	0.86261	9	
	1	0.99785	0.06540	0.99656	0.08280	0.99496	0.10018	1	
	2	1.99571	0.13080	1.99313	0.16561	1.98993	0.20037	2	
	3	2.99357	0.19620	2.98969	0.24842	2.98490	0.30056	3	
	4	3.99143	0.26161	3.98626	0.33123	3.97987	0.40075	4	
45	5	4.98929	0.32701	4.98282	0.41404	4.97484	0.50094	5	15
	6	5.98715	0.39241	5.97939	0.49684	5.96981	0.60112	6	
	7	6.98501	0.45782	6.97595	0.57965	6.96477	0.70131	7	
	8	7.98287	0.52322	7.97252	0.66246	7.95974	0.80150	8	
	9	8.98073	0.58862	8.96908	0.74527	8.95471	0.90169	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		86°		85°		84°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	6° Lat.	6° Dep.	7° Lat.	7° Dep.	8° Lat.	8° Dep.	Distance.	Minutes.
0	1	0.99452	0.10452	0.99254	0.12186	0.99026	0.13917	1	60
	2	1.98904	0.20905	1.98509	0.24373	1.98053	0.27834	2	
	3	2.98356	0.31358	2.97763	0.36560	2.97080	0.41751	3	
	4	3.97808	0.41811	3.97018	0.48747	3.96107	0.55669	4	
	5	4.97261	0.52264	4.96273	0.60934	4.95134	0.69586	5	
	6	5.96713	0.62717	5.95519	0.73121	5.94160	0.83503	6	
	7	6.96165	0.73169	6.94782	0.85308	6.93187	0.97421	7	
	8	7.95617	0.83622	7.94038	0.97495	7.92214	1.11338	8	
	9	8.95069	0.94075	8.93291	1.09682	8.91241	1.25255	9	
15	1	0.99405	0.10886	0.99200	0.12619	0.98965	0.14349	1	45
	2	1.98811	0.21773	1.98400	0.25239	1.97930	0.28698	2	
	3	2.98216	0.32660	2.97601	0.37859	2.96895	0.43047	3	
	4	3.97622	0.43546	3.96801	0.50479	3.95860	0.57397	4	
	5	4.97028	0.54433	4.96002	0.63099	4.94825	0.71746	5	
	6	5.96433	0.65320	5.95202	0.75719	5.93790	0.86095	6	
	7	6.95839	0.76206	6.94403	0.88339	6.92755	1.00444	7	
	8	7.95245	0.87093	7.93603	1.00959	7.91721	1.14794	8	
	9	8.94650	0.97980	8.92804	1.13579	8.90686	1.29143	9	
30	1	0.99357	0.11320	0.99144	0.13052	0.98901	0.14780	1	30
	2	1.98714	0.22640	1.98288	0.26105	1.97803	0.29561	2	
	3	2.98071	0.33960	2.97433	0.39157	2.96704	0.44342	3	
	4	3.97428	0.45281	3.96577	0.52210	3.95606	0.59123	4	
	5	4.96786	0.56601	4.95722	0.65263	4.94508	0.73904	5	
	6	5.96143	0.67921	5.94866	0.78315	5.93409	0.88685	6	
	7	6.95500	0.79242	6.94011	0.91368	6.92311	1.03466	7	
	8	7.94857	0.90562	7.93155	1.04420	7.91212	1.18247	8	
	9	8.94214	1.01882	8.92300	1.17473	8.90114	1.33028	9	
45	1	0.99306	0.11753	0.99086	0.13485	0.98836	0.15212	1	15
	2	1.98613	0.23507	1.98173	0.26970	1.97672	0.30424	2	
	3	2.97920	0.35261	2.97259	0.40455	2.96508	0.45637	3	
	4	3.97227	0.47014	3.96346	0.53940	3.95344	0.60849	4	
	5	4.96534	0.58768	4.95432	0.67425	4.94180	0.76061	5	
	6	5.95841	0.70522	5.94519	0.80910	5.93016	0.91274	6	
	7	6.95147	0.82276	6.93606	0.94395	6.91853	1.06486	7	
	8	7.94454	0.94029	7.92692	1.07880	7.90689	1.21698	8	
	9	8.93761	1.05783	8.91779	1.21365	8.89525	1.36911	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		83°		82°		81°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—Continued.

Minutes.	Distance.	9°		10°		11°		Distance.	Minutes.
		Lat.	Dep.	Lat.	Dep.	Lat.	Dep.		
	1	0.98768	0.15643	0.98480	0.17364	0.98162	0.19081	1	
	2	1.97537	0.31286	1.96961	0.34729	1.96325	0.38162	2	
	3	2.96306	0.46930	2.95442	0.52094	2.94488	0.57243	3	
	4	3.95075	0.62573	3.93923	0.69459	3.92650	0.76324	4	
0	5	4.93844	0.78217	4.92403	0.86824	4.90813	0.95405	5	60
	6	5.92612	0.93860	5.90884	1.04188	5.88976	1.14486	6	
	7	6.91381	1.09504	6.89365	1.21553	6.87139	1.33566	7	
	8	7.90150	1.25147	7.87846	1.38918	7.85301	1.52648	8	
	9	8.88919	1.40791	8.86327	1.56283	8.83464	1.71729	9	
	1	0.98699	0.16074	0.98404	0.17794	0.98078	0.19509	1	
	2	1.97399	0.32148	1.96808	0.35588	1.96157	0.39018	2	
	3	2.96098	0.48222	2.95212	0.53383	2.94235	0.58527	3	
	4	3.94798	0.64297	3.93616	0.71177	3.92314	0.78036	4	
15	5	4.93498	0.80371	4.92020	0.88971	4.90392	0.97545	5	45
	6	5.92197	0.96445	5.90424	1.06766	5.88471	1.17054	6	
	7	6.90897	1.12519	6.88828	1.24560	6.86549	1.36563	7	
	8	7.89597	1.28594	7.87232	1.42354	7.84628	1.56072	8	
	9	8.88296	1.44668	8.85636	1.60149	8.82706	1.75581	9	
	1	0.98628	0.16504	0.98325	0.18223	0.97992	0.19936	1	
	2	1.97257	0.33009	1.96650	0.36447	1.95984	0.39873	2	
	3	2.95885	0.49514	2.94976	0.54670	2.93977	0.59810	3	
	4	3.94514	0.66019	3.93301	0.72894	3.91969	0.79747	4	
30	5	4.93142	0.82523	4.91627	0.91117	4.89962	0.99683	5	30
	6	5.91771	0.99028	5.89952	1.09341	5.87954	1.19620	6	
	7	6.90399	1.15533	6.88278	1.27564	6.85947	1.39557	7	
	8	7.89028	1.32038	7.86603	1.45788	7.83939	1.59494	8	
	9	8.87657	1.48542	8.84929	1.64011	8.81932	1.79431	9	
	1	0.98555	0.16935	0.98245	0.18652	0.97904	0.20364	1	
	2	1.97111	0.33870	1.96490	0.37304	1.95809	0.40728	2	
	3	2.95666	0.50805	2.94735	0.55957	2.93713	0.61092	3	
	4	3.94222	0.67740	3.92980	0.74609	3.91618	0.81456	4	
45	5	4.92778	0.84675	4.91225	0.93262	4.89522	1.01820	5	15
	6	5.91333	1.01610	5.89470	1.11914	5.87427	1.22185	6	
	7	6.89889	1.18545	6.87715	1.30566	6.85331	1.42549	7	
	8	7.88444	1.35480	7.85960	1.49219	7.83236	1.62913	8	
	9	8.87000	1.52415	8.84205	1.67871	8.81140	1.83277	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		80°		79°		78°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	12° Lat.	12° Dep.	13° Lat.	13° Dep.	14° Lat.	14° Dep.	Distance.	Minutes.
	1	0.97814	0.20791	0.97437	0.22495	0.97029	0.24192	1	
	2	1.95629	0.41582	1.94874	0.44990	1.94059	0.48384	2	
	3	2.93444	0.62373	2.92311	0.67485	2.91088	0.72576	3	
	4	3.91259	0.83164	3.89748	0.89980	3.88118	0.96768	4	
0	5	4.89073	1.03955	4.87185	1.12475	4.85147	1.20961	5	60
	6	5.86888	1.24747	5.84622	1.34970	5.82177	1.45153	6	
	7	6.84703	1.45538	6.82059	1.57465	6.79206	1.69345	7	
	8	7.82518	1.66329	7.79496	1.79960	7.76236	1.93537	8	
	9	8.80332	1.87120	8.76933	2.02455	8.73266	2.17729	9	
	1	0.97723	0.21217	0.97337	0.22920	0.96923	0.24615	1	
	2	1.95446	0.42435	1.94675	0.45840	1.93846	0.49230	2	
	3	2.93169	0.63653	2.92013	0.68760	2.90769	0.73845	3	
	4	3.90892	0.84871	3.89351	0.91680	3.87692	0.98461	4	
15	5	4.88615	1.06088	4.86689	1.14600	4.84615	1.23076	5	45
	6	5.86338	1.27306	5.84027	1.37520	5.81538	1.47691	6	
	7	6.84061	1.48524	6.81365	1.60440	6.78461	1.72307	7	
	8	7.81784	1.69742	7.78703	1.83360	7.75384	1.96922	8	
	9	8.79507	1.90959	8.76041	2.06280	8.72307	2.21537	9	
	1	0.97629	0.21644	0.97237	0.23344	0.96814	0.25038	1	
	2	1.95259	0.43288	1.94474	0.46689	1.93629	0.50076	2	
	3	2.92888	0.64932	2.91711	0.70033	2.90444	0.75114	3	
	4	3.90518	0.86576	3.88948	0.93378	3.87259	1.00152	4	
30	5	4.88148	1.08220	4.86185	1.16722	4.84073	1.25190	5	30
	6	5.85777	1.29864	5.83422	1.40067	5.80888	1.50228	6	
	7	6.83407	1.51508	6.80659	1.63411	6.77703	1.75266	7	
	8	7.81036	1.73152	7.77896	1.86756	7.74518	2.00304	8	
	9	8.78666	1.94796	8.75133	2.10100	8.71332	2.25342	9	
	1	0.97534	0.22069	0.97134	0.23768	0.96704	0.25460	1	
	2	1.95068	0.44139	1.94268	0.47537	1.93409	0.50920	2	
	3	2.92602	0.66209	2.91402	0.71305	2.90113	0.76380	3	
	4	3.90136	0.88278	3.88536	0.95074	3.86818	1.01840	4	
45	5	4.87671	1.10348	4.85671	1.18843	4.83523	1.27301	5	15
	6	5.85205	1.32418	5.82805	1.42611	5.80227	1.52761	6	
	7	6.82739	1.54488	6.79939	1.66380	6.76932	1.78221	7	
	8	7.80273	1.76557	7.77073	1.90148	7.73636	2.03681	8	
	9	8.77808	1.98627	8.74207	2.13917	8.70341	2.29141	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		77°		76°		75°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	15° Lat.	15° Dep.	16° Lat.	16° Dep.	17° Lat.	17° Dep.	Distance.	Minutes.
	1	0.96592	0.25881	0.96126	0.27563	0.95630	0.29237	1	
	2	1.93185	0.51763	1.92252	0.55127	1.91260	0.58474	2	
	3	2.89777	0.77645	2.88378	0.82691	2.86891	0.87711	3	
	4	3.86370	1.03527	3.84504	1.10254	3.82521	1.16948	4	
0	5	4.82962	1.29409	4.80630	1.37818	4.78152	1.46185	5	60
	6	5.79555	1.55291	5.76757	1.65382	5.73782	1.75423	6	
	7	6.76148	1.81173	6.72883	1.92946	6.69413	2.04660	7	
	8	7.72740	2.07055	7.69009	2.20509	7.65043	2.33897	8	
	9	8.69333	2.32937	8.65135	2.48073	8.60674	2.63134	9	
	1	0.96478	0.26303	0.96005	0.27982	0.95502	0.29654	1	
	2	1.92957	0.52606	1.92010	0.55965	1.91004	0.59308	2	
	3	2.89436	0.78909	2.88015	0.83948	2.86506	0.88962	3	
	4	3.85914	1.05212	3.84020	1.11931	3.82008	1.18616	4	
15	5	4.82393	1.31515	4.80025	1.39914	4.77510	1.48270	5	45
	6	5.78872	1.57818	5.76030	1.67897	5.73012	1.77924	6	
	7	6.75351	1.84121	6.72035	1.95880	6.68514	2.07579	7	
	8	7.71829	2.10424	7.68040	2.23863	7.64016	2.37233	8	
	9	8.68308	2.36728	8.64045	2.51846	8.59518	2.66887	9	
	1	0.96363	0.26723	0.95882	0.28401	0.95371	0.30070	1	
	2	1.92726	0.53447	1.91764	0.56803	1.90743	0.60141	2	
	3	2.89089	0.80171	2.87646	0.85204	2.86115	0.90211	3	
	4	3.85452	1.06895	3.83528	1.13606	3.81486	1.20282	4	
30	5	4.81815	1.33619	4.79410	1.42007	4.76858	1.50352	5	30
	6	5.78178	1.60343	5.75292	1.70409	5.72230	1.80423	6	
	7	6.74541	1.87066	6.71174	1.98810	6.67601	2.10494	7	
	8	7.70904	2.13790	7.67056	2.27212	7.62973	2.40564	8	
	9	8.67267	2.40514	8.62938	2.55613	8.58345	2.70635	9	
	1	0.96245	0.27144	0.95757	0.28819	0.95239	0.30486	1	
	2	1.92491	0.54288	1.91514	0.57639	1.90479	0.60972	2	
	3	2.88736	0.81432	2.87271	0.86458	2.85718	0.91459	3	
	4	3.84982	1.08576	3.83028	1.15278	3.80958	1.21945	4	
45	5	4.81227	1.35720	4.78785	1.44098	4.76197	1.52432	5	15
	6	5.77473	1.62864	5.74542	1.72917	5.71437	1.82918	6	
	7	6.73718	1.90008	6.70299	2.01737	6.66677	2.13405	7	
	8	7.69964	2.17152	7.66057	2.30557	7.61916	2.43891	8	
	9	8.66209	2.44296	8.61814	2.59376	8.57156	2.74377	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		74°		73°		72°			

TRAVERSE TABLE.

DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	18° Lat.	18° Dep.	19° Lat.	19° Dep.	20° Lat.	20° Dep.	Distance.	Minutes.
	1	0.95105	0.30901	0.94551	0.32556	0.93969	0.34202	1	
	2	1.90211	0.61803	1.89103	0.65113	1.87938	0.68404	2	
	3	2.85316	0.92705	2.83655	0.97670	2.81907	1.02606	3	
	4	3.80422	1.23606	3.78207	1.30227	3.75877	1.36808	4	
0	5	4.75528	1.54508	4.72759	1.62784	4.69846	1.71010	5	60
	6	5.70633	1.85410	5.67311	1.95340	5.63815	2.05212	6	
	7	6.65739	2.16311	6.61863	2.27897	6.57784	2.39414	7	
	8	7.60845	2.47213	7.56414	2.60454	7.51754	2.73616	8	
	9	8.55950	2.78115	8.50966	2.93011	8.45723	3.07818	9	
	1	0.94969	0.31316	0.94408	0.32969	0.93819	0.34611	1	
	2	1.89939	0.62632	1.88817	0.65938	1.87638	0.69223	2	
	3	2.84909	0.93949	2.83226	0.98907	2.81457	1.03835	3	
	4	3.79879	1.25265	3.77635	1.31876	3.75276	1.38446	4	
15	5	4.74849	1.56581	4.72044	1.64845	4.69095	1.73058	5	45
	6	5.69819	1.87898	5.66453	1.97814	5.62914	2.07670	6	
	7	6.64789	2.19214	6.60862	2.30783	6.56733	2.42281	7	
	8	7.59759	2.50531	7.55271	2.63752	7.50553	2.76893	8	
	9	8.54729	2.81847	8.49680	2.96721	8.44372	3.11505	9	
	1	0.94832	0.31730	0.94264	0.33380	0.93667	0.35020	1	
	2	1.89664	0.63460	1.88528	0.66761	1.87334	0.70041	2	
	3	2.84497	0.95191	2.82792	1.00142	2.81001	1.05062	3	
	4	3.79329	1.26921	3.77056	1.33522	3.74668	1.40082	4	
30	5	4.74161	1.58652	4.71320	1.66903	4.68336	1.75103	5	30
	6	5.68994	1.90382	5.65584	2.00284	5.62003	2.10124	6	
	7	6.63826	2.22113	6.59849	2.33664	6.55670	2.45145	7	
	8	7.58658	2.53843	7.54113	2.67045	7.49337	2.80165	8	
	9	8.53491	2.85574	8.48377	3.00426	8.43004	3.15186	9	
	1	0.94693	0.32143	0.94117	0.33791	0.93513	0.35429	1	
	2	1.89386	0.64287	1.88235	0.67583	1.87027	0.70858	2	
	3	2.84079	0.96431	2.82352	1.01375	2.80540	1.06287	3	
	4	3.78772	1.28575	3.76470	1.35166	3.74054	1.41716	4	
45	5	4.73465	1.60719	4.70588	1.68958	4.67567	1.77145	5	15
	6	5.68158	1.92863	5.64705	2.02750	5.61081	2.12574	6	
	7	6.62851	2.25007	6.58823	2.36541	6.54594	2.48003	7	
	8	7.57544	2.57151	7.52940	2.70333	7.48108	2.83432	8	
	9	8.52237	2.89295	8.47058	3.04125	8.41621	3.18861	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		71°		70°		69°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	21° Lat.	21° Dep.	22° Lat.	22° Dep.	23° Lat.	23° Dep.	Distance.	Minutes.
	1	0.93358	0.35836	0.92718	0.37460	0.92050	0.39073	1	
	2	1.86716	0.71673	1.85436	0.74921	1.84100	0.78146	2	
	3	2.80074	1.07510	2.78155	1.12381	2.76151	1.17219	3	
	4	3.73432	1.43347	3.70873	1.49842	3.68201	1.56292	4	
0	5	4.66790	1.79183	4.63591	1.87303	4.60252	1.95365	5	60
	6	5.60148	2.15020	5.56310	2.24763	5.52302	2.34438	6	
	7	6.53506	2.50857	6.49028	2.62224	6.44353	2.73511	7	
	8	7.46864	2.86694	7.41747	2.99685	7.36403	3.12584	8	
	9	8.40222	3.22531	8.34465	3.37145	8.28454	3.51657	9	
	1	0.93200	0.36243	0.92554	0.37864	0.91879	0.39474	1	
	2	1.86401	0.72487	1.85108	0.75729	1.83758	0.78948	2	
	3	2.79602	1.08731	2.77662	1.13594	2.75637	1.18423	3	
	4	3.72803	1.44975	3.70216	1.51459	3.67516	1.57897	4	
15	5	4.66004	1.81219	4.62770	1.89324	4.59395	1.97372	5	45
	6	5.59204	2.17462	5.55324	2.27189	5.51274	2.36846	6	
	7	6.52405	2.53706	6.47878	2.65054	6.43153	2.76320	7	
	8	7.45606	2.89950	7.40432	3.02918	7.35032	3.15795	8	
	9	8.38807	3.26194	8.32986	3.40783	8.26912	3.55269	9	
	1	0.93041	0.36650	0.92388	0.38268	0.91706	0.39874	1	
	2	1.86083	0.73300	1.84776	0.76536	1.83412	0.79749	2	
	3	2.79125	1.09950	2.77164	1.14805	2.75118	1.19624	3	
	4	3.72167	1.46600	3.69552	1.53073	3.66824	1.59499	4	
30	5	4.65208	1.83250	4.61940	1.91341	4.58530	1.99374	5	30
	6	5.58250	2.19900	5.54328	2.29610	5.50236	2.39249	6	
	7	6.51292	2.56550	6.46716	2.67878	6.41942	2.79124	7	
	8	7.44334	2.93200	7.39104	3.06146	7.33648	3.18999	8	
	9	8.37375	3.29851	8.31492	3.44415	8.25354	3.58874	9	
	1	0.92881	0.37055	0.92220	0.38671	0.91531	0.40274	1	
	2	1.85762	0.74111	1.84440	0.77342	1.83062	0.80549	2	
	3	2.78643	1.11167	2.76660	1.16013	2.74593	1.20824	3	
	4	3.71524	1.48222	3.68880	1.54684	3.66124	1.61098	4	
45	5	4.64405	1.85278	4.61100	1.93355	4.57655	2.01373	5	15
	6	5.57286	2.22334	5.53320	2.32026	5.49186	2.41648	6	
	7	6.50167	2.59390	6.45540	2.70697	6.40718	2.81922	7	
	8	7.43048	2.96445	7.37760	3.09368	7.32249	3.22197	8	
	9	8.35929	3.33501	8.29980	3.48039	8.23780	3.62472	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		68°		67°		66°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	24° Lat.	24° Dep.	25° Lat.	25° Dep.	26° Lat.	26° Dep.	Distance.	Minutes.
	1	0.91354	0.40673	0.90630	0.42261	0.89879	0.43837	1	
	2	1.82709	0.81347	1.81261	0.84523	1.79758	0.87674	2	
	3	2.74063	1.22020	2.71892	1.26785	2.69638	1.31511	3	
	4	3.65418	1.62694	3.62523	1.69047	3.59517	1.75348	4	
0	5	4.56772	2.03368	4.53153	2.11309	4.49397	2.19185	5	60
	6	5.48127	2.44041	5.43784	2.53570	5.39276	2.63022	6	
	7	6.39481	2.84715	6.34415	2.95832	6.29155	3.06859	7	
	8	7.30836	3.25389	7.25046	3.38094	7.19035	3.50696	8	
	9	8.22190	3.66062	8.15677	3.80356	8.08914	3.94533	9	
	1	0.91176	0.41071	0.90445	0.42656	0.89687	0.44228	1	
	2	1.82352	0.82143	1.80891	0.85313	1.79374	0.88457	2	
	3	2.73528	1.23215	2.71336	1.27970	2.69061	1.32686	3	
	4	3.64704	1.64287	3.61782	1.70627	3.58749	1.76915	4	
15	5	4.55881	2.05359	4.52227	2.13284	4.48436	2.21144	5	45
	6	5.47057	2.46431	5.42673	2.55941	5.38123	2.65373	6	
	7	6.38233	2.87503	6.33118	2.98598	6.27810	3.09602	7	
	8	7.29409	3.28575	7.23564	3.41254	7.17498	3.53830	8	
	9	8.20585	3.69647	8.14009	3.83911	8.07185	3.98059	9	
	1	0.90996	0.41469	0.90258	0.43051	0.89493	0.44619	1	
	2	1.81992	0.82938	1.80517	0.86102	1.78986	0.89239	2	
	3	2.72988	1.24407	2.70775	1.29153	2.68480	1.33859	3	
	4	3.63984	1.65877	3.61034	1.72204	3.57973	1.78479	4	
30	5	4.54980	2.07346	4.51292	2.15255	4.47467	2.23098	5	30
	6	5.45976	2.48815	5.41551	2.58306	5.36960	2.67718	6	
	7	6.36972	2.90285	6.31809	3.01357	6.26454	3.12338	7	
	8	7.27969	3.31754	7.22068	3.44408	7.15947	3.56958	8	
	9	8.18965	3.73223	8.12326	3.87459	8.05440	4.01578	9	
	1	0.90814	0.41866	0.90069	0.43444	0.89297	0.45009	1	
	2	1.81628	0.83732	1.80139	0.86889	1.78595	0.90019	2	
	3	2.72442	1.25598	2.70209	1.30333	2.67893	1.35029	3	
	4	3.63257	1.67464	3.60279	1.73778	3.57191	1.80039	4	
45	5	4.54071	2.09330	4.50349	2.17222	4.46489	2.25049	5	15
	6	5.44885	2.51196	5.40418	2.60667	5.35787	2.70059	6	
	7	6.35700	2.93062	6.30488	3.04111	6.25085	3.15068	7	
	8	7.26514	3.34928	7.20558	3.47556	7.14383	3.60078	8	
	9	8.17328	3.76794	8.10628	3.91000	8.03681	4.05088	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		65°		64°		63°			

TRAVERSE TABLE.

DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	27° Lat.	27° Dep.	28° Lat.	28° Dep.	29° Lat.	29° Dep.	Distance.	Minutes.
0	1	0.89100	0.45399	0.88294	0.46947	0.87462	0.48481	1	60
	2	1.78201	0.90798	1.76589	0.93894	1.74924	0.96962	2	
	3	2.67301	1.36197	2.64884	1.40841	2.62386	1.45443	3	
	4	3.56402	1.81596	3.53179	1.87788	3.49848	1.93924	4	
	5	4.45503	2.26995	4.41473	2.34735	4.37310	2.42405	5	
	6	5.34603	2.72394	5.29768	2.81682	5.24772	2.90886	6	
	7	6.23704	3.17793	6.18063	3.28630	6.12234	3.39367	7	
	8	7.12805	3.63193	7.06358	3.75577	6.99696	3.87848	8	
	9	8.01905	4.08591	7.94652	4.22524	7.87156	4.36329	9	
15	1	0.88901	0.45787	0.88089	0.47332	0.87249	0.48862	1	45
	2	1.77803	0.91574	1.76178	0.94664	1.74499	0.97724	2	
	3	2.66705	1.37362	2.64267	1.41996	2.61748	1.46566	3	
	4	3.55606	1.83149	3.52356	1.89328	3.48998	1.95448	4	
	5	4.44508	2.28937	4.40445	2.36660	4.36248	2.44310	5	
	6	5.33410	2.74724	5.28534	2.83992	5.23497	2.93172	6	
	7	6.22311	3.20511	6.16623	3.31324	6.10747	3.42034	7	
	8	7.11213	3.66299	7.04712	3.78656	6.97996	3.90896	8	
	9	8.00115	4.12086	7.92801	4.25988	7.85246	4.39759	9	
30	1	0.88701	0.46174	0.87881	0.47715	0.87035	0.49242	1	30
	2	1.77402	0.92349	1.75763	0.95431	1.74071	0.98484	2	
	3	2.66103	1.38524	2.63645	1.43147	2.61106	1.47727	3	
	4	3.54804	1.84699	3.51526	1.90863	3.48142	1.96969	4	
	5	4.43505	2.30874	4.39408	2.38579	4.35177	2.46211	5	
	6	5.32206	2.77049	5.27290	2.86295	5.22213	2.95454	6	
	7	6.20907	3.23224	6.15171	3.34011	6.09248	3.44696	7	
	8	7.09608	3.69398	7.03053	3.81727	6.96284	3.93938	8	
	9	7.98309	4.15573	7.90935	4.29442	7.83320	4.43181	9	
45	1	0.88498	0.46561	0.87672	0.48098	0.86819	0.49621	1	15
	2	1.76997	0.93122	1.75345	0.96197	1.73639	0.99243	2	
	3	2.65496	1.39684	2.63018	1.44296	2.60459	1.48864	3	
	4	3.53995	1.86245	3.50690	1.92395	3.47279	1.98486	4	
	5	4.42493	2.32807	4.38363	2.40494	4.34099	2.48108	5	
	6	5.30992	2.79368	5.26036	2.88593	5.20919	2.97729	6	
	7	6.19491	3.25930	6.13708	3.36692	6.07739	3.47351	7	
	8	7.07990	3.72491	7.01381	3.84791	6.94559	3.96973	8	
	9	7.96488	4.19053	7.89054	4.32889	7.81378	4.46594	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		62°		61°		60°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	30°		31°		32°		Distance.	Minutes.
		Lat.	Dep.	Lat.	Dep.	Lat.	Dep.		
	1	0.86602	0.50000	0.85716	0.51503	0.84804	0.52991	1	
	2	1.73205	1.00000	1.71433	1.03007	1.69609	1.05983	2	
	3	2.59807	1.50000	2.57150	1.54511	2.54414	1.58975	3	
	4	3.46410	2.00000	3.42866	2.06015	3.39219	2.11967	4	
0	5	4.33012	2.50000	4.28583	2.57519	4.24024	2.64959	5	60
	6	5.19615	3.00000	5.14300	3.09022	5.08828	3.17951	6	
	7	6.06217	3.50000	6.00017	3.60526	5.93633	3.70943	7	
	8	6.92820	4.00000	6.85733	4.12030	6.78438	4.23935	8	
	9	7.79422	4.50000	7.71450	4.63534	7.63243	4.76927	9	
	1	0.86383	0.50377	0.85491	0.51877	0.84572	0.53361	1	
	2	1.72767	1.00754	1.70982	1.03754	1.69145	1.06722	2	
	3	2.59150	1.51132	2.56473	1.55631	2.53718	1.60084	3	
	4	3.45534	2.01509	3.41964	2.07509	3.38291	2.13445	4	
15	5	4.31917	2.51887	4.27456	2.59386	4.22863	2.66807	5	45
	6	5.18301	3.02264	5.12947	3.11263	5.07436	3.20168	6	
	7	6.04684	3.52641	5.98438	3.63141	5.92009	3.73530	7	
	8	6.91068	4.03019	6.83929	4.15018	6.76582	4.26891	8	
	9	7.77451	4.53396	7.69420	4.66895	7.61155	4.80253	9	
	1	0.86162	0.50753	0.85264	0.52249	0.84339	0.53730	1	
	2	1.72325	1.01507	1.70528	1.04499	1.68678	1.07460	2	
	3	2.58488	1.52261	2.55792	1.56749	2.53017	1.61190	3	
	4	3.44651	2.03015	3.41056	2.08999	3.37356	2.14920	4	
30	5	4.30814	2.53769	4.26320	2.61249	4.21695	2.68650	5	30
	6	5.16977	3.04523	5.11584	3.13499	5.06034	3.22380	6	
	7	6.03140	3.55276	5.96948	3.65749	5.90373	3.76110	7	
	8	6.89303	4.06030	6.82112	4.17998	6.74713	4.29840	8	
	9	7.75466	4.56784	7.67376	4.70248	7.59052	4.83570	9	
	1	0.85940	0.51129	0.85035	0.52621	0.84103	0.54097	1	
	2	1.71881	1.02258	1.70070	1.05242	1.68207	1.08194	2	
	3	2.57821	1.53387	2.55105	1.57864	2.52311	1.62292	3	
	4	3.43762	2.04517	3.40140	2.10485	3.36415	2.16389	4	
45	5	4.29703	2.55646	4.25176	2.63107	4.20519	2.70487	5	15
	6	5.15643	3.06775	5.10211	3.15728	5.04623	3.24584	6	
	7	6.01584	3.57905	5.95246	3.68349	5.88827	3.78682	7	
	8	6.87525	4.09034	6.80281	4.20971	6.72831	4.32779	8	
	9	7.73465	4.60163	7.65316	4.73592	7.56935	4.86877	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		59°		58°		57°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—Continued.

Minutes.	Distance.	33° Lat.	33° Dep.	34° Lat.	34° Dep.	35° Lat.	35° Dep.	Distance.	Minutes.
	1	0.83867	0.54463	0.82903	0.55919	0.81915	0.57357	1	
	2	1.67734	1.08927	1.65807	1.11838	1.63830	1.14715	2	
	3	2.51601	1.63391	2.48711	1.67757	2.45745	1.72072	3	
	4	3.35468	2.17855	3.31615	2.23677	3.27660	2.29430	4	
0	5	4.19335	2.72319	4.14518	2.79596	4.09576	2.86788	5	60
	6	5.03202	3.26783	4.97422	3.35515	4.91491	3.44145	6	
	7	5.87069	3.81247	5.80326	3.91435	5.73406	4.01503	7	
	8	6.70936	4.35711	6.63230	4.47354	6.55321	4.58861	8	
	9	7.54803	4.90175	7.46133	5.03273	7.37236	5.16218	9	
	1	0.83628	0.54829	0.82659	0.56280	0.81664	0.57714	1	
	2	1.67257	1.09658	1.65318	1.12560	1.63328	1.15429	2	
	3	2.50885	1.64487	2.47977	1.68841	2.44992	1.73143	3	
	4	3.34514	2.19317	3.30636	2.25121	3.26656	2.30858	4	
15	5	4.18143	2.74146	4.13295	2.81402	4.08320	2.88572	5	45
	6	5.01771	3.28975	4.95954	3.37682	4.89984	3.46287	6	
	7	5.85400	3.83805	5.78613	3.93963	5.71649	4.04001	7	
	8	6.69028	4.38634	6.61272	4.50243	6.53313	4.61716	8	
	9	7.52657	4.93463	7.43931	5.06524	7.34977	5.19430	9	
	1	0.83388	0.55193	0.82412	0.56640	0.81411	0.58070	1	
	2	1.66777	1.10387	1.64825	1.13281	1.62823	1.16140	2	
	3	2.50165	1.65581	2.47237	1.69921	2.44234	1.74210	3	
	4	3.33554	2.20774	3.29650	2.26562	3.25646	2.32281	4	
30	5	4.16942	2.75968	4.12063	2.83203	4.07057	2.90351	5	30
	6	5.00331	3.31162	4.94475	3.39843	4.88469	3.48421	6	
	7	5.83720	3.86355	5.76888	3.96484	5.69880	4.06492	7	
	8	6.67108	4.41549	6.59300	4.53124	6.51292	4.64562	8	
	9	7.50497	4.96743	7.41713	5.09765	7.32703	5.22632	9	
	1	0.83147	0.55557	0.82164	5.56999	0.81157	0.58425	1	
	2	1.66294	1.11114	1.64329	1.13999	1.62314	1.16850	2	
	3	2.49441	1.66671	2.46494	1.70999	2.43472	1.75275	3	
	4	3.32588	2.22228	3.28658	2.27998	3.24629	2.33700	4	
45	5	4.15735	2.77785	4.10823	2.84998	4.05787	2.92125	5	15
	6	4.98882	3.33342	4.92988	3.41998	4.86944	3.50550	6	
	7	5.82029	3.88899	5.75152	3.98997	5.68101	4.08975	7	
	8	6.65176	4.44456	6.57317	4.55997	6.49260	4.67400	8	
	9	7.48323	5.00013	7.39482	5.12997	7.30416	5.25825	9	
Minutes.	Distance.	56° Dep.	56° Lat.	55° Dep.	55° Lat.	54° Dep.	54° Lat.	Distance.	Minutes.

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	36° Lat.	36° Dep.	37° Lat.	37° Dep.	38° Lat.	38° Dep.	Distance.	Minutes.
	1	0.80901	0.58778	0.79863	0.60181	0.78801	0.61566	1	
	2	1.61803	1.17557	1.59727	1.20363	1.57602	1.23132	2	
	3	2.42705	1.76335	2.39590	1.80544	2.36403	1.84698	3	
	4	3.23606	2.35114	3.19454	2.40726	3.15204	2.46264	4	
0	5	4.04508	2.93892	3.99317	3.00907	3.94005	3.07830	5	60
	6	4.85410	3.52671	4.79181	3.61089	4.72806	3.69396	6	
	7	5.66311	4.11449	5.59044	4.21270	5.51607	4.30963	7	
	8	6.47213	4.70228	6.38908	4.81452	6.30408	4.92529	8	
	9	7.28115	5.29006	7.18771	5.41633	7.09209	5.54095	9	
	1	0.80644	0.59130	0.79600	0.60529	1.78531	0.61909	1	
	2	1.61288	1.18261	1.59200	1.21058	1.57063	1.23818	2	
	3	2.41933	1.77392	2.38800	1.81588	2.35595	1.85728	3	
	4	3.22577	2.36523	3.18400	2.42117	3.14126	2.47637	4	
15	5	4.03222	2.95654	3.98001	3.02647	3.92658	3.09547	5	45
	6	4.83866	3.54785	4.77601	3.63176	4.71190	3.71456	6	
	7	5.64511	4.13916	5.57201	4.23705	5.49721	4.33365	7	
	8	6.45155	4.73047	6.36801	4.84235	6.28253	4.95275	8	
	9	7.25800	5.32178	7.16401	5.44764	7.06785	5.57184	9	
	1	0.80385	0.59482	0.79335	0.60876	0.78260	0.62251	1	
	2	1.60771	1.18964	1.58670	1.21752	1.56521	1.24502	2	
	3	2.41157	1.78446	2.38005	1.82628	2.34782	1.86754	3	
	4	3.21542	2.37929	3.17341	2.43504	3.13043	2.49005	4	
30	5	4.01928	2.97411	3.96676	3.04380	3.91304	3.11257	5	30
	6	4.82314	3.56893	4.76011	3.65256	4.69564	3.73508	6	
	7	5.62699	4.16375	5.55347	4.26132	5.47825	4.35760	7	
	8	6.43085	4.75858	6.34682	4.87009	6.26086	4.98011	8	
	9	7.23471	5.35340	7.14017	5.47885	7.04347	5.60263	9	
	1	0.80125	0.59832	0.79068	0.61221	0.77988	0.62592	1	
	2	1.60250	1.19664	1.58137	1.22443	1.55946	1.25184	2	
	3	2.40376	1.79497	2.37206	1.83665	2.33965	1.87777	3	
	4	3.20501	2.39329	3.16275	2.44886	3.11953	2.50369	4	
45	5	4.00626	2.99162	3.95344	3.06108	3.89942	3.12961	5	15
	6	4.80752	3.58994	4.74413	3.67330	4.67930	3.75554	6	
	7	5.60877	4.18827	5.53482	4.28552	5.45919	4.38146	7	
	8	6.41003	4.78659	6.32551	4.89773	6.23907	5.00738	8	
	9	7.21128	5.38492	7.11620	5.50995	7.01896	5.63331	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		53°		52°		51°			

TRAVERSE TABLE.

DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	39° Lat.	39° Dep.	40° Lat.	40° Dep.	41° Lat.	41° Dep.	Distance.	Minutes.
0	1	0.77714	0.62932	0.76604	0.64278	0.75470	0.65605	1	60
	2	1.55429	1.25864	1.53208	1.28557	1.50941	1.31211	2	
	3	2.33143	1.88796	2.29813	1.92836	2.26412	1.96817	3	
	4	3.10858	2.51728	3.06417	2.57115	3.01883	2.62423	4	
	5	3.88573	3.14660	3.83022	3.21393	3.77354	3.28029	5	
	6	4.66287	3.77592	4.59626	3.85672	4.52825	3.93635	6	
	7	5.44002	4.40524	5.36231	4.49951	5.28296	4.59241	7	
	8	6.21716	5.03456	6.12835	5.14230	6.03767	5.24847	8	
	9	6.99431	5.66388	6.89439	5.78508	6.79238	5.90453	9	
15	1	0.77439	0.63270	0.76323	0.64612	0.75184	0.65934	1	45
	2	1.54878	1.26541	1.52646	1.29224	1.50368	1.31869	2	
	3	2.32317	1.89811	2.28969	1.93837	2.25552	1.97803	3	
	4	3.09757	2.53082	3.05293	2.58449	3.00736	2.63738	4	
	5	3.87196	3.16352	3.81616	3.23062	3.75920	3.29672	5	
	6	4.64635	3.79623	4.57939	3.87674	4.51104	3.95607	6	
	7	5.42074	4.42893	5.34262	4.52286	5.26288	4.61542	7	
	8	6.19514	5.06164	6.10586	5.16899	6.01472	5.27476	8	
	9	6.96953	5.69434	6.86909	5.81511	6.76656	5.93411	9	
30	1	0.77162	0.63607	0.76040	0.64944	0.74895	0.66262	1	30
	2	1.54324	1.27215	1.52081	1.29889	1.49791	1.32524	2	
	3	2.31487	1.90823	2.28121	1.94834	2.24686	1.98786	3	
	4	3.08649	2.54431	3.04162	2.59779	2.99582	2.65048	4	
	5	3.85812	3.18039	3.80203	3.24724	3.74477	3.31310	5	
	6	4.62974	3.81646	4.56243	3.89668	4.49373	3.97572	6	
	7	5.40137	4.45254	5.32284	4.54613	5.24268	4.63834	7	
	8	6.17299	5.08862	6.08324	5.19558	5.99164	5.30096	8	
	9	6.94462	5.72470	6.84365	5.84503	6.74060	5.96358	9	
45	1	0.76884	0.63943	0.75756	0.65276	0.74605	0.66588	1	15
	2	1.53768	1.27887	1.51513	1.30552	1.49211	1.33176	2	
	3	2.30652	1.91831	2.27269	1.95828	2.23817	1.99764	3	
	4	3.07536	2.55775	3.03026	2.61104	2.98422	2.66352	4	
	5	3.84420	3.19719	3.78782	2.26380	3.73028	3.32940	5	
	6	4.61305	3.83663	4.54539	3.91656	4.47634	3.99529	6	
	7	5.38189	4.47607	5.30295	4.56932	5.22240	4.66117	7	
	8	6.15073	5.11551	6.06052	5.22208	5.96845	5.32705	8	
	9	6.91957	5.75495	6.81808	5.87484	6.71451	5.99293	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		50°		49°		48°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—CONTINUED.

Minutes.	Distance.	42° Lat.	42° Dep.	43° Lat.	43° Dep.	44° Lat.	44° Dep.	Distance.	Minutes.
	1	0.74314	0.66913	0.73135	0.68199	0.71933	0.69465	1	
	2	1.48628	1.33826	1.46270	1.36399	1.43867	1.38931	2	
	3	2.22943	2.00739	2.19406	2.04599	2.15801	2.08397	3	
	4	2.97257	2.67652	2.92541	2.72799	2.87735	2.77863	4	
0	5	3.71572	3.34565	3.65676	3.40999	3.59669	3.47329	5	60
	6	4.45886	4.01478	4.38812	4.09199	4.31603	4.16795	6	
	7	5.20201	4.68391	5.11947	4.77398	5.03537	4.86260	7	
	8	5.94515	5.35304	5.85082	5.45598	5.75471	5.55726	8	
	9	6.68830	6.02217	6.58218	6.13798	6.47405	6.25192	9	
	1	0.74021	0.67236	0.72837	0.68518	0.71630	0.69779	1	
	2	1.48043	1.34473	1.45674	1.37036	1.43260	1.39558	2	
	3	2.22065	2.01710	2.18511	2.05554	2.14890	2.09337	3	
	4	2.96087	2.68946	2.91348	2.74073	2.86520	2.79116	4	
15	5	3.70109	3.36183	3.64185	3.42591	3.58151	3.48895	5	45
	6	4.44130	4.03420	4.37022	4.11109	4.29781	4.18674	6	
	7	5.18152	4.70656	5.09859	4.79628	5.01411	4.88453	7	
	8	5.92174	5.37893	5.82696	5.48146	5.73041	5.58232	8	
	9	6.66196	6.05130	6.55533	6.16664	6.44671	6.28011	9	
	1	0.73727	0.67559	0.72537	0.68835	0.71325	0.70090	1	
	2	1.47455	1.35118	1.45074	1.37670	1.42650	1.40181	2	
	3	2.21183	2.02677	2.17612	2.06506	2.13975	2.10272	3	
	4	2.94910	2.70236	2.90149	2.75341	2.85300	2.80363	4	
30	5	3.68638	3.37795	3.62687	3.44177	3.56625	3.50454	5	30
	6	4.42366	4.05354	4.35224	4.13012	4.27950	4.20545	6	
	7	5.16094	4.72913	5.07762	4.81848	4.99275	4.90636	7	
	8	5.89821	5.40472	5.80299	5.50683	5.70600	5.60727	8	
	9	6.63549	6.08031	6.52836	6.19519	6.41925	6.30818	9	
	1	0.73432	0.67880	0.72236	0.69151	0.71018	0.70401	1	
	2	1.46864	1.35760	1.44472	1.38302	1.42037	1.40802	2	
	3	2.20296	2.03640	2.16709	2.07453	2.13055	2.11204	3	
	4	2.93729	2.71520	2.88945	2.76605	2.84074	2.81605	4	
45	5	3.67161	3.39400	3.61182	3.45756	3.55092	3.52007	5	15
	6	4.40593	4.07280	4.33418	4.14907	4.26111	4.22408	6	
	7	5.14025	4.75160	5.05654	4.84059	4.97129	4.92810	7	
	8	5.87458	5.43040	5.77891	5.53210	5.68148	5.63211	8	
	9	6.60890	6.10920	6.50127	6.22361	6.39166	6.33613	9	
Minutes.	Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.	Minutes.
		47°		46°		45°			

TRAVERSE TABLE.
DIFFERENCES OF LATITUDE AND DEPARTURE.—Continued.

Distance.	45° Lat.	45° Dep.	Distance.
1	0.70710	0.70710	1
2	1.41421	1.41421	2
3	2.12132	2.12132	3
4	2.82842	2.82842	4
5	3.53553	3.53553	5
6	4.24264	4.24264	6
7	4.94974	4.94974	7
8	5.65685	5.65685	8
9	6.36396	6.36396	9
Distance.	Dep. 45°	Lat. 45°	Distance.

LOGARITHMS OF MERIDIAN RADIUS OF CURVATURE ρ_m IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
	7.317	7.317	7.317	7.317	7.317	7.317	7.317	7.317	7.317	7.317	7.317
0′	7379	7392	7433	7500	7593	7714	7861	8034	8233	8458	8709
1	7379	7392	7434	7501	7595	7716	7864	8037	8237	8462	8713
2	7379	7393	7435	7503	7597	7719	7866	8040	8240	8466	8718
3	7379	7394	7436	7504	7599	7721	7869	8043	8244	8470	8722
4	7379	7394	7437	7506	7600	7723	7872	8046	8247	8474	8727
5	7379	7395	7438	7507	7602	7726	7875	8050	8251	8478	8731
6	7379	7395	7438	7508	7604	7728	7877	8053	8255	8482	8735
7	7379	7396	7439	7510	7606	7730	7880	8056	8258	8486	8740
8	7379	7396	7440	7511	7608	7732	7883	8059	8262	8490	8744
9	7379	7397	7441	7513	7610	7735	7885	8062	8265	8494	8749
10	7379	7397	7442	7514	7612	7737	7888	8065	8269	8498	8753
11	7379	7398	7443	7515	7614	7739	7891	8068	8273	8502	8758
12	7379	7398	7444	7517	7616	7742	7894	8071	8276	8506	8762
13	7379	7399	7445	7518	7618	7744	7896	8075	8280	8510	8767
14	7379	7399	7446	7520	7619	7746	7899	8078	8283	8514	8771
15	7380	7400	7447	7521	7621	7749	7902	8081	8287	8518	8776
16	7380	7401	7448	7522	7623	7751	7905	8084	8291	8523	8780
17	7380	7401	7449	7524	7625	7753	7908	8087	8294	8527	8785
18	7380	7402	7450	7525	7627	7755	7910	8091	8298	8531	8789
19	7380	7402	7451	7527	7629	7757	7913	8094	8301	8535	8794
20	7380	7403	7452	7528	7631	7760	7916	8097	8305	8539	8798
21	7380	7404	7453	7530	7633	7762	7919	8100	8309	8543	8803
22	7380	7404	7454	7531	7635	7765	7922	8104	8312	8547	8807
23	7381	7405	7455	7533	7637	7767	7924	8107	8316	8551	8812
24	7381	7405	7456	7534	7638	7770	7927	8110	8320	8555	8816
25	7381	7406	7458	7535	7640	7772	7930	8114	8324	8559	8821
26	7381	7407	7459	7537	7642	7774	7933	8117	8327	8564	8826
27	7381	7407	7460	7538	7644	7777	7936	8120	8331	8568	8830
28	7382	7408	7461	7540	7646	7779	7938	8123	8335	8572	8835
29	7382	7408	7462	7541	7648	7782	7941	8127	8338	8576	8839
30	7382	7409	7463	7543	7650	7784	7944	8130	8342	8580	8844
31	7382	7410	7464	7545	7652	7786	7947	8133	8346	8584	8849
32	7383	7410	7465	7546	7654	7789	7950	8137	8350	8588	8853
33	7383	7411	7466	7548	7656	7791	7953	8140	8353	8593	8858
34	7383	7412	7467	7549	7658	7794	7956	8144	8357	8597	8862
35	7384	7413	7469	7551	7661	7796	7959	8147	8361	8601	8867
36	7384	7413	7470	7553	7663	7799	7961	8150	8365	8605	8872
37	7384	7414	7471	7554	7665	7801	7964	8154	8369	8609	8876
38	7384	7415	7472	7556	7667	7804	7967	8157	8372	8614	8881
39	7385	7415	7473	7557	7669	7806	7970	8161	8376	8618	8885
40	7385	7416	7474	7559	7671	7809	7973	8164	8380	8622	8890
41	7385	7417	7475	7561	7673	7811	7976	8167	8384	8626	8895
42	7386	7418	7476	7562	7675	7814	7979	8171	8388	8631	8899
43	7386	7418	7478	7564	7677	7816	7982	8174	8392	8635	8904
44	7386	7419	7479	7566	7679	7819	7985	8178	8396	8639	8909
45	7387	7420	7480	7567	7682	7821	7988	8181	8400	8643	8914
46	7387	7421	7482	7569	7684	7824	7991	8184	8403	8648	8918
47	7387	7422	7483	7571	7686	7826	7994	8188	8407	8652	8923
48	7387	7422	7484	7573	7688	7829	7997	8191	8411	8656	8928
49	7388	7423	7486	7574	7690	7831	8000	8195	8415	8661	8932
50	7388	7424	7487	7576	7692	7834	8003	8198	8419	8665	8937
51	7388	7425	7488	7578	7694	7837	8006	8201	8423	8669	8942
52	7389	7426	7489	7579	7696	7839	8009	8205	8427	8674	8947
53	7389	7427	7490	7581	7699	7842	8012	8208	8431	8678	8951
54	7390	7428	7491	7583	7701	7845	8015	8212	8435	8683	8956
55	7390	7429	7493	7584	7703	7848	8019	8215	8439	8687	8961
56	7390	7429	7494	7586	7705	7850	8022	8219	8442	8691	8966
57	7391	7430	7496	7588	7707	7853	8025	8222	8446	8696	8971
58	7391	7431	7497	7590	7710	7856	8028	8226	8450	8700	8975
59	7392	7432	7498	7591	7712	7858	8031	8229	8454	8705	8980
60	7392	7433	7500	7593	7714	7861	8034	8233	8458	8709	8985

P. P.

	1	2	3	4	5
10	.2	.3	.5	.7	.8
20	.3	.7	1.0	1.3	1.7
30	.5	1.0	1.5	2.0	2.5
40	.7	1.3	2.0	2.7	3.3
50	.8	1.7	2.5	3.3	4.2
60	1.0	2.0	3.0	4.0	5.0

LOGARITHMS OF MERIDIAN RADIUS OF CURVATURE ρ_m IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°
	7.317	7.317	7.317	7.317	7.318	7.318	7.318	7.318	7.318	7.318
0′	8985	9285	9611	9960	0333	0730	1149	1591	2054	2539
1	8990	9290	9617	9966	0340	0737	1156	1599	2062	2547
2	8995	9296	9622	9972	0346	0744	1163	1606	2070	2556
3	8999	9301	9628	9978	0353	0750	1171	1614	2078	2564
4	9004	9306	9633	9984	0359	0757	1178	1621	2086	2572
5	9009	9312	9639	9990	0366	0764	1185	1629	2094	2580
6	9014	9317	9645	9996	0372	0771	1192	1637	2102	2589
7	9019	9322	9650	*0002	0379	0778	1199	1644	2110	2597
8	9023	9327	9656	*0008	0385	0784	1207	1652	2118	2605
9	9028	9333	9661	*0014	0392	0791	1214	1659	2126	2614
10	9033	9338	9667	*0020	0398	0798	1221	1667	2134	2622
11	9038	9343	9673	*0026	0404	0805	1228	1675	2142	2630
12	9043	9349	9678	*0032	0411	0812	1236	1682	2150	2639
13	9048	9354	9684	*0039	0418	0819	1243	1690	2158	2647
14	9053	9359	9690	*0045	0424	0826	1250	1697	2166	2655
15	9058	9365	9696	*0051	0430	0833	1258	1705	2174	2663
16	9062	9370	9701	*0057	0437	0839	1265	1713	2182	2672
17	9067	9375	9707	*0063	0443	0846	1272	1720	2190	2680
18	9072	9380	9713	*0070	0450	0853	1279	1728	2198	2688
19	9077	9386	9718	*0076	0456	0860	1287	1735	2206	2697
20	9082	9391	9724	*0082	0463	0867	1294	1743	2214	2705
21	9087	9396	9730	*0088	0470	0874	1301	1751	2222	2713
22	9092	9402	9736	*0094	0476	0881	1309	1758	2230	2722
23	9097	9407	9741	*0101	0483	0888	1316	1766	2238	2730
24	9102	9413	9747	*0107	0489	0895	1323	1774	2246	2739
25	9107	9418	9753	*0113	0496	0902	1330	1781	2254	2747
26	9112	9423	9759	*0119	0503	0909	1338	1789	2262	2755
27	9117	9429	9765	*0125	0509	0916	1345	1797	2270	2764
28	9122	9434	9770	*0132	0516	0923	1352	1805	2278	2772
29	9127	9440	9776	*0138	0522	0930	1360	1812	2286	2781
30	9132	9445	9782	*0144	0529	0937	1367	1820	2294	2789
31	9137	9450	9788	*0150	0536	0944	1374	1828	2302	2797
32	9142	9456	9794	*0156	0542	0951	1382	1835	2310	2806
33	9147	9461	9800	*0163	0549	0958	1389	1843	2318	2814
34	9152	9467	9806	*0169	0555	0965	1397	1851	2326	2823
35	9157	9472	9812	*0175	0562	0972	1404	1858	2334	2831
36	9162	9477	9817	*0181	0569	0979	1411	1866	2343	2840
37	9167	9483	9823	*0187	0575	0986	1419	1874	2351	2848
38	9172	9488	9829	*0194	0582	0993	1426	1882	2359	2857
39	9177	9494	9835	*0200	0588	1000	1434	1889	2367	2865
40	9182	9499	9841	*0206	0595	1007	1441	1897	2375	2874
41	9187	9505	9847	*0212	0602	1014	1448	1905	2383	2882
42	9192	9510	9853	*0219	0608	1021	1456	1913	2391	2891
43	9197	9516	9859	*0225	0615	1028	1463	1920	2400	2899
44	9202	9521	9865	*0231	0622	1035	1471	1928	2408	2908
45	9207	9527	9871	*0238	0629	1042	1479	1936	2416	2916
46	9213	9533	9876	*0244	0635	1050	1486	1944	2424	2925
47	9218	9538	9882	*0250	0642	1057	1494	1952	2432	2933
48	9223	9544	9888	*0256	0649	1064	1501	1959	2441	2942
49	9228	9549	9894	*0263	0655	1071	1509	1967	2449	2950
50	9233	9555	9900	*0269	0662	1078	1516	1975	2457	2959
51	9238	9561	9906	*0275	0669	1085	1524	1983	2465	2968
52	9243	9566	9912	*0282	0676	1092	1531	1991	2473	2976
53	9249	9572	9918	*0288	0682	1099	1539	1999	2482	2985
54	9254	9577	9924	*0295	0689	1106	1546	2007	2490	2993
55	9259	9583	9930	*0301	0696	1113	1554	2014	2498	3002
56	9264	9589	9936	*0307	0703	1121	1561	2022	2506	3011
57	9269	9594	9942	*0314	0710	1128	1569	2030	2514	3019
58	9275	9600	9948	*0320	0716	1135	1576	2038	2523	3028
59	9280	9605	9954	*0327	0723	1142	1584	2046	2531	3036
60	9285	9611	9960	*0333	0730	1149	1591	2054	2539	3045

P. P.

	4	5	6	7	8	9
10	.7	.8	1.0	1.2	1.3	1.5
20	1.3	1.7	2.0	2.3	2.7	3.0
30	2.0	2.5	3.0	3.5	4.0	4.5
40	2.7	3.3	4.0	4.7	5.3	6.0
50	3.3	4.2	5.0	5.8	6.7	7.5
60	4.0	5.0	6.0	7.0	8.0	9.0

LOGARITHMS OF MERIDIAN RADIUS OF CURVATURE ρ_m IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
	7.318	**7.318**	**7.318**	**7.318**	**7.318**	**7.318**	**7.318**	**7.318**	**7.318**	**7.318**
0′	3045	3570	4115	4678	5259	5858	6474	7105	7751	8412
1	3053	3579	4124	4688	5269	5868	6484	7116	7762	8423
2	3062	3588	4133	4697	5279	5878	6494	7126	7773	8434
3	3070	3597	4142	4707	5289	5889	6505	7137	7784	8445
4	3079	3606	4152	4716	5299	5899	6515	7148	7795	8457
5	3088	3614	4161	4726	5309	5909	6526	7158	7806	8468
6	3096	3623	4170	4735	5319	5919	6536	7169	7817	8479
7	3105	3632	4179	4745	5328	5929	6546	7180	7828	8490
8	3113	3641	4189	4754	5338	5939	6557	7190	7839	8501
9	3122	3650	4198	4764	5348	5949	6567	7201	7850	8512
10	3131	3659	4207	4774	5358	5960	6578	7212	7860	8523
11	3139	3668	4216	4783	5368	5970	6588	7222	7871	8535
12	3148	3677	4226	4793	5378	5980	6599	7233	7882	8546
13	3157	3686	4235	4802	5388	5990	6609	7244	7893	8557
14	3165	3695	4244	4812	5398	6000	6620	7254	7904	8568
15	3174	3704	4254	4822	5408	6011	6630	7265	7915	8579
16	3183	3713	4263	4831	5417	6021	6640	7276	7926	8591
17	3191	3722	4272	4841	5427	6031	6651	7287	7937	8602
18	3200	3731	4282	4851	5437	6041	6661	7297	7948	8613
19	3209	3740	4291	4860	5447	6051	6672	7308	7959	8624
20	3217	3749	4300	4870	5457	6062	6682	7319	7970	8635
21	3226	3758	4310	4879	5467	6072	6693	7329	7981	8647
22	3235	3767	4319	4889	5477	6082	6703	7340	7992	8658
23	3244	3776	4328	4899	5487	6092	6714	7351	8003	8669
24	3252	3785	4338	4908	5497	6102	6724	7362	8014	8680
25	3261	3794	4347	4918	5507	6113	6735	7372	8025	8691
26	3270	3804	4356	4928	5517	6123	6745	7383	8036	8703
27	3278	3813	4366	4937	5527	6133	6756	7394	8047	8714
28	3287	3822	4375	4947	5537	6143	6766	7405	8058	8725
29	3296	3831	4384	4957	5547	6154	6777	7416	8069	8736
30	3305	3840	4394	4966	5557	6164	6787	7426	8080	8747
31	3313	3849	4403	4976	5567	6174	6798	7437	8091	8759
32	3322	3858	4413	4986	5577	6185	6808	7448	8102	8770
33	3331	3867	4422	4996	5587	6195	6819	7459	8113	8781
34	3340	3876	4431	5005	5597	6205	6829	7469	8124	8792
35	3349	3885	4441	5015	5607	6215	6840	7480	8135	8804
36	3357	3894	4450	5025	5617	6226	6851	7491	8146	8815
37	3366	3904	4460	5034	5627	6236	6861	7502	8157	8826
38	3375	3913	4469	5044	5637	6246	6872	7513	8168	8838
39	3384	3922	4479	5054	5647	6256	6882	7523	8179	8849
40	3393	3931	4488	5064	5657	6267	6893	7534	8190	8860
41	3401	3940	4498	5073	5667	6277	6903	7545	8201	8871
42	3410	3949	4507	5083	5677	6287	6914	7556	8212	8883
43	3419	3958	4516	5093	5687	6298	6924	7567	8223	8894
44	3428	3967	4526	5103	5697	6308	6935	7578	8234	8905
45	3437	3977	4535	5112	5707	6318	6946	7588	8246	8916
46	3446	3986	4545	5122	5717	6329	6956	7599	8257	8928
47	3454	3995	4554	5132	5727	6339	6967	7610	8268	8939
48	3463	4004	4564	5142	5737	6349	6977	7621	8279	8950
49	3472	4013	4573	5151	5747	6360	6988	7632	8280	8962
50	3481	4022	4583	5161	5757	6370	6999	7643	8301	8973
51	3490	4032	4592	5171	5767	6380	7009	7653	8312	8984
52	3499	4041	4602	5181	5777	6391	7020	7664	8323	8996
53	3508	4050	4611	5191	5787	6401	7030	7675	8334	9007
54	3516	4059	4621	5200	5798	6411	7041	7686	8345	9018
55	3525	4068	4630	5210	5808	6422	7052	7697	8356	9030
56	3534	4078	4640	5220	5818	6432	7062	7708	8368	9041
57	3543	4086	4649	5230	5828	6442	7073	7719	8379	9052
58	3552	4096	4659	5240	5838	6453	7084	7729	8390	9064
59	3561	4105	4668	5250	5848	6463	7094	7740	8401	9075
60	3570	4115	4678	5259	5858	6474	7105	7751	8412	9086

P. P.

	8	**9**	**10**	**11**	**12**
10	1.3	1.5	1.7	1.8	2.0
20	2.6	3.0	3.3	3.7	4.0
30	4.0	4.5	5.0	5.5	6.0
40	5.3	6.0	6.7	7.3	8.0
50	6.7	7.5	8.3	9.2	10.0
60	8.0	9.0	10.0	11.0	12.0

LOGARITHMS OF MERIDIAN RADIUS OF CURVATURE ρ_m IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°
	7.318	7.318	7.319	7.319	7.319	7.319	7.319	7.319	7.319	7.319
0′	9086	9773	0472	1182	1902	2631	3369	4114	4866	5623
1	9098	9785	0484	1194	1914	2643	3381	4126	4878	5636
2	9109	9796	0495	1206	1926	2656	3394	4139	4891	5649
3	9120	9807	0507	1218	1938	2668	3406	4151	4904	5661
4	9132	9819	0519	1230	1950	2680	3418	4164	4916	5674
5	9143	9831	0531	1241	1962	2692	3431	4176	4929	5687
6	9154	9843	0542	1253	1974	2705	3443	4189	4941	5699
7	9166	9854	0554	1265	1986	2717	3455	4201	4954	5712
8	9177	9866	0566	1277	1999	2729	3468	4214	4966	5725
9	9189	9877	0577	1289	2011	2741	3480	4226	4979	5737
10	9200	9889	0590	1301	2023	2753	3492	4239	4992	5750
11	9211	9900	0601	1313	2035	2766	3505	4251	5004	5763
12	9223	9912	0613	1325	2047	2778	3517	4264	5017	5775
13	9234	9924	0625	1337	2059	2790	3530	4276	5029	5788
14	9245	9935	0637	1349	2071	2803	3542	4289	5042	5801
15	9257	9947	0648	1361	2083	2815	3554	4301	5055	5813
16	9268	9958	0660	1373	2095	2827	3567	4314	5067	5826
17	9280	9970	0672	1385	2108	2839	3579	4326	5080	5839
18	9291	9982	0684	1397	2120	2852	3592	4339	5092	5851
19	9302	9993	0696	1409	2132	2864	3604	4351	5105	5864
20	9314	*0005	0707	1421	2144	2876	3616	4364	5118	5877
21	9325	*0016	0719	1433	2156	2888	3629	4376	5130	5890
22	9337	*0028	0731	1445	2168	2901	3641	4389	5143	5902
23	9348	*0040	0743	1457	2180	2913	3654	4401	5156	5915
24	9360	*0051	0755	1469	2192	2925	3666	4414	5168	5928
25	9371	*0063	0766	1481	2205	2938	3678	4426	5181	5940
26	9382	*0075	0778	1493	2217	2950	3691	4439	5193	5953
27	9393	*0086	0790	1505	2229	2962	3703	4451	5206	5966
28	9405	*0098	0802	1517	2241	2974	3716	4464	5219	5978
29	9417	*0110	0814	1529	2253	2987	3728	4477	5231	5991
30	9428	*0121	0826	1541	2265	2999	3741	4489	5244	6004
31	9440	*0133	0837	1553	2278	3011	3753	4502	5256	6017
32	9451	*0144	0849	1565	2290	3024	3765	4514	5269	6029
33	9463	*0156	0861	1577	2302	3036	3778	4527	5282	6042
34	9474	*0168	0873	1589	2314	3048	3790	4539	5294	6055
35	9485	*0179	0885	1601	2326	3060	3803	4552	5307	6067
36	9497	*0191	0897	1613	2338	3073	3815	4564	5320	6080
37	9508	*0203	0908	1625	2351	3085	3828	4577	5332	6093
38	9520	*0214	0920	1637	2363	3097	3840	4589	5345	6106
39	9531	*0226	0932	1649	2375	3110	3852	4602	5358	6118
40	9543	*0238	0944	1661	2387	3122	3865	4614	5370	6131
41	9554	*0249	0956	1673	2399	3134	3877	4627	5383	6144
42	9566	*0261	0968	1685	2411	3147	3890	4640	5395	6156
43	9577	*0273	0980	1697	2424	3159	3902	4652	5408	6169
44	9589	*0285	0992	1709	2436	3171	3915	4665	5421	6182
45	9600	*0296	1003	1721	2448	3184	3927	4677	5433	6195
46	9612	*0308	1015	1733	2460	3196	3939	4690	5446	6207
47	9623	*0320	1027	1745	2472	3208	3952	4702	5459	6220
48	9635	*0331	1039	1757	2485	3221	3964	4715	5471	6233
49	9646	*0343	1051	1769	2497	3233	3977	4727	5484	6245
50	9658	*0355	1063	1781	2509	3245	3989	4740	5497	6258
51	9669	*0366	1075	1793	2521	3258	4002	4753	5509	6271
52	9681	*0378	1087	1805	2533	3270	4014	4765	5522	6284
53	9692	*0390	1098	1817	2546	3282	4027	4778	5535	6296
54	9704	*0402	1110	1829	2558	3295	4039	4790	5547	6309
55	9715	*0413	1122	1841	2570	3307	4052	4803	5560	6322
56	9727	*0425	1134	1854	2582	3319	4064	4815	5573	6335
57	9739	*0437	1146	1866	2594	3332	4077	4828	5585	6347
58	9750	*0449	1158	1878	2607	3344	4089	4841	5598	6360
59	9762	*0460	1170	1890	2619	3356	4101	4853	5611	6373
60	9773	*0472	1182	1902	2631	3369	4114	4866	5623	6385

P. P.

	11
10	1.8
20	3.7
30	5.5
40	7.3
50	9.2
60	11.0

	12
10	2.0
20	4.0
30	6.0
40	8.0
50	10.0
60	12.0

	13
10	2.2
20	4.3
30	6.5
40	8.7
50	10.8
60	13.0

Table 10.

LOGARITHMS OF MERIDIAN RADIUS OF CURVATURE ρ_m IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	41°	42°	43°	44°	45°	46°	47°	48°	49°	50°
	7.319	7.319	7.319	7.319	7.319	7.320	7.320	7.320	7.320	7.320
0′	6385	7152	7921	8692	9464	0236	1007	1776	2543	3306
1	6398	7164	7933	8704	9476	0248	1020	1789	2556	3319
2	6411	7177	7946	8717	9489	0261	1033	1802	2569	3331
3	6424	7190	7959	8730	9502	0274	1045	1815	2581	3344
4	6436	7203	7972	8743	9515	0287	1058	1827	2594	3357
5	6449	7216	7985	8756	9528	0300	1071	1840	2607	3369
6	6462	7228	7998	8769	9541	0313	1084	1853	2619	3382
7	6475	7241	8010	8782	9554	0326	1097	1866	2632	3395
8	6487	7254	8023	8794	9566	0338	1110	1879	2645	3407
9	6500	7267	8036	8807	9579	0351	1122	1892	2658	3420
10	6513	7280	8049	8820	9592	0364	1135	1904	2670	3433
11	6526	7292	8062	8833	9605	0377	1148	1917	2683	3445
12	6538	7305	8075	8846	9618	0390	1161	1930	2696	3458
13	6551	7318	8087	8859	9631	0403	1174	1943	2709	3471
14	6564	7331	8100	8872	9644	0416	1187	1955	2721	3483
15	6577	7344	8113	8884	9657	0429	1199	1968	2734	3496
16	6589	7356	8126	8897	9669	0441	1212	1981	2747	3509
17	6602	7369	8139	8910	9682	0454	1225	1994	2760	3521
18	6615	7382	8152	8923	9695	0467	1238	2007	2772	3534
19	6628	7395	8165	8936	9708	0480	1251	2019	2785	3547
20	6640	7408	8177	8949	9721	0493	1264	2032	2798	3559
21	6653	7420	8190	8962	9734	0506	1276	2045	2811	3572
22	6666	7433	8203	8975	9747	0519	1289	2058	2823	3585
23	6679	7446	8216	8987	9760	0531	1302	2071	2836	3597
24	6692	7459	8229	9000	9772	0544	1315	2083	2849	3610
25	6704	7472	8242	9013	9785	0557	1328	2096	2861	3623
26	6717	7485	8254	9026	9798	0570	1341	2109	2874	3635
27	6730	7497	8267	9039	9811	0583	1353	2122	2887	3648
28	6743	7510	8280	9052	9824	0596	1366	2134	2900	3661
29	6755	7523	8293	9065	9837	0609	1379	2147	2912	3673
30	6768	7536	8306	9077	9850	0621	1392	2160	2925	3686
31	6781	7549	8319	9090	9862	0634	1405	2173	2938	3699
32	6794	7561	8332	9103	9875	0647	1418	2186	2950	3711
33	6806	7574	8344	9116	9888	0660	1430	2198	2963	3724
34	6819	7587	8357	9129	9901	0673	1443	2211	2976	3736
35	6832	7600	8370	9142	9914	0686	1456	2224	2989	3749
36	6844	7613	8383	9155	9927	0699	1469	2237	3001	3762
37	6858	7626	8396	9168	9940	0711	1482	2249	3014	3774
38	6870	7638	8409	9180	9953	0724	1494	2262	3027	3787
39	6883	7651	8422	9193	9965	0737	1507	2275	3039	3800
40	6896	7664	8434	9206	9978	0750	1520	2288	3052	3812
41	6909	7677	8447	9219	9991	0763	1533	2301	3065	3825
42	6921	7690	8460	9232	*0004	0776	1546	2313	3078	3838
43	6934	7702	8473	9245	*0017	0788	1559	2326	3090	3850
44	6947	7715	8486	9258	*0030	0801	1571	2339	3103	3863
45	6960	7728	8499	9270	*0043	0814	1584	2352	3116	3875
46	6973	7741	8512	9283	*0055	0827	1597	2364	3128	3888
47	6985	7754	8524	9296	*0068	0840	1610	2377	3141	3901
48	6998	7767	8537	9309	*0081	0853	1623	2390	3154	3913
49	7011	7779	8550	9322	*0094	0866	1635	2403	3166	3926
50	7024	7792	8563	9335	*0107	0878	1648	2415	3179	3938
51	7036	7805	8576	9348	*0120	0891	1661	2428	3192	3951
52	7049	7818	8589	9361	*0133	0904	1674	2441	3205	3964
53	7062	7831	8692	9373	*0146	0917	1687	2454	3217	3976
54	7075	7844	8614	9386	*0158	0930	1699	2466	3230	3989
55	7088	7856	8627	9399	*0171	0943	1712	2479	3243	4002
56	7100	7869	8640	9412	*0184	0955	1725	2492	3255	4014
57	7113	7882	8653	9425	*0197	0968	1738	2505	3268	4027
58	7126	7895	8666	9438	*0210	0981	1751	2517	3281	4039
59	7139	7908	8679	9451	*0223	0994	1763	2530	3293	4052
60	7152	7921	8692	9464	*0236	1007	1776	2543	3306	4065

P. P.

12	
10	2.0
20	4.0
30	6.0
40	8.0
50	10.0
60	12.0

13	
10	2.2
20	4.3
30	6.5
40	8.7
50	10.8
60	13.0

LOGARITHMS OF MERIDIAN RADIUS OF CURVATURE ρ_m IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	51°	52°	53°	54°	55°	56°	57°	58°	59°	60°
	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.321
0′	4065	4817	5564	6303	7034	7756	8467	9168	9857	0534
1	4077	4829	5576	6315	7046	7768	8479	9180	9868	0545
2	4090	4842	5589	6327	7058	7780	8491	9191	9880	0556
3	4102	4854	5601	6340	7070	7792	8502	9203	9891	0567
4	4115	4867	5613	6352	7082	7804	8514	9214	9903	0578
5	4127	4879	5625	6364	7094	7815	8526	9226	9914	0589
6	4140	4892	5638	6376	7107	7827	8538	9238	9925	0601
7	4152	4904	5650	6388	7119	7839	8550	9249	9937	0612
8	4165	4917	5662	6401	7131	7851	8561	9261	9948	0623
9	4177	4929	5675	6413	7143	7863	8573	9272	9960	0634
10	4190	4942	5687	6425	7155	7875	8585	9284	9971	0645
11	4203	4954	5699	6437	7167	7887	8597	9295	9982	0656
12	4215	4967	5712	6449	7179	7899	8608	9307	9994	0667
13	4228	4979	5724	6462	7191	7911	8620	9318	*0005	0678
14	4240	4992	5737	6474	7203	7923	8632	9330	*0016	0689
15	4253	5004	5749	6486	7215	7934	8643	9341	*0027	0701
16	4266	5017	5761	6498	7227	7946	8655	9353	*0039	0712
17	4278	5029	5774	6510	7239	7958	8667	9364	*0050	0723
18	4291	5042	5786	6523	7251	7970	8679	9376	*0061	0734
19	4303	5054	5799	6535	7263	7982	8690	9387	*0073	0745
20	4316	5067	5811	6547	7275	7994	8702	9399	*0084	0756
21	4328	5079	5823	6559	7287	8006	8714	9410	*0095	0767
22	4341	5092	5836	6571	7299	8018	8725	9422	*0107	0778
23	4353	5104	5848	6584	7311	8030	8737	9433	*0118	0789
24	4366	5117	5860	6596	7323	8042	8749	9445	*0129	0800
25	4378	5129	5872	6608	7335	8053	8760	9456	*0140	0812
26	4391	5141	5885	6620	7348	8065	8772	9468	*0152	0823
27	4403	5154	5897	6632	7360	8077	8784	9479	*0163	0834
28	4416	5166	5909	6645	7372	8089	8796	9491	*0174	0845
29	4428	5179	5922	6657	7384	8101	8807	9502	*0186	0856
30	4441	5191	5934	6669	7396	8113	8819	9514	*0197	0867
31	4454	5203	5946	6681	7408	8125	8831	9525	*0208	0878
32	4466	5216	5959	6693	7420	8137	8842	9537	*0219	0889
33	4479	5228	5971	6706	7432	8148	8854	9548	*0231	0900
34	4491	5241	5983	6718	7444	8160	8866	9560	*0242	0911
35	4504	5253	5995	6730	7456	8172	8877	9571	*0253	0922
36	4517	5266	6008	6742	7468	8184	8889	9583	*0264	0933
37	4529	5278	6020	6754	7480	8196	8901	9594	*0275	0944
38	4542	5291	6032	6767	7492	8207	8913	9606	*0287	0955
39	4554	5303	6045	6779	7504	8219	8924	9617	*0298	0966
40	4567	5316	6057	6791	7516	8231	8936	9629	*0309	0977
41	4579	5328	6069	6803	7528	8243	8948	9640	*0320	0988
42	4592	5341	6082	6815	7540	8255	8959	9652	*0332	0999
43	4604	5353	6094	6828	7552	8266	8971	9663	*0343	1010
44	4617	5366	6106	6840	7564	8278	8982	9675	*0354	1021
45	4629	5378	6118	6852	7576	8290	8994	9686	*0365	1032
46	4642	5390	6131	6864	7588	8302	9006	9697	*0377	1043
47	4654	5403	6143	6876	7600	8314	9017	9709	*0388	1054
48	4667	5415	6155	6889	7612	8325	9029	9720	*0399	1065
49	4679	5428	6168	6901	7624	8337	9040	9732	*0411	1076
50	4692	5440	6180	6913	7636	8349	9052	9743	*0422	1087
51	4704	5452	6192	6925	7648	8361	9064	9754	*0433	1098
52	4717	5465	6205	6937	7660	8373	9075	9766	*0444	1109
53	4729	5477	6217	6949	7672	8384	9087	9777	*0456	1120
54	4742	5490	6229	6961	7684	8396	9098	9789	*0467	1131
55	4754	5502	6241	6973	7696	8408	9110	9800	*0478	1142
56	4767	5514	6254	6986	7708	8420	9122	9811	*0489	1153
57	4779	5527	6266	6998	7720	8432	9133	9823	*0500	1164
58	4792	5539	6278	7010	7732	8443	9145	9834	*0512	1175
59	4804	5552	6291	7022	7744	8455	9156	9846	*0523	1186
60	4817	5564	6303	7034	7756	8467	9168	9857	*0534	1197

P. P.

	13	12	11
10	2.2	2.0	1.8
20	4.3	4.0	3.7
30	6.5	6.0	5.5
40	8.7	8.0	7.3
50	10.8	10.0	9.2
60	13.0	12.0	11.0

LOGARITHMS OF MERIDIAN RADIUS OF CURVATURE ρ_m IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°
	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321
0′	1197	1845	2479	3097	3698	4282	4848	5396	5924	6432
1	1208	1856	2489	3107	3708	4292	4857	5405	5933	6440
2	1219	1866	2500	3117	3718	4301	4867	5414	5941	6448
3	1230	1877	2510	3127	3728	4311	4876	5423	5950	6457
4	1241	1888	2521	3137	3738	4320	4885	5432	5958	6465
5	1251	1898	2531	3147	3747	4330	4894	5440	5967	6473
6	1262	1909	2541	3158	3757	4340	4904	5449	5976	6481
7	1273	1920	2552	3168	3767	4349	4913	5458	5984	6489
8	1284	1931	2562	3178	3777	4359	4922	5467	5993	6498
9	1295	1941	2573	3188	3787	4368	4932	5476	6001	6506
10	1306	1952	2583	3198	3797	4378	4941	5485	6010	6514
11	1317	1963	2593	3208	3807	4387	4950	5494	6018	6522
12	1328	1973	2604	3218	3817	4397	4959	5503	6027	6530
13	1338	1984	2614	3228	3826	4406	4969	5512	6035	6539
14	1349	1994	2625	3238	3836	4416	4978	5521	6044	6547
15	1360	2005	2635	3248	3846	4425	4987	5529	6052	6555
16	1371	2016	2645	3259	3856	4435	4996	5538	6061	6563
17	1382	2026	2656	3269	3866	4444	5005	5547	6069	6571
18	1392	2037	2666	3279	3875	4454	5015	5556	6078	6580
19	1403	2047	2677	3289	3885	4463	5024	5565	6086	6588
20	1414	2058	2687	3299	3895	4473	5033	5574	6095	6596
21	1425	2069	2697	3309	3905	4482	5042	5583	6103	6604
22	1436	2079	2708	3319	3915	4492	5051	5592	6112	6612
23	1447	2090	2718	3329	3924	4501	5060	5600	6120	6621
24	1458	2100	2728	3339	3934	4511	5069	5609	6129	6629
25	1468	2111	2738	3349	3944	4520	5078	5618	6137	6637
26	1479	2122	2749	3360	3954	4530	5088	5627	6146	6645
27	1490	2132	2759	3370	3964	4539	5097	5636	6154	6653
28	1501	2143	2769	3380	3973	4549	5106	5644	6163	6662
29	1512	2153	2780	3390	3983	4558	5115	5653	6171	6670
30	1523	2164	2790	3400	3993	4568	5124	5662	6180	6678
31	1534	2175	2800	3410	4003	4577	5133	5671	6188	6686
32	1545	2185	2811	3420	4012	4587	5142	5680	6197	6694
33	1555	2196	2821	3430	4022	4596	5151	5688	6205	6702
34	1566	2206	2831	3440	4032	4606	5160	5697	6214	6710
35	1577	2217	2841	3450	4041	4615	5169	5706	6222	6718
36	1588	2228	2852	3460	4051	4624	5179	5715	6230	6727
37	1599	2238	2862	3470	4061	4634	5188	5724	6239	6735
38	1609	2249	2872	3480	4071	4643	5197	5732	6247	6743
39	1620	2259	2883	3490	4080	4653	5206	5741	6256	6751
40	1631	2270	2893	3500	4090	4662	5215	5750	6264	6759
41	1642	2280	2903	3510	4100	4671	5224	5759	6272	6767
42	1652	2291	2913	3520	4109	4681	5233	5767	6281	6775
43	1663	2301	2924	3530	4119	4690	5242	5776	6289	6783
44	1674	2312	2934	3540	4128	4699	5251	5785	6298	6791
45	1684	2322	2944	3549	4138	4708	5260	5793	6306	6799
46	1695	2333	2954	3559	4148	4718	5270	5802	6314	6807
47	1706	2343	2964	3569	4157	4727	5279	5811	6323	6815
48	1717	2354	2975	3579	4167	4736	5288	5820	6331	6823
49	1727	2364	2985	3589	4176	4746	5297	5828	6340	6831
50	1738	2375	2995	3599	4186	4755	5306	5837	6348	6839
51	1749	2385	3005	3609	4196	4764	5315	5846	6356	6847
52	1759	2396	3015	3619	4205	4774	5324	5854	6365	6855
53	1770	2406	3026	3629	4215	4783	5333	5863	6373	6863
54	1781	2417	3036	3639	4224	4792	5342	5872	6382	6871
55	1791	2427	3046	3648	4234	4801	5351	5880	6390	6879
56	1802	2437	3056	3658	4244	4811	5360	5889	6398	6887
57	1813	2448	3066	3668	4253	4820	5369	5898	6407	6895
58	1824	2458	3077	3678	4263	4829	5378	5907	6415	6903
59	1834	2469	3087	3688	4272	4839	5387	5915	6424	6911
60	1845	2479	3097	3698	4282	4848	5396	5924	6432	6919

P. P.

	11
10	1.8
20	3.7
30	5.5
40	7.3
50	9.2
60	11.0

	10
10	1.7
20	3.3
30	5.0
40	6.7
50	8.3
60	10.0

	9
10	1.5
20	3.0
30	4.5
40	6.0
50	7.5
60	9.0

	8
10	1.3
20	2.6
30	4.0
40	5.3
50	6.7
60	8.0

LOGARITHMS OF MERIDIAN RADIUS OF CURVATURE ρ_m IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°
	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.322	7.322
0′	6919	7385	7829	8251	8650	9025	9377	9704	0007	0284
1	6927	7392	7836	8258	8656	9031	9383	9709	0012	0288
2	6935	7400	7843	8265	8663	9037	9388	9714	0017	0293
3	6943	7407	7851	8271	8669	9043	9394	9720	0021	0297
4	6951	7415	7858	8278	8676	9049	9399	9725	0026	0302
5	6958	7422	7865	8285	8682	9055	9405	9730	0031	0306
6	6966	7430	7872	8292	8688	9061	9411	9735	0036	0310
7	6974	7437	7879	8299	8695	9067	9416	9740	0041	0315
8	6982	7445	7887	8305	8701	9073	9422	9746	0045	0319
9	6990	7452	7894	8312	8708	9079	9427	9751	0050	0324
10	6998	7460	7901	8319	8714	9085	9433	9756	0055	0328
11	7006	7467	7908	8326	8720	9091	9438	9761	0060	0332
12	7014	7475	7915	8332	8727	9097	9444	9766	0064	0337
13	7021	7482	7922	8339	8733	9103	9449	9771	0069	0341
14	7029	7490	7929	8346	8739	9109	9455	9776	0074	0345
15	7037	7497	7936	8353	8745	9115	9460	9781	0078	0349
16	7045	7505	7944	8359	8752	9121	9466	9787	0083	0354
17	7053	7512	7951	8366	8758	9127	9471	9792	0088	0358
18	7060	7520	7958	8373	8764	9133	9477	9797	0093	0362
19	7068	7527	7965	8379	8771	9139	9482	9802	0097	0367
20	7076	7535	7972	8386	8777	9145	9488	9807	0102	0371
21	7084	7542	7979	8393	8783	9151	9493	9812	0107	0375
22	7092	7550	7986	8399	8790	9157	9499	9817	0111	0379
23	7099	7557	7993	8406	8796	9163	9504	9822	0116	0384
24	7107	7565	8000	8413	8802	9169	9510	9827	0120	0388
25	7115	7572	8007	8419	8808	9174	9515	9832	0125	0392
26	7123	7580	8014	8426	8815	9180	9521	9838	0130	0396
27	7131	7587	8021	8433	8821	9186	9526	9843	0134	0400
28	7138	7595	8028	8440	8827	9192	9532	9848	0139	0405
29	7146	7602	8035	8446	8834	9198	9537	9853	0143	0409
30	7154	7610	8042	8453	8840	9204	9543	9858	0148	0413
31	7162	7617	8049	8460	8846	9210	9548	9863	0153	0417
32	7170	7625	8056	8466	8852	9216	9554	9868	0157	0421
33	7177	7632	8063	8473	8859	9221	9559	9873	0162	0426
34	7185	7639	8070	8479	8865	9227	9565	9878	0166	0430
35	7193	7646	8077	8486	8871	9233	9570	9883	0171	0434
36	7201	7654	8084	8493	8877	9239	9575	9888	0176	0438
37	7209	7661	8091	8499	8883	9245	9581	9893	0180	0442
38	7216	7668	8098	8506	8890	9250	9586	9898	0185	0447
39	7224	7676	8105	8512	8896	9256	9592	9903	0189	0451
40	7232	7683	8112	8519	8902	9262	9597	9908	0194	0455
41	7240	7690	8119	8526	8908	9268	9602	9913	0199	0459
42	7247	7798	8126	8532	8914	9274	9608	9918	0203	0463
43	7255	7705	8133	8539	8921	9279	9613	9923	0208	0467
44	7263	7712	8140	8545	8927	9285	9619	9928	0212	0471
45	7270	7719	8147	8552	8933	9291	9624	9933	0217	0475
46	7278	7727	8154	8559	8939	9297	9629	9938	0222	0480
47	7286	7734	8161	8565	8945	9303	9635	9943	0226	0484
48	7294	7741	8168	8572	8952	9308	9640	9948	0231	0488
49	7301	7749	8175	8578	8958	9314	9646	9953	0235	0492
50	7309	7756	8182	8585	8964	9320	9651	9958	0240	0496
51	7317	7763	8189	8591	8970	9326	9656	9963	0244	0500
52	7324	7771	8196	8598	8976	9331	9662	9968	0249	0504
53	7332	7778	8203	8604	8982	9337	9667	9973	0253	0508
54	7339	7785	8210	8611	8988	9343	9672	9978	0258	0512
55	7347	7792	8216	8617	8994	9348	9677	9982	0262	0516
56	7355	7800	8223	8624	9001	9354	9683	9987	0266	0520
57	7362	7807	8230	8630	9007	9360	9688	9992	0271	0524
58	7370	7814	8237	8637	9013	9366	9693	9997	0275	0528
59	7377	7822	8244	8643	9019	9371	9699	*0002	0280	0532
60	7385	7829	8251	8650	9025	9377	9704	*0007	0284	0536

P. P.

10	1.3
20	2.6
30	4.0
40	5.3
50	6.7
60	8.0

7	
10	1.2
20	2.3
30	3.5
40	4.7
50	5.8
60	7.0

6	
10	1.0
20	2.0
30	3.0
40	4.0
50	5.0
60	6.0

5	
10	.8
20	1.7
30	2.5
40	3.3
50	4.2
60	5.0

4	
10	.7
20	1.3
30	2.0
40	2.7
50	3.3
60	4.0

LOGARITHMS OF MERIDIAN RADIUS OF CURVATURE ρ_m IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	81°	82°	83°	84°	85°	86°	87°	88°	89°
	7.322	7.322	7.322	7.322	7.322	7.322	7.322	7.322	7.322
0′	0536	0763	0963	1138	1285	1407	1501	1569	1609
1	0540	0766	0966	1141	1287	1409	1502	1570	1609
2	0544	0770	0969	1143	1289	1410	1504	1571	1610
3	0548	0773	0972	1146	1292	1412	1505	1571	1610
4	0552	0777	0975	1148	1294	1414	1506	1572	1611
5	0556	0780	0978	1151	1296	1415	1507	1573	1611
6	0560	0784	0982	1154	1298	1417	1509	1574	1611
7	0564	0787	0985	1156	1300	1419	1510	1575	1612
8	0568	0791	0988	1159	1303	1421	1511	1575	1612
9	0572	0794	0991	1161	1305	1422	1513	1576	1613
10	0576	0798	0994	1164	1307	1424	1514	1577	1613
11	0580	0801	0997	1167	1309	1426	1515	1578	1613
12	0584	0805	1000	1169	1311	1427	1517	1579	1614
13	0588	0808	1003	1172	1314	1429	1518	1579	1614
14	0592	0812	1006	1174	1316	1431	1519	1580	1615
15	0595	0815	1009	1177	1318	1432	1520	1581	1615
16	0599	0819	1012	1180	1320	1434	1522	1582	1615
17	0603	0822	1015	1182	1322	1436	1523	1583	1616
18	0607	0826	1018	1185	1325	1438	1524	1583	1616
19	0611	0829	1021	1187	1327	1439	1526	1584	1617
20	0615	0833	1024	1190	1329	1441	1527	1585	1617
21	0619	0836	1027	1192	1331	1443	1528	1586	1617
22	0623	0840	1030	1195	1333	1444	1529	1586	1617
23	0626	0843	1033	1197	1335	1446	1530	1587	1618
24	0630	0846	1036	1200	1337	1447	1531	1588	1618
25	0634	0849	1039	1202	1339	1449	1532	1588	1618
26	0638	0853	1042	1205	1341	1451	1534	1589	1618
27	0642	0856	1045	1207	1343	1452	1535	1590	1618
28	0645	0859	1048	1210	1345	1454	1536	1591	1619
29	0649	0863	1051	1212	1347	1455	1537	1591	1619
30	0653	0866	1054	1215	1349	1457	1538	1592	1619
31	0657	0869	1057	1217	1351	1459	1539	1593	1619
32	0660	0873	1060	1220	1353	1460	1540	1593	1619
33	0664	0876	1062	1222	1355	1462	1541	1594	1620
34	0668	0879	1065	1225	1357	1463	1542	1595	1620
35	0671	0882	1068	1227	1359	1465	1543	1595	1620
36	0675	0886	1071	1229	1361	1467	1545	1596	1620
37	0679	0889	1074	1232	1363	1468	1546	1597	1620
38	0683	0892	1076	1234	1365	1470	1547	1598	1621
39	0686	0896	1079	1237	1367	1471	1548	1598	1621
40	0690	0899	1082	1239	1369	1473	1549	1599	1621
41	0694	0902	1085	1241	1371	1474	1550	1599	1621
42	0697	0906	1088	1244	1373	1476	1551	1600	1621
43	0701	0909	1090	1246	1375	1477	1552	1600	1621
44	0705	0912	1093	1249	1377	1479	1553	1601	1621
45	0708	0915	1096	1251	1378	1480	1554	1601	1621
46	0712	0919	1099	1253	1380	1481	1555	1602	1622
47	0716	0922	1102	1256	1382	1483	1556	1602	1622
48	0720	0925	1104	1258	1384	1484	1557	1603	1622
49	0723	0929	1107	1261	1386	1486	1558	1603	1622
50	0727	0932	1110	1263	1388	1487	1559	1604	1622
51	0731	0935	1113	1265	1390	1488	1560	1604	1622
52	0734	0938	1116	1267	1392	1490	1561	1605	1622
53	0738	0941	1118	1270	1394	1491	1562	1605	1622
54	0741	0944	1121	1272	1396	1493	1563	1606	1622
55	0745	0947	1124	1274	1397	1494	1564	1606	1622
56	0749	0951	1127	1276	1399	1495	1565	1607	1623
57	0752	0954	1130	1278	1401	1497	1566	1607	1623
58	0756	0957	1132	1281	1403	1498	1567	1608	1623
59	0759	0960	1135	1283	1405	1500	1568	1608	1623
60	0763	0963	1138	1285	1407	1501	1569	1609	1623

P. P.

	4	3	2	1
10	.7	.5	.3	.2
20	1.3	1.0	.7	.3
30	2.0	1.5	1.0	.5
40	2.7	2.0	1.3	.7
50	3.3	2.5	1.7	.8
60	4.0	3.0	2.0	1.0

LOGARITHMS OF RADIUS OF CURVATURE OF NORMAL SECTION ρ_n IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.320
0′	6875	6880	6893	6916	6947	6987	7036	7094	7160	7235	7319
1	6875	6880	6893	6916	6948	6988	7037	7095	7161	7236	7320
2	6875	6880	6894	6917	6949	6989	7038	7096	7162	7238	7322
3	6875	6880	6894	6917	6949	6989	7039	7097	7164	7239	7323
4	6875	6880	6894	6918	6950	6990	7040	7098	7165	7240	7325
5	6875	6881	6894	6918	6950	6991	7041	7099	7166	7241	7326
6	6875	6881	6895	6918	6951	6992	7041	7100	7167	7243	7327
7	6875	6881	6895	6919	6951	6993	7042	7101	7168	7244	7329
8	6875	6881	6895	6919	6952	6993	7043	7102	7170	7245	7330
9	6875	6881	6896	6920	6953	6994	7044	7103	7171	7247	7332
10	6875	6881	6896	6920	6953	6995	7045	7104	7172	7248	7333
11	6875	6881	6896	6920	6954	6996	7046	7105	7173	7249	7334
12	6875	6881	6897	6921	6955	6996	7047	7106	7174	7251	7336
13	6875	6882	6897	6921	6955	6997	7048	7107	7176	7252	7338
14	6875	6882	6898	6922	6956	6998	7049	7108	7177	7254	7339
15	6876	6882	6898	6922	6956	6999	7050	7109	7178	7255	7341
16	6876	6882	6898	6923	6957	6999	7050	7111	7179	7256	7342
17	6876	6882	6899	6923	6957	7000	7051	7112	7180	7258	7343
18	6876	6883	6899	6924	6958	7001	7052	7113	7182	7259	7345
19	6876	6883	6900	6924	6959	7001	7053	7114	7183	7261	7346
20	6876	6883	6900	6925	6959	7002	7054	7115	7184	7262	7348
21	6876	6883	6900	6925	6960	7003	7055	7116	7185	7263	7350
22	6876	6883	6901	6926	6960	7004	7056	7117	7186	7265	7351
23	6876	6884	6901	6926	6961	7004	7057	7118	7188	7266	7353
24	6876	6884	6901	6927	6962	7005	7058	7119	7189	7268	7354
25	6876	6884	6902	6927	6962	7006	7059	7120	7190	7269	7356
26	6876	6884	6902	6928	6963	7007	7060	7122	7191	7270	7358
27	6876	6884	6902	6928	6964	7008	7061	7123	7192	7272	7359
28	6876	6885	6902	6929	6965	7008	7062	7124	7194	7273	7361
29	6876	6885	6903	6929	6965	7009	7063	7125	7195	7275	7362
30	6876	6885	6903	6930	6966	7010	7064	7126	7196	7276	7364
31	6877	6885	6903	6930	6967	7011	7065	7127	7197	7277	7366
32	6877	6886	6904	6931	6967	7012	7066	7128	7199	7279	7367
33	6877	6886	6904	6931	6968	7013	7067	7129	7200	7280	7368
34	6877	6886	6905	6932	6969	7014	7068	7130	7201	7282	7370
35	6877	6887	6905	6932	6969	7015	7069	7131	7202	7283	7371
36	6877	6887	6905	6933	6970	7015	7070	7133	7204	7284	7373
37	6877	6887	6906	6933	6971	7016	7070	7134	7205	7286	7374
38	6877	6887	6906	6934	6972	7017	7071	7135	7206	7287	7376
39	6877	6888	6907	6935	6972	7018	7072	7136	7208	7289	7377
40	6877	6888	6907	6935	6973	7019	7073	7137	7209	7290	7379
41	6877	6888	6907	6936	6974	7020	7074	7138	7210	7291	7381
42	6877	6888	6908	6936	6974	7021	7075	7139	7212	7293	7382
43	6877	6889	6909	6937	6975	7021	7076	7140	7213	7294	7384
44	6877	6889	6909	6937	6976	7022	7077	7141	7214	7296	7385
45	6878	6889	6910	6938	6976	7023	7078	7142	7216	7297	7387
46	6878	6889	6910	6938	6977	7024	7079	7144	7217	7298	7389
47	6878	6889	6910	6939	6978	7025	7080	7145	7218	7300	7390
48	6878	6890	6911	6939	6979	7025	7081	7146	7219	7301	7392
49	6878	6890	6911	6940	6979	7026	7082	7147	7221	7303	7393
50	6878	6890	6911	6941	6980	7027	7083	7148	7222	7304	7395
51	6878	6890	6912	6942	6981	7028	7084	7149	7223	7305	7397
52	6878	6891	6912	6942	6981	7029	7085	7150	7225	7307	7398
53	6879	6891	6913	6943	6982	7030	7086	7152	7226	7308	7400
54	6879	6891	6913	6943	6983	7031	7087	7153	7227	7310	7401
55	6879	6892	6914	6944	6983	7032	7088	7154	7228	7311	7403
56	6879	6892	6914	6944	6984	7032	7090	7155	7230	7313	7405
57	6879	6892	6915	6945	6985	7033	7091	7156	7231	7314	7406
58	6880	6892	6915	6945	6986	7034	7092	7158	7232	7316	7408
59	6880	6893	6916	6946	6986	7035	7093	7159	7234	7317	7409
60	6880	6893	6916	6947	6987	7036	7094	7160	7235	7319	7411

P. P.

1	
10	.2
20	.3
30	.5
40	.7
50	.8
60	1.0

2	
10	.3
20	.7
30	1.0
40	1.3
50	1.7
60	2.0

TABLE 11.

LOGARITHMS OF RADIUS OF CURVATURE OF NORMAL SECTION ρ_n IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°
	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.320
0′	7411	7511	7619	7736	7860	7992	8132	8279	8434	8595
1	7413	7513	7621	7738	7862	7994	8134	8282	8437	8598
2	7414	7514	7623	7740	7864	7997	8137	8284	8439	8601
3	7416	7516	7625	7742	7867	7999	8139	8287	8442	8603
4	7417	7518	7627	7744	7869	8001	8142	8289	8444	8606
5	7419	7519	7628	7746	7871	8003	8144	8292	8447	8609
6	7421	7521	7630	7748	7873	8006	8146	8295	8450	8612
7	7422	7523	7632	7750	7875	8008	8149	8297	8452	8615
8	7424	7525	7634	7752	7878	8010	8151	8300	8455	8617
9	7425	7526	7636	7754	7880	8013	8154	8302	8457	8620
10	7427	7528	7638	7756	7882	8015	8156	8305	8460	8623
11	7429	7530	7640	7758	7884	8017	8158	8307	8463	8626
12	7430	7532	7642	7760	7886	8020	8161	8310	8465	8629
13	7432	7533	7644	7762	7888	8022	8163	8312	8468	8631
14	7433	7535	7646	7764	7890	8024	8166	8315	8471	8634
15	7435	7537	7647	7766	7892	8026	8168	8317	8473	8637
16	7437	7539	7649	7768	7895	8029	8170	8320	8476	8640
17	7438	7541	7651	7770	7897	8031	8173	8322	8479	8643
18	7440	7542	7653	7772	7899	8033	8175	8325	8482	8645
19	7441	7544	7655	7774	7901	8036	8178	8327	8484	8648
20	7443	7546	7657	7776	7903	8038	8180	8330	8487	8651
21	7445	7548	7659	7778	7905	8040	8182	8333	8490	8654
22	7446	7550	7661	7780	7907	8043	8185	8335	8492	8657
23	7448	7551	7663	7782	7910	8045	8187	8338	8495	8659
24	7450	7553	7665	7784	7912	8047	8190	8340	8498	8662
25	7451	7555	7666	7786	7914	8049	8192	8343	8500	8665
26	7453	7557	7668	7789	7916	8052	8195	8346	8503	8668
27	7455	7559	7670	7791	7918	8054	8197	8348	8506	8671
28	7457	7560	7672	7793	7921	8056	8200	8351	8509	8673
29	7458	7562	7674	7795	7923	8059	82 2	8353	8511	8676
30	7460	7564	7676	7797	7925	8061	8205	8356	8514	8679
31	7462	7566	7678	7799	7927	8063	8207	8358	8517	8682
32	7463	7568	7680	7801	7929	8066	8210	8361	8519	8685
33	7465	7569	7682	7803	7932	8068	8212	8363	8522	8687
34	7466	7571	7684	7805	7934	8071	8215	8366	8525	8690
35	7468	7573	7686	7807	7936	8073	8217	8368	8527	8693
36	7470	7575	7688	7810	7938	8075	8219	8371	8530	8696
37	7471	7577	7690	7812	7940	8078	8222	8373	8533	8699
38	7473	7578	7692	7814	7943	8080	8224	8376	8536	8701
39	7474	7580	7694	7816	7945	8083	8227	8378	8538	8704
40	7476	7582	7696	7818	7947	8085	8229	8381	8541	8707
41	7478	7584	7698	7820	7949	8087	8231	8384	8544	8710
42	7479	7586	7700	7822	7952	8090	8234	8386	8546	8713
43	7481	7588	7702	7824	7954	8092	8236	8389	8549	8715
44	7483	7590	7704	7826	7956	8094	8239	8391	8552	8718
45	7484	7591	7706	7828	7958	8096	8241	8394	8554	8721
46	7486	7593	7708	7831	7961	8099	8244	8397	8557	8724
47	7488	7595	7710	7833	7963	8101	8246	8399	8560	8727
48	7490	7597	7712	7835	7965	8103	8249	8402	8563	8729
49	7491	7599	7714	7837	7968	8106	8251	8404	8565	8732
50	7493	7601	7716	7839	7970	8108	8254	8407	8568	8735
51	7495	7603	7718	7841	7972	8110	8256	8410	8571	8738
52	7497	7605	7720	7843	7974	8113	8259	8412	8573	8741
53	7498	7606	7722	7845	7977	8115	8261	8415	8576	8743
54	7500	7608	7724	7847	7979	8118	8264	8418	8579	8746
55	7502	7610	7726	7849	7981	8120	8266	8420	8581	8749
56	7504	7612	7728	7852	7983	8122	8269	8423	8584	8752
57	7506	7614	7730	7854	7985	8125	8271	8426	8587	8755
58	7507	7615	7732	7856	7988	8127	8274	8429	8590	8757
59	7509	7617	7734	7858	7990	8130	8276	8431	8592	8760
60	7511	7619	7736	7860	7992	8132	8279	8434	8595	8763

P. P.

	1	2	3
10	.2	.3	.5
20	.3	.7	1.0
30	.5	1.0	1.5
40	.7	1.3	2.0
50	.8	1.7	2.5
60	1.0	2.0	3.0

LOGARITHMS OF RADIUS OF CURVATURE OF NORMAL SECTION ρ_n IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
	7.320	7.320	7.320	7.320	7.320	7.320	7.320	7.321	7.321	7.321
0′	8763	8939	9120	9308	9502	9701	9907	0117	0332	0553
1	8766	8942	9123	9311	9505	9705	9910	0121	0336	0556
2	8769	8945	9126	9314	9508	9708	9913	0124	0340	0560
3	8772	8948	9129	9318	9512	9712	9917	0128	0343	0564
4	8775	8951	9132	9321	9515	9715	9920	0131	0347	0567
5	8778	8953	9136	9324	9518	9718	9924	0135	0351	0571
6	8780	8956	9139	9327	9521	9722	9927	0138	0354	0575
7	8784	8959	9142	9330	9525	9725	9931	0142	0358	0579
8	8786	8962	9145	9333	9528	9728	9934	0145	0361	0582
9	8789	8965	9148	9337	9531	9732	9938	0149	0365	0586
10	8792	8968	9151	9340	9535	9735	9941	0153	0369	0590
11	8795	8971	9154	9343	9538	9739	9945	0156	0372	0594
12	8798	8974	9157	9346	9541	9742	9948	0159	0376	0597
13	8800	8977	9160	9349	9545	9745	9952	0163	0380	0601
14	8804	8980	9163	9353	9548	9749	9955	0167	0383	0605
15	8807	8983	9167	9356	9551	9752	9959	0170	0387	0608
16	8810	8986	9170	9359	9554	9756	9962	0174	0391	0612
17	8812	8989	9173	9362	9558	9759	9966	0177	0394	0616
18	8815	8992	9176	9365	9561	9762	9969	0181	0398	0620
19	8818	8995	9179	9368	9564	9766	9973	0185	0402	0623
20	8821	8998	9182	9372	9568	9769	9976	0188	0405	0627
21	8824	9001	9185	9375	9571	9773	9980	0192	0409	0631
22	8827	9004	9188	9378	9574	9776	9983	0195	0413	0635
23	8830	9007	9191	9381	9578	9779	9987	0199	0416	0638
24	8833	9010	9195	9384	9581	9783	9990	0203	0420	0642
25	8836	9013	9198	9388	9584	9786	9994	0206	0424	0646
26	8839	9016	9201	9391	9588	9790	9997	0210	0427	0649
27	8841	9020	9204	9394	9591	9793	*0001	0213	0431	0653
28	8844	9023	9207	9398	9594	9796	*0004	0217	0435	0657
29	8847	9026	9210	9401	9598	9800	*0008	0220	0438	0661
30	8850	9029	9213	9404	9601	9803	*0011	0224	0442	0664
31	8853	9032	9216	9407	9604	9807	*0015	0228	0446	0668
32	8856	9035	9220	9411	9608	9810	*0018	0231	0449	0672
33	8859	9038	9223	9414	9611	9814	*0022	0235	0453	0676
34	8862	9041	9226	9417	9614	9817	*0025	0238	0457	0679
35	8865	9044	9229	9420	9618	9820	*0029	0242	0460	0683
36	8868	9047	9232	9424	9621	9824	*0032	0246	0464	0687
37	8871	9050	9235	9427	9624	9827	*0036	0249	0468	0691
38	8874	9053	9238	9430	9628	9831	*0039	0253	0471	0694
39	8877	9056	9242	9433	9631	9834	*0043	0256	0475	0698
40	8879	9059	9245	9437	9634	9838	*0046	0260	0479	0702
41	8882	9062	9248	9440	9638	9841	*0050	0264	0482	0706
42	8885	9065	9251	9443	9641	9844	*0053	0267	0486	0710
43	8888	9068	9254	9446	9644	9848	*0057	0271	0490	0713
44	8891	9071	9257	9450	9648	9851	*0060	0274	0493	0717
45	8894	9074	9260	9453	9651	9855	*0064	0278	0497	0721
46	8897	9077	9264	9456	9654	9858	*0067	0282	0501	0725
47	8900	9080	9267	9459	9658	9862	*0071	0285	0505	0728
48	8903	9083	9270	9463	9661	9865	*0074	0289	0508	0732
49	8906	9086	9273	9466	9664	9869	*0078	0293	0512	0736
50	8909	9089	9276	9469	9668	9872	*0082	0296	0516	0740
51	8912	9093	9279	9472	9671	9875	*0085	0300	0519	0743
52	8915	9096	9283	9476	9674	9879	*0089	0303	0523	0747
53	8918	9099	9286	9479	9678	9882	*0092	0307	0527	0751
54	8921	9102	9289	9482	9681	9886	*0096	0311	0530	0755
55	8924	9105	9292	9485	9685	9889	*0099	0314	0534	0759
56	8927	9108	9295	9489	9688	9893	*0103	0318	0538	0762
57	8930	9111	9298	9492	9691	9896	*0106	0322	0542	0766
58	8933	9114	9302	9495	9695	9900	*0110	0325	0545	0770
59	8936	9117	9305	9498	9698	9903	*0113	0329	0549	0774
60	8939	9120	9308	9502	9701	9907	*0117	0332	0553	0777

P. P.

	2
10	.3
20	.7
30	1.0
40	1.3
50	1.7
60	2.0

	3
10	.5
20	1.0
30	1.5
40	2.0
50	2.5
60	3.0

	4
10	.7
20	1.3
30	2.0
40	2.7
50	3.3
60	4.0

LOGARITHMS OF RADIUS OF CURVATURE OF NORMAL SECTION ρ_n IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°
	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321
0′	0777	1006	1239	1476	1716	1959	2205	2453	2704	2956
1	0781	1010	1243	1480	1720	1963	2209	2457	2708	2961
2	0785	1014	1247	1484	1724	1967	2213	2462	2712	2965
3	0789	1018	1251	1488	1728	1971	2217	2466	2716	2969
4	0793	1022	1255	1492	1732	1975	2221	2470	2721	2973
5	0796	1026	1259	1496	1736	1979	2226	2474	2725	2978
6	0800	1029	1263	1500	1740	1983	2230	2478	2729	2982
7	0804	1033	1267	1504	1744	1988	2234	2482	2733	2986
8	0808	1037	1271	1508	1748	1992	2238	2487	2737	2990
9	0811	1041	1275	1512	1752	1996	2242	2491	2742	2994
10	0815	1045	1279	1516	1756	2000	2246	2495	2746	2999
11	0819	1049	1282	1520	1760	2004	2250	2499	2750	3003
12	0823	1053	1286	1524	1764	2008	2254	2503	2754	3007
13	0827	1057	1290	1528	1768	2012	2259	2507	2758	3011
14	0830	1060	1294	1532	1772	2016	2263	2512	2763	3016
15	0834	1064	1298	1536	1776	2020	2267	2516	2767	3020
16	0838	1068	1302	1540	1780	2024	2271	2520	2771	3024
17	0842	1072	1306	1544	1784	2028	2275	2524	2775	3028
18	0846	1076	1310	1548	1789	2033	2279	2528	2779	3032
19	0849	1080	1314	1552	1793	2037	2283	2532	2784	3037
20	0853	1084	1318	1556	1797	2041	2287	2537	2788	3041
21	0857	1087	1322	1560	1801	2045	2292	2541	2792	3045
22	0861	1091	1326	1564	1805	2049	2296	2545	2796	3049
23	0865	1095	1330	1568	1809	2053	2300	2549	2800	3054
24	0869	1099	1334	1572	1813	2057	2304	2553	2805	3058
25	0872	1103	1337	1576	1817	2061	2308	2557	2809	3062
26	0876	1107	1341	1580	1821	2065	2312	2562	2813	3066
27	0880	1111	1345	1584	1825	2069	2316	2566	2817	3071
28	0884	1115	1349	1588	1829	2073	2321	2570	2822	3075
29	0888	1118	1353	1592	1833	2077	2325	2574	2826	3079
30	0891	1122	1357	1596	1837	2082	2329	2578	2830	3083
31	0895	1126	1361	1600	1841	2086	2333	2583	2834	3087
32	0899	1130	1365	1604	1845	2090	2337	2587	2838	3092
33	0903	1134	1369	1608	1849	2094	2341	2591	2843	3096
34	0907	1138	1373	1612	1853	2098	2345	2595	2847	3100
35	0910	1142	1377	1616	1857	2102	2350	2599	2851	3104
36	0914	1146	1381	1620	1861	2106	2354	2603	2855	3109
37	0918	1150	1385	1624	1865	2110	2358	2608	2859	3113
38	0922	1153	1389	1628	1870	2114	2362	2612	2864	3117
39	0926	1157	1393	1632	1874	2119	2366	2616	2868	3121
40	0930	1161	1397	1636	1878	2123	2370	2620	2872	3126
41	0933	1165	1401	1640	1882	2127	2374	2624	2876	3130
42	0937	1169	1405	1644	1886	2131	2379	2629	2880	3134
43	0941	1173	1409	1648	1890	2135	2383	2633	2885	3138
44	0945	1177	1412	1652	1894	2139	2387	2637	2889	3143
45	0949	1181	1416	1656	1898	2143	2391	2641	2893	3147
46	0953	1185	1420	1660	1902	2147	2395	2645	2897	3151
47	0956	1189	1424	1664	1906	2151	2399	2649	2902	3155
48	0960	1192	1428	1668	1910	2156	2403	2654	2906	3160
49	0964	1196	1432	1672	1914	2160	2408	2658	2910	3164
50	0968	1200	1436	1676	1918	2164	2412	2662	2914	3168
51	0972	1204	1440	1680	1922	2168	2416	2666	2918	3172
52	0976	1208	1444	1684	1926	2172	2420	2670	2923	3177
53	0979	1212	1448	1688	1931	2176	2424	2675	2927	3181
54	0983	1216	1452	1692	1935	2180	2428	2679	2931	3185
55	0987	1220	1456	1696	1939	2184	2433	2683	2935	3189
56	0991	1224	1460	1700	1943	2188	2437	2687	2940	3193
57	0995	1228	1464	1704	1947	2193	2441	2691	2944	3198
58	0999	1231	1468	1708	1951	2197	2445	2696	2948	3202
59	1003	1235	1472	1712	1955	2201	2449	2700	2952	3206
60	1006	1239	1476	1716	1959	2205	2453	2704	2956	3210

P. P.

	3	4	5
10	.5	.7	.8
20	1.0	1.3	1.7
30	1.5	2.0	2.5
40	2.0	2.7	3.3
50	2.5	3.3	4.2
60	3.0	4.0	5.0

LOGARITHMS OF RADIUS OF CURVATURE OF NORMAL SECTION ρ_n IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	41°	42°	43°	44°	45°	46°	47°	48°	49°	50°
	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321
0′	3210	3466	3722	3979	4236	4494	4751	5007	5263	5517
1	3215	3470	3726	3983	4241	4498	4755	5012	5267	5522
2	3219	3474	3731	3988	4245	4502	4760	5016	5271	5526
3	3223	3479	3735	3992	4249	4507	4764	5020	5276	5530
4	3227	3483	3739	3996	4254	4511	4768	5024	5280	5534
5	3232	3487	3744	4001	4258	4515	4772	5029	5284	5538
6	3236	3491	3748	4005	4262	4520	4777	5033	5288	5543
7	3240	3496	3752	4009	4267	4524	4781	5037	5293	5547
8	3244	3500	3756	4013	4271	4528	4785	5042	5297	5551
9	3249	3504	3761	4018	4275	4532	4789	5046	5301	5555
10	3253	3508	3765	4022	4279	4537	4794	5050	5305	5560
11	3257	3513	3769	4026	4284	4541	4798	5054	5310	5564
12	3261	3517	3774	4031	4288	4545	4802	5059	5314	5568
13	3266	3521	3778	4035	4292	4550	4807	5063	5318	5572
14	3270	3526	3782	4039	4297	4554	4811	5067	5322	5576
15	3274	3530	3786	4043	4301	4558	4815	5071	5327	5581
16	3278	3534	3791	4048	4305	4562	4819	5076	5331	5585
17	3283	3538	3795	4052	4309	4567	4824	5080	5335	5589
18	3287	3543	3799	4056	4314	4571	4828	5084	5339	5593
19	3291	3547	3803	4061	4318	4575	4832	5088	5344	5598
20	3295	3551	3808	4065	4322	4580	4837	5093	5348	5602
21	3300	3555	3812	4069	4327	4584	4841	5097	5352	5606
22	3304	3560	3816	4073	4331	4588	4845	5101	5356	5610
23	3308	3564	3821	4078	4335	4592	4849	5105	5361	5614
24	3312	3568	3825	4082	4339	4597	4854	5110	5365	5619
25	3317	3573	3829	4086	4344	4601	4858	5114	5369	5623
26	3321	3577	3833	4091	4348	4605	4862	5118	5373	5627
27	3325	3581	3838	4095	4352	4610	4866	5123	5378	5631
28	3329	3585	3842	4099	4357	4614	4871	5127	5382	5636
29	3334	3590	3846	4104	4361	4618	4875	5131	5386	5640
30	3338	3594	3851	4108	4365	4622	4879	5135	5390	5644
31	3342	3598	3855	4112	4369	4627	4884	5140	5395	5648
32	3347	3602	3859	4116	4374	4631	4888	5144	5399	5652
33	3351	3607	3863	4121	4378	4635	4892	5148	5403	5657
34	3355	3611	3868	4125	4382	4640	4896	5152	5407	5661
35	3359	3615	3872	4129	4387	4644	4901	5157	5412	5665
36	3364	3620	3876	4134	4391	4648	4905	5161	5416	5669
37	3368	3624	3881	4138	4395	4652	4909	5165	5420	5673
38	3372	3628	3885	4142	4399	4657	4913	5169	5424	5678
39	3376	3632	3889	4146	4404	4661	4918	5174	5428	5682
40	3381	3637	3893	4151	4408	4665	4922	5178	5433	5686
41	3385	3641	3898	4155	4412	4670	4926	5182	5437	5690
42	3389	3645	3902	4159	4417	4674	4931	5186	5441	5694
43	3393	3649	3906	4164	4421	4678	4935	5191	5445	5699
44	3398	3654	3911	4168	4425	4682	4939	5195	5450	5703
45	3402	3658	3915	4172	4430	4687	4943	5199	5454	5707
46	3406	3662	3919	4176	4434	4691	4948	5203	5458	5711
47	3410	3667	3923	4181	4438	4695	4952	5208	5462	5716
48	3415	3671	3928	4185	4442	4700	4956	5212	5467	5720
49	3419	3675	3932	4189	4447	4704	4960	5216	5471	5724
50	3423	3679	3936	4194	4451	4708	4965	5220	5475	5728
51	3427	3684	3941	4198	4455	4712	4969	5225	5479	5732
52	3432	3688	3945	4202	4460	4717	4973	5229	5484	5737
53	3436	3692	3949	4206	4464	4721	4978	5233	5488	5741
54	3440	3697	3953	4211	4468	4725	4982	5237	5492	5745
55	3445	3701	3958	4215	4472	4730	4986	5242	5496	5749
56	3449	3705	3962	4219	4477	4734	4990	5246	5500	5753
57	3453	3709	3966	4224	4481	4738	4995	5250	5505	5758
58	3457	3714	3971	4228	4485	4742	4999	5254	5509	5762
59	3462	3718	3975	4232	4490	4747	5003	5259	5513	5766
60	3466	3722	3979	4236	4494	4751	5007	5263	5517	5770

P. P.

	4
10	.7
20	1.3
30	2.0
40	2.7
50	3.3
60	4.0

	5
10	.8
20	1.7
30	2.5
40	3.3
50	4.2
60	5.0

LOGARITHMS OF RADIUS OF CURVATURE OF NORMAL SECTION ρ_n IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	51°	52°	53°	54°	55°	56°	57°	58°	59°	60°
	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321
0′	5770	6021	6270	6517	6760	7001	7238	7472	7701	7927
1	5774	6025	6274	6521	6764	7005	7242	7476	7705	7931
2	5778	6029	6278	6525	6768	7009	7246	7480	7709	7934
3	5783	6034	6282	6529	6772	7013	7250	7483	7712	7938
4	5787	6038	6286	6533	6776	7017	7254	7487	7716	7942
5	5791	6042	6290	6537	6780	7021	7257	7491	7720	7945
6	5795	6046	6295	6541	6785	7025	7261	7495	7724	7949
7	5799	6050	6299	6545	6789	7029	7265	7499	7728	7953
8	5804	6055	6303	6549	6793	7033	7269	7502	7731	7957
9	5808	6059	6307	6553	6797	7037	7273	7506	7735	7960
10	5812	6063	6311	6557	6801	7041	7277	7510	7739	7964
11	5816	6067	6315	6561	6805	7045	7281	7514	7743	7968
12	5820	6071	6319	6565	6809	7049	7285	7518	7747	7971
13	5825	6075	6324	6569	6813	7053	7289	7522	7750	7975
14	5829	6079	6328	6573	6817	7057	7293	7526	7754	7979
15	5833	6083	6332	6577	6821	7060	7296	7529	7758	7982
16	5837	6088	6336	6582	6825	7064	7300	7533	7762	7986
17	5841	6092	6340	6586	6829	7068	7304	7537	7766	7990
18	5846	6096	6345	6590	6833	7072	7308	7541	7769	7994
19	5850	6100	6349	6594	6837	7076	7312	7545	7773	7997
20	5854	6104	6353	6598	6841	7080	7316	7549	7777	8001
21	5858	6108	6357	6602	6845	7084	7320	7552	7781	8005
22	5862	6112	6361	6606	6849	7088	7324	7557	7785	8008
23	5867	6117	6365	6610	6853	7092	7328	7560	7788	8012
24	5871	6121	6369	6614	6857	7096	7332	7564	7792	8016
25	5875	6125	6373	6618	6861	7100	7335	7568	7796	8019
26	5879	6129	6378	6623	6865	7104	7339	7572	7800	8023
27	5883	6133	6382	6627	6869	7108	7343	7576	7804	8027
28	5888	6138	6386	6631	6873	7112	7347	7579	7807	8031
29	5892	6142	6390	6635	6877	7116	7351	7583	7811	8034
30	5896	6146	6394	6639	6881	7120	7355	7587	7815	8038
31	5900	6150	6398	6643	6885	7124	7359	7591	7819	8042
32	5904	6154	6402	6647	6889	7128	7363	7595	7822	8045
33	5909	6158	6406	6651	6893	7132	7367	7598	7826	8049
34	5913	6162	6410	6655	6897	7136	7371	7602	7830	8053
35	5917	6166	6414	6659	6901	7139	7374	7606	7833	8056
36	5921	6171	6419	6663	6905	7143	7378	7610	7837	8060
37	5925	6175	6423	6667	6909	7147	7382	7614	7841	8064
38	5930	6179	6427	6671	6913	7151	7386	7617	7845	8068
39	5934	6183	6431	6675	6917	7155	7390	7621	7848	8071
40	5938	6187	6435	6679	6921	7159	7394	7625	7852	8075
41	5942	6191	6439	6683	6925	7163	7398	7629	7856	8079
42	5946	6195	6443	6687	6929	7167	7402	7633	7860	8082
43	5951	6200	6447	6691	6933	7171	7406	7636	7863	8086
44	5955	6204	6451	6695	6937	7175	7410	7640	7867	8089
45	5959	6208	6455	6699	6941	7179	7413	7644	7871	8093
46	5963	6212	6460	6704	6945	7183	7417	7648	7875	8097
47	5967	6216	6464	6708	6949	7187	7421	7652	7879	8100
48	5972	6221	6468	6712	6953	7191	7425	7655	7882	8104
49	5976	6225	6472	6716	6957	7195	7429	7659	7886	8107
50	5980	6229	6476	6720	6961	7199	7433	7663	7890	8111
51	5984	6233	6480	6724	6965	7203	7437	7667	7894	8115
52	5988	6237	6484	6728	6969	7207	7441	7671	7897	8118
53	5992	6241	6488	6732	6973	7211	7445	7674	7901	8122
54	5996	6245	6492	6736	6977	7215	7449	7678	7905	8126
55	6000	6249	6496	6740	6981	7218	7452	7682	7908	8129
56	6005	6254	6501	6744	6985	7222	7456	7686	7912	8133
57	6009	6258	6505	6748	6989	7226	7460	7690	7916	8137
58	6013	6262	6509	6752	6993	7230	7464	7693	7920	8141
59	6017	6266	6513	6756	6997	7234	7468	7697	7923	8144
60	6021	6270	6517	6760	7001	7238	7472	7701	7927	8148

P. P.

	5
10	.8
20	1.7
30	2.5
40	3.3
50	4.2
60	5.0

	4
10	.7
20	1.3
30	2.0
40	2.7
50	3.3
60	4.0

	3
10	.5
20	1.0
30	1.5
40	2.0
50	2.5
60	3.0

LOGARITHMS OF RADIUS OF CURVATURE OF NORMAL SECTION ρ_n IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°
	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321	7.321
0′	8148	8364	8575	8781	8982	9176	9365	9548	9724	9893
1	8152	8368	8578	8784	8985	9179	9368	9551	9727	9896
2	8155	8371	8582	8788	8989	9182	9371	9554	9730	9898
3	8159	8375	8585	8791	8992	9186	9374	9557	9732	9901
4	8162	8378	8589	8795	8995	9189	9377	9560	9735	9904
5	8166	8382	8592	8798	8998	9192	9380	9562	9738	9906
6	8170	8386	8596	8801	9002	9195	9384	9565	9741	9909
7	8173	8389	8599	8805	9005	9198	9387	9568	9744	9912
8	8177	8393	8603	8808	9008	9202	9390	9571	9746	9915
9	8180	8396	8606	8812	9012	9205	9393	9574	9749	9917
10	8184	8400	8610	8815	9015	9208	9396	9577	9752	9920
11	8188	8403	8613	8818	9018	9211	9399	9580	9755	9923
12	8191	8407	8617	8822	9021	9214	9402	9583	9758	9926
13	8195	8410	8620	8825	9025	9218	9405	9586	9761	9928
14	8198	8414	8624	8829	9028	9221	9408	9589	9764	9931
15	8202	8417	8627	8832	9031	9224	9411	9592	9766	9934
16	8206	8421	8631	8835	9034	9227	9415	9595	9769	9937
17	8209	8424	8634	8839	9037	9230	9418	9598	9772	9940
18	8213	8428	8638	8842	9041	9234	9421	9601	9775	9942
19	8216	8431	8641	8846	9044	9237	9424	9604	9778	9945
20	8220	8435	8645	8849	9047	9240	9427	9607	9781	9948
21	8224	8438	8648	8852	9050	9243	9430	9610	9784	9951
22	8227	8442	8652	8856	9054	9246	9433	9613	9787	9953
23	8231	8445	8655	8859	9057	9250	9436	9616	9789	9956
24	8235	8449	8659	8862	9060	9253	9439	9619	9792	9959
25	8238	8452	8662	8865	9063	9256	9442	9621	9795	9961
26	8242	8456	8665	8869	9067	9259	9445	9624	9798	9964
27	8246	8459	8669	8872	9070	9262	9448	9627	9801	9967
28	8250	8463	8672	8875	9073	9266	9451	9630	9803	9970
29	8253	8466	8676	8879	9077	9269	9454	9633	9806	9972
30	8257	8470	8679	8882	9080	9272	9457	9636	9809	9975
31	8261	8473	8682	8885	9083	9275	9460	9639	9812	9978
32	8264	8477	8686	8889	9086	9278	9463	9642	9815	9980
33	8268	8480	8689	8892	9090	9281	9466	9645	9817	9983
34	8271	8484	8693	8896	9093	9284	9469	9648	9820	9986
35	8275	8487	8696	8899	9096	9287	9472	9651	9823	9988
36	8279	8491	8699	8902	9099	9291	9475	9654	9826	9991
37	8282	8494	8703	8906	9102	9294	9478	9657	9829	9994
38	8286	8498	8706	8909	9106	9297	9481	9660	9831	9997
39	8289	8501	8710	8913	9109	9300	9484	9663	9834	9999
40	8293	8505	8713	8916	9112	9303	9487	9666	9837	*0002
41	8296	8508	8716	8919	9115	9306	9490	9669	9840	*0005
42	8300	8512	8720	8923	9118	9309	9493	9672	9843	*0007
43	8303	8515	8723	8926	9122	9312	9496	9675	9845	*0010
44	8307	8519	8727	8929	9125	9315	9499	9678	9848	*0013
45	8310	8522	8730	8932	9128	9318	9502	9680	9851	*0015
46	8314	8526	8733	8936	9131	9322	9506	9683	9854	*0018
47	8317	8529	8737	8939	9134	9325	9509	9686	9857	*0021
48	8321	8533	8740	8942	9138	9328	9512	9689	9859	*0024
49	8324	8536	8744	8946	9141	9331	9515	9692	9862	*0026
50	8328	8540	8747	8949	9144	9334	9518	9695	9865	*0029
51	8332	8543	8750	8952	9147	9337	9521	9698	9868	*0032
52	8335	8547	8754	8956	9150	9340	9524	9701	9871	*0034
53	8339	8550	8757	8959	9154	9343	9527	9704	9873	*0037
54	8342	8554	8761	8962	9157	9346	9530	9707	9876	*0039
55	8346	8557	8764	8965	9160	9349	9533	9709	9879	*0042
56	8350	8561	8767	8969	9163	9353	9536	9712	9882	*0045
57	8353	8564	8771	8972	9166	9356	9539	9715	9885	*0047
58	8357	8568	8774	8975	9170	9359	9542	9718	9887	*0050
59	8360	8571	8778	8979	9173	9362	9545	9721	9890	*0052
60	8364	8575	8781	8982	9176	9365	9548	9724	9893	*0055

P. P.

4	
10	.7
20	1.3
30	2.0
40	2.7
50	3.3
60	4.0

3	
10	.5
20	1.0
30	1.5
40	2.0
50	2.5
60	3.0

2	
10	.3
20	.7
30	1.0
40	1.3
50	1.7
60	2.0

Table 11.

LOGARITHMS OF RADIUS OF CURVATURE OF NORMAL SECTION ρ_n IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°
	7.322	**7.322**	**7.322**	**7.322**	**7.322**	**7.322**	**7.322**	**7.322**	**7.322**	**7.322**
0′	0055	0210	0359	0499	0632	0757	0875	0984	1085	1177
1	0058	0213	0361	0501	0634	0759	0877	0986	1087	1178
2	0060	0215	0364	0504	0636	0761	0879	0987	1088	1180
3	0063	0218	0366	0506	0639	0763	0880	0989	1090	1181
4	0066	0220	0369	0508	0641	0765	0882	0991	1091	1183
5	0068	0223	0371	0510	0643	0767	0884	0992	1093	1184
6	0071	0226	0373	0513	0645	0769	0886	0994	1095	1186
7	0074	0228	0376	0515	0647	0771	0888	0996	1096	1187
8	0077	0231	0378	0517	0650	0773	0889	0998	1098	1189
9	0079	0233	0381	0520	0652	0775	0891	0999	1099	1190
10	0082	0236	0383	0522	0654	0777	0893	1001	1101	1192
11	0085	0238	0385	0524	0656	0779	0895	1003	1102	1193
12	0087	0241	0388	0526	0658	0781	0897	1004	1104	1195
13	0090	0243	0390	0529	0660	0783	0899	1006	1105	1196
14	0092	0246	0392	0531	0662	0785	0901	1008	1107	1198
15	0095	0248	0394	0533	0664	0787	0902	1009	1108	1199
16	0098	0251	0397	0535	0667	0789	0904	1011	1110	1200
17	0100	0253	0399	0537	0669	0791	0906	1013	1111	1202
18	0103	0256	0401	0540	0671	0793	0908	1015	1113	1203
19	0105	0258	0404	0542	0673	0795	0910	1016	1114	1205
20	0108	0261	0406	0544	0675	0797	0912	1018	1116	1206
21	0111	0263	0408	0546	0677	0799	0914	1020	1118	1207
22	0113	0266	0411	0549	0679	0801	0916	1021	1119	1209
23	0116	0268	0413	0551	0681	0803	0917	1023	1121	1210
24	0118	0271	0416	0553	0683	0805	0919	1025	1122	1212
25	0121	0273	0418	0555	0685	0807	0921	1026	1124	1213
26	0124	0276	0420	0558	0688	0809	0923	1028	1126	1214
27	0126	0278	0423	0560	0690	0811	0925	1030	1127	1216
28	0129	0281	0425	0562	0692	0813	0926	1032	1129	1217
29	0131	0283	0428	0565	0694	0815	0928	1033	1130	1219
30	0134	0286	0430	0567	0696	0817	0930	1035	1132	1220
31	0137	0288	0432	0569	0698	0819	0932	1037	1133	1221
32	0139	0291	0435	0571	0700	0821	0934	1038	1135	1223
33	0142	0293	0437	0574	0702	0823	0935	1040	1136	1224
34	0144	0296	0439	0576	0704	0825	0937	1042	1138	1226
35	0147	0298	0441	0578	0706	0826	0939	1043	1139	1227
36	0150	0300	0444	0580	0708	0828	0941	1045	1141	1228
37	0152	0303	0446	0582	0710	0830	0943	1047	1142	1230
38	0155	0305	0448	0585	0712	0832	0944	1049	1144	1231
39	0157	0308	0451	0587	0714	0834	0946	1050	1145	1233
40	0160	0310	0453	0589	0716	0836	0948	1052	1147	1234
41	0162	0312	0455	0591	0718	0838	0950	1054	1148	1235
42	0165	0315	0458	0593	0720	0840	0952	1055	1150	1237
43	0167	0317	0460	0596	0722	0842	0953	1057	1151	1238
44	0170	0320	0462	0598	0724	0844	0955	1058	1153	1240
45	0172	0322	0464	0600	0726	0846	0957	1060	1154	1241
46	0175	0324	0467	0602	0729	0848	0959	1062	1156	1242
47	0177	0327	0469	0604	0731	0850	0961	1063	1157	1244
48	0180	0329	0471	0607	0733	0852	0962	1065	1159	1245
49	0182	0332	0474	0609	0735	0854	0964	1066	1160	1247
50	0185	0334	0476	0611	0737	0856	0966	1068	1162	1248
51	0187	0336	0478	0613	0739	0858	0968	1070	1163	1249
52	0190	0339	0481	0615	0741	0860	0970	1071	1165	1251
53	0192	0341	0483	0617	0743	0862	0971	1073	1166	1252
54	0195	0344	0485	0619	0745	0864	0973	1075	1168	1253
55	0197	0346	0487	0621	0747	0865	0975	1076	1169	1254
56	0200	0349	0490	0624	0749	0867	0977	1078	1171	1256
57	0202	0351	0492	0626	0751	0869	0979	1080	1172	1257
58	0205	0354	0494	0628	0753	0871	0980	1082	1174	1258
59	0207	0356	0497	0630	0755	0873	0982	1083	1175	1260
60	0210	0359	0499	0632	0757	0875	0984	1085	1177	1261

P. P.

3	
10	.5
20	1.0
30	1.5
40	2.0
50	2.5
60	3.0

2	
10	.3
20	.7
30	1.0
40	1.3
50	1.7
60	2.0

1	
10	.2
20	.3
30	.5
40	.7
50	.8
60	1.0

LOGARITHMS OF RADIUS OF CURVATURE OF NORMAL SECTION ρ_n IN ENGLISH FEET.

[Derivation of table explained on p. xlv.]

Lat.	81°	82°	83°	84°	85°	86°	87°	88°	89°
	7.322	7.322	7.322	7.322	7.322	7.322	7.322	7.322	7.322
0′	1261	1337	1403	1461	1511	1551	1583	1605	1619
1	1262	1338	1404	1462	1512	1552	1583	1605	1619
2	1264	1339	1405	1463	1512	1552	1584	1606	1619
3	1265	1340	1406	1464	1513	1553	1584	1606	1619
4	1266	1341	1407	1465	1514	1553	1585	1606	1619
5	1267	1342	1408	1465	1514	1554	1585	1606	1619
6	1269	1344	1410	1466	1515	1555	1585	1607	1620
7	1270	1345	1411	1467	1516	1555	1586	1607	1620
8	1271	1346	1412	1468	1517	1556	1586	1607	1620
9	1273	1347	1413	1469	1517	1556	1587	1608	1620
10	1274	1348	1414	1470	1518	1557	1587	1608	1620
11	1275	1349	1415	1471	1519	1558	1587	1608	1620
12	1277	1350	1416	1472	1519	1558	1588	1609	1620
13	1278	1352	1417	1473	1520	1559	1588	1609	1620
14	1279	1353	1418	1474	1521	1559	1589	1609	1620
15	1280	1354	1419	1474	1521	1560	1589	1609	1620
16	1282	1355	1420	1475	1522	1561	1589	1610	1621
17	1283	1356	1421	1476	1523	1561	1590	1610	1621
18	1284	1358	1422	1477	1524	1562	1590	1610	1621
19	1286	1359	1423	1478	1524	1562	1591	1611	1621
20	1287	1360	1424	1479	1525	1563	1591	1611	1621
21	1288	1361	1425	1480	1526	1563	1591	1611	1621
22	1290	1362	1426	1481	1526	1564	1592	1611	1621
23	1291	1363	1427	1481	1527	1564	1592	1612	1621
24	1292	1364	1428	1482	1528	1565	1593	1612	1621
25	1293	1365	1429	1483	1528	1565	1593	1612	1621
26	1295	1367	1430	1484	1529	1566	1593	1612	1622
27	1296	1368	1431	1485	1530	1566	1594	1612	1622
28	1297	1369	1432	1485	1531	1567	1594	1613	1622
29	1299	1370	1433	1486	1531	1567	1595	1613	1622
30	1300	1371	1434	1487	1532	1568	1595	1613	1622
31	1301	1372	1435	1488	1533	1568	1595	1613	1622
32	1302	1373	1436	1489	1533	1569	1596	1613	1622
33	1304	1374	1437	1489	1534	1569	1596	1614	1622
34	1305	1375	1438	1490	1535	1570	1597	1614	1622
35	1306	1376	1438	1491	1535	1570	1597	1614	1622
36	1307	1378	1439	1492	1536	1571	1597	1614	1623
37	1308	1379	1440	1493	1537	1571	1598	1614	1623
38	1310	1380	1441	1493	1538	1572	1598	1615	1623
39	1311	1381	1442	1494	1538	1572	1599	1615	1623
40	1312	1382	1443	1495	1539	1573	1599	1615	1623
41	1313	1383	1444	1496	1540	1573	1599	1615	1623
42	1315	1384	1445	1497	1540	1574	1600	1615	1623
43	1316	1385	1446	1497	1541	1574	1600	1616	1623
44	1317	1386	1447	1498	1541	1575	1600	1616	1623
45	1318	1387	1447	1499	1542	1575	1600	1616	1623
46	1320	1389	1448	1500	1543	1576	1601	1616	1623
47	1321	1390	1449	1501	1543	1576	1601	1616	1623
48	1322	1391	1450	1501	1544	1577	1601	1617	1623
49	1324	1392	1451	1502	1544	1577	1602	1617	1623
50	1325	1393	1452	1503	1545	1578	1602	1617	1623
51	1326	1394	1453	1504	1546	1578	1602	1617	1623
52	1327	1395	1454	1505	1546	1579	1603	1617	1623
53	1329	1396	1455	1505	1547	1579	1603	1618	1623
54	1330	1397	1456	1506	1547	1580	1603	1618	1623
55	1331	1398	1456	1507	1548	1580	1603	1618	1623
56	1332	1399	1457	1508	1549	1581	1604	1618	1623
57	1333	1400	1458	1509	1549	1581	1604	1618	1623
58	1335	1401	1459	1509	1550	1582	1604	1619	1623
59	1336	1402	1460	1510	1550	1582	1605	1619	1623
60	1337	1403	1461	1511	1551	1583	1605	1619	1623

P. P.

2	
10	.3
20	.7
30	1.0
40	1.3
50	1.7
60	2.0

1	
10	.2
20	.3
30	.5
40	.7
50	.8
60	1.0

Table 12.

LOGARITHMS OF RADIUS OF CURVATURE ρ_α (IN METRES) OF SECTION OF EARTH'S SURFACE INCLINED TO MERIDIAN AT AZIMUTH α.

[Formula for ρ_α given on p. xlv.]

Azimuth.	LATITUDE.									
	22°	23°	24°	25°	26°	27°	28°	29°	30°	31°
0°	6.80237	6.80242	6.80248	6.80254	6.80260	6.80266	6.80272	6.80279	6.80285	6.80292
5	239	244	250	256	262	268	274	280	287	294
10	244	250	255	261	267	273	279	285	292	298
15	254	259	264	270	276	282	288	294	300	306
20	266	271	277	282	288	293	299	305	311	317
25	282	287	292	297	302	308	313	319	325	331
30	300	305	309	314	319	324	330	335	340	346
35	320	324	329	333	338	343	348	353	358	363
40	341	345	350	354	358	362	367	372	377	382
45	364	367	371	375	379	383	387	391	396	400
50	386	389	392	396	399	403	407	411	415	419
55	407	410	413	416	420	423	426	430	434	437
60	427	430	432	435	438	442	445	448	451	455
65	445	448	450	453	455	458	461	464	467	470
70	461	463	465	468	470	473	475	478	481	484
75	473	476	478	480	482	484	487	489	492	494
80	483	485	487	489	491	493	495	498	500	502
85	489	490	492	494	496	498	501	503	505	507
90	490	492	494	496	498	500	502	504	507	509

Azimuth.	LATITUDE.									
	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°
0°	6.80299	6.80306	6.80313	6.80320	6.80327	6.80335	6.80342	6.80350	6.80357	6.80365
5	300	307	314	322	329	336	344	351	359	366
10	305	312	319	326	333	340	348	355	363	370
15	313	320	326	333	340	348	355	362	369	376
20	324	330	337	343	350	357	364	371	378	385
25	337	343	349	355	362	368	375	382	388	395
30	352	358	364	370	376	382	388	394	401	407
35	369	374	380	385	391	397	402	408	414	420
40	386	392	397	402	407	412	418	423	429	434
45	405	410	414	419	424	429	434	439	444	449
50	423	428	432	436	441	445	450	454	459	464
55	441	445	449	453	457	461	465	469	474	478
60	458	462	465	469	472	476	480	484	487	491
65	473	476	480	483	486	489	493	496	500	503
70	486	489	492	495	498	501	504	507	510	514
75	497	500	502	505	508	510	513	516	519	522
80	505	507	510	512	515	517	520	523	525	528
85	510	512	514	517	519	522	524	527	529	532
90	511	514	516	518	521	523	526	528	531	533

LOGARITHMS OF RADIUS OF CURVATURE ρ_a (IN METRES) OF SECTION OF EARTH'S SURFACE INCLINED TO MERIDIAN AT AZIMUTH a.

[Formula for ρ_a given on p. xlv.]

Azimuth.	LATITUDE.									
	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°
0°	6.80373	6.80380	6.80388	6.80396	6.80404	6.80411	6.80419	6.80426	6.80434	6.80442
5	374	382	389	397	404	412	420	428	435	443
10	378	385	393	400	408	415	423	430	438	445
15	384	391	399	406	413	420	428	435	442	450
20	392	399	406	413	420	427	434	441	448	455
25	402	408	415	422	429	436	442	449	456	463
30	413	420	426	433	439	446	452	458	465	471
35	426	432	438	444	450	456	462	468	474	480
40	440	446	451	457	462	468	474	479	485	490
45	454	459	464	470	475	480	485	490	495	500
50	468	473	478	482	487	492	496	501	506	510
55	482	486	490	495	499	503	508	512	516	520
60	495	499	502	506	510	514	518	522	526	530
65	507	510	514	517	520	524	528	531	534	538
70	517	520	523	526	529	532	536	539	542	545
75	525	528	530	534	536	539	542	545	548	551
80	531	534	536	539	542	544	547	550	553	555
85	534	537	540	542	545	548	550	553	555	558
90	536	538	541	544	546	549	551	554	556	559

Azimuth.	LATITUDE.								
	52°	53°	54°	55°	56°	57°	58°	59°	60°
0°	6.80449	6.80457	6.80464	6.80471	6.80479	6.80486	6.80493	6.80500	6.80506
5	450	458	465	472	479	486	493	500	507
10	453	460	467	474	481	488	495	502	509
15	457	464	471	478	485	492	498	505	511
20	462	469	476	483	489	496	502	509	515
25	469	476	482	489	495	501	508	514	520
30	477	484	490	496	502	508	514	519	525
35	486	492	498	503	509	515	520	525	531
40	496	501	506	512	517	522	527	532	537
45	505	510	515	520	525	530	534	539	543
50	515	520	524	528	533	537	542	546	550
55	524	528	533	537	541	545	548	552	556
60	533	537	541	544	548	552	555	558	562
65	541	545	548	551	555	558	561	564	567
70	548	551	554	557	560	563	566	569	572
75	554	557	559	562	565	568	570	573	575
80	558	561	563	566	568	571	573	576	578
85	560	563	566	568	570	573	575	578	580
90	561	564	566	569	571	574	576	578	580

LOGARITHMS OF FACTORS $\frac{\rho''}{2\rho_m\rho_n}$ FOR COMPUTING SPHEROIDAL EXCESS OF TRIANGLES.

UNIT = THE ENGLISH FOOT.

[Derivation and use of table explained on p. lviii.]

ϕ	log. factor and change per minute.	ϕ	log. factor and change per minute.	ϕ	log. factor and change per minute.	ϕ	log. factor and change per minute.
0°	0.37498 —0.00	20°	0.37429 —0.12	40°	0.37255 —0.18	60°	0.37056 —0.15
1	498 —0.02	21	422 —0.12	41	244 —0.17	61	047 —0.15
2	497 —0.02	22	415 —0.12	42	234 —0.17	62	038 —0.13
3	496 —0.02	23	408 —0.12	43	224 —0.17	63	030 —0.13
4	495 —0.03	24	401 —0.13	44	214 —0.18	64	022 —0.13
5	493 —0.03	**25**	393 —0.13	**45**	203 —0.17	**65**	014 —0.13
6	491 —0.03	26	385 —0.13	46	193 —0.17	66	006 —0.13
7	489 —0.03	27	377 —0.15	47	183 —0.17	67	0.36998 —0.12
8	487 —0.05	28	368 —0.13	48	173 —0.18	68	991 —0.12
9	484 —0.07	29	360 —0.15	49	162 —0.17	69	984 —0.12
10	480 —0.07	**30**	351 —0.15	**50**	152 —0.17	**70**	977 —0.10
11	476 —0.07	31	342 —0.15	51	142 —0.17	71	971 —0.12
12	472 —0.07	32	333 —0.17	52	132 —0.17	72	964 —0.08
13	468 —0.08	33	323 —0.15	53	122 —0.17	73	959 —0.10
14	463 —0.07	34	314 —0.17	54	112 —0.15	74	953 —0.08
15	459 —0.10	**35**	304 —0.15	**55**	103 —0.17	**75**	948 —0.08
16	453 —0.08	36	295 —0.17	56	093 —0.17	76	943 —0.08
17	448 —0.10	37	285 —0.17	57	083 —0.15	77	938 —0.07
18	442 —0.10	38	275 —0.17	58	074 —0.15	78	934 —0.07
19	436 —0.12	39	265 —0.17	59	065 —0.15	79	930 —0.07
20	429 —0.12	**40**	255 —0.18	**60**	056 —0.15	**80**	926

LOGARITHMS OF FACTORS $\frac{\rho''}{2\rho_m\rho_n}$ FOR COMPUTING SPHEROIDAL EXCESS OF TRIANGLES.

UNIT = THE METRE.

[Derivation and use of table explained on p. lviii.]

φ	log. factor and change per minute.	φ	log. factor and change per minute.	φ	log. factor and change per minute.	φ	log. factor and change per minute.
0°	1.40695	20°	1.40626	40°	1.40452	60°	1.40253
	— 0.00		— 0.12		— 0.18		— 0.15
1	695	21	619	41	441	61	244
	— 0.02		— 0.12		— 0.17		— 0.15
2	694	22	612	42	431	62	235
	— 0.02		— 0.12		— 0.17		— 0.13
3	693	23	605	43	421	63	227
	— 0.02		— 0.13		— 0.17		— 0.13
4	692	24	597	44	411	64	219
	— 0.03		— 0.12		— 0.18		— 0.15
5	690	25	590	45	400	65	210
	— 0.03		— 0.13		— 0.17		— 0.12
6	688	26	582	46	390	66	203
	— 0.03		— 0.15		— 0.17		— 0.13
7	686	27	573	47	380	67	195
	— 0.05		— 0.13		— 0.18		— 0.12
8	683	28	565	48	369	68	188
	— 0.05		— 0.15		— 0.17		— 0.12
9	680	29	556	49	359	69	181
	— 0.05		— 0.13		— 0.17		— 0.12
10	677	30	548	50	349	70	174
	— 0.07		— 0.15		— 0.17		— 0.10
11	673	31	539	51	339	71	168
	— 0.07		— 0.15		— 0.17		— 0.12
12	669	32	530	52	329	72	161
	— 0.07		— 0.17		— 0.17		— 0.10
13	665	33	520	53	319	73	155
	— 0.08		— 0.15		— 0.17		— 0.08
14	660	34	511	54	309	74	150
	— 0.08		— 0.17		— 0.17		— 0.10
15	655	35	501	55	299	75	144
	— 0.08		— 0.17		— 0.15		— 0.08
16	650	36	491	56	290	76	139
	— 0.10		— 0.15		— 0.17		— 0.07
17	644	37	482	57	280	77	135
	— 0.08		— 0.17		— 0.15		— 0.08
18	639	38	472	58	271	78	130
	— 0.12		— 0.17		— 0.15		— 0.07
19	632	39	462	59	262	79	126
	— 0.10		— 0.17		— 0.15		— 0.05
20	626	40	452	60	253	80	123
	— 0.12		— 0.18		— 0.15		

Table 15.

LOGARITHMS OF FACTORS FOR COMPUTING DIFFERENCES OF LATITUDE, LONGITUDE, AND AZIMUTH IN SECONDARY TRIANGULATION.

UNIT=THE ENGLISH FOOT.

[Derivation and use of table explained on p. lx.]

ϕ	a_1	$b_1=c_1$	a_2	b_2	c_2	ϕ	a_1	$b_1=c_1$	a_2	b_2	c_2
0°00′	7.99669	7.99374	—∞	—∞	0.372	10°00′	7.99655	7.99369	9.621	9.926	0.398
10	669	374	7.839	8.137	0.372	10	655	369	9.628	9.933	0.399
20	669	374	8.140	8.438	0.372	20	654	369	9.636	9.941	0.400
30	669	374	8.316	8.614	0.372	30	654	369	9.643	9.948	0.401
40	669	374	8.441	8.739	0.372	40	654	369	9.650	9.955	0.402
50	669	374	8.538	8.836	0.372	50	653	369	9.657	9.963	0.403
1 00	669	374	8.617	8.915	0.372	11 00	653	368	9.663	9.970	0.404
10	669	374	8.684	8.982	0.372	10	652	368	9.670	9.977	0.404
20	668	374	8.742	9.040	0.372	20	652	368	9.677	9.983	0.405
30	668	374	8.793	9.091	0.373	30	651	368	9.683	9.990	0.406
40	668	374	8.839	9.137	0.373	40	651	368	9.690	9.997	0.407
50	668	374	8.880	9.179	0.373	50	650	368	9.696	0.003	0.408
2 00	668	374	8.918	9.216	0.373	12 00	650	367	9.702	0.010	0.409
10	668	373	8.953	9.251	0.373	10	649	367	9.708	0.016	0.410
20	668	373	8.985	9.283	0.373	20	649	367	9.714	0.023	0.412
30	668	373	9.015	9.314	0.374	30	648	367	9.720	0.029	0.413
40	668	373	9.043	9.342	0.374	40	648	367	9.726	0.035	0.414
50	668	373	9.069	9.368	0.374	50	647	367	9.732	0.041	0.415
3 00	668	373	9.094	9.393	0.374	13 00	646	366	9.738	0.048	0.416
10	667	373	9.118	9.417	0.375	10	646	366	9.744	0.054	0.417
20	667	373	9.140	9.439	0.375	20	645	366	9.749	0.060	0.418
30	667	373	9.161	9.460	0.375	30	645	366	9.755	0.065	0.419
40	667	373	9.182	9.481	0.376	40	644	366	9.761	0.071	0.420
50	667	373	9.201	9.500	0.376	50	644	365	9.766	0.077	0.422
4 00	667	373	9.220	9.519	0.376	14 00	643	365	9.771	0.083	0.423
10	666	373	9.237	9.537	0.377	10	642	365	9.777	0.088	0.424
20	666	373	9.254	9.554	0.377	20	642	365	9.782	0.094	0.425
30	666	373	9.271	9.570	0.377	30	641	365	9.787	0.100	0.426
40	666	373	9.287	9.586	0.378	40	640	364	9.792	0.105	0.428
50	666	373	9.302	9.602	0.378	50	640	364	9.798	0.111	0.429
5 00	665	373	9.317	9.617	0.379	15 00	639	364	9.803	0.116	0.430
10	665	373	9.331	9.631	0.379	10	639	364	9.808	0.121	0.431
20	665	372	9.345	9.645	0.379	20	638	363	9.813	0.127	0.433
30	665	372	9.358	9.659	0.380	30	637	363	9.818	0.132	0.434
40	664	372	9.372	9.672	0.380	40	637	363	9.822	0.137	0.435
50	664	372	9.384	9.685	0.381	50	636	363	9.827	0.142	0.437
6 00	664	372	9.397	9.697	0.381	16 00	635	363	9.832	0.147	0.438
10	664	372	9.409	9.709	0.382	10	635	362	9.837	0.153	0.439
20	663	372	9.420	9.721	0.383	20	634	362	9.841	0.158	0.441
30	663	372	9.432	9.732	0.383	30	633	362	9.846	0.163	0.442
40	663	372	9.443	9.744	0.384	40	632	362	9.851	0.168	0.443
50	662	372	9.453	9.755	0.384	50	632	361	9.855	0.173	0.445
7 00	662	372	9.464	9.765	0.385	17 00	631	361	9.860	0.178	0.446
10	662	371	9.474	9.776	0.386	10	630	361	9.864	0.182	0.448
20	662	371	9.484	9.786	0.386	20	630	361	9.869	0.187	0.449
30	661	371	9.494	9.796	0.387	30	629	360	9.873	0.192	0.450
40	661	371	9.504	9.806	0.387	40	628	360	9.878	0.197	0.452
50	661	371	9.513	9.816	0.388	50	627	360	9.882	0.202	0.453
8 00	660	371	9.523	9.825	0.389	18 00	627	360	9.886	0.206	0.455
10	660	371	9.532	9.834	0.389	10	626	359	9.890	0.211	0.456
20	659	371	9.541	9.843	0.390	20	625	359	9.895	0.216	0.458
30	659	371	9.549	9.852	0.391	30	624	359	9.899	0.220	0.459
40	659	370	9.558	9.861	0.392	40	624	359	9.903	0.225	0.461
50	658	370	9.566	9.870	0.392	50	623	358	9.907	0.229	0.463
9 00	658	370	9.575	9.878	0.393	19 00	622	358	9.911	0.234	0.464
10	657	370	9.583	9.886	0.394	10	621	358	9.915	0.239	0.466
20	657	370	9.591	9.895	0.395	20	620	358	9.919	0.243	0.467
30	657	370	9.598	9.903	0.396	30	620	357	9.923	0.248	0.469
40	656	370	9.606	9.910	0.396	40	619	357	9.927	0.252	0.470
50	656	369	9.614	9.918	0.397	50	618	357	9.931	0.256	0.472
10 00	655	369	9.621	9.926	0.398	20.00	617	357	9.935	0.261	0.474

LOGARITHMS OF FACTORS FOR COMPUTING DIFFERENCES OF LATITUDE, LONGITUDE, AND AZIMUTH IN SECONDARY TRIANGULATION.

UNIT = THE ENGLISH FOOT.

[Derivation and use of table explained on p. lx.]

ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2	ϕ	a_1	$b_2 = c_2$	a_2	b_2	c_2
20°00′	7.99617	7.99357	9.935	0.261	0.474	30°00′	7.99558	7.99337	0.135	0.496	0.593
10	616	356	9.939	0.265	0.475	10	557	337	0.138	0.500	0.595
20	615	356	9.943	0.270	0.477	20	556	336	0.141	0.503	0.598
30	615	356	9.947	0.274	0.479	30	555	336	0.144	0.507	0.600
40	614	355	9.951	0.278	0.480	40	554	335	0.146	0.511	0.603
50	613	355	9.955	0.282	0.482	50	553	335	0.149	0.514	0.605
21 00	612	355	9.958	0.287	0.484	31 00	552	335	0.152	0.518	0.607
10	611	355	9.962	0.291	0.486	10	550	334	0.155	0.522	0.610
20	610	354	9.966	0.295	0.487	20	549	334	0.158	0.525	0.612
30	609	354	9.970	0.299	0.489	30	548	333	0.161	0.529	0.615
40	608	354	9.973	0.304	0.491	40	547	333	0.164	0.532	0.617
50	608	353	9.977	0.308	0.493	50	546	333	0.166	0.536	0.619
22 00	607	353	9.981	0.312	0.494	32 00	545	332	0.169	0.540	0.622
10	606	353	9.984	0.316	0.496	10	544	332	0.172	0.543	0.624
20	605	353	9.988	0.320	0.498	20	542	332	0.175	0.547	0.627
30	604	352	9.991	0.324	0.500	30	541	331	0.177	0.550	0.629
40	603	352	9.995	0.328	0.502	40	540	331	0.180	0.554	0.632
50	602	352	9.998	0.332	0.503	50	539	330	0.183	0.558	0.634
23 00	601	351	0.002	0.336	0.505	33 00	538	330	0.186	0.561	0.637
10	600	351	0.005	0.340	0.507	10	537	330	0.188	0.565	0.639
20	600	351	0.009	0.344	0.509	20	535	329	0.191	0.568	0.642
30	599	350	0.012	0.348	0.511	30	534	329	0.194	0.572	0.644
40	598	350	0.016	0.352	0.513	40	533	328	0.197	0.575	0.647
50	597	350	0.019	0.356	0.515	50	532	328	0.199	0.579	0.650
24 00	596	349	0.023	0.360	0.517	34 00	531	328	0.202	0.583	0.652
10	595	349	0.026	0.364	0.518	10	529	327	0.205	0.586	0.655
20	594	349	0.029	0.368	0.520	20	528	327	0.208	0.590	0.657
30	593	348	0.033	0.372	0.522	30	527	326	0.210	0.593	0.660
40	592	348	0.036	0.376	0.524	40	526	326	0.213	0.597	0.663
50	591	348	0.039	0.380	0.526	50	525	326	0.216	0.600	0.665
25 00	590	347	0.043	0.384	0.528	35 00	523	325	0.218	0.604	0.668
10	589	347	0.046	0.388	0.530	10	522	325	0.221	0.608	0.671
20	588	347	0.049	0.392	0.532	20	521	324	0.224	0.611	0.673
30	587	346	0.052	0.396	0.534	30	520	324	0.226	0.615	0.676
40	586	346	0.056	0.399	0.536	40	519	324	0.229	0.618	0.679
50	585	346	0.059	0.403	0.538	50	517	323	0.232	0.622	0.681
26 00	584	345	0.062	0.407	0.540	36 00	516	323	0.234	0.625	0.684
10	583	345	0.065	0.411	0.543	10	515	322	0.237	0.629	0.687
20	582	345	0.068	0.415	0.545	20	514	322	0.239	0.632	0.689
30	581	344	0.072	0.418	0.547	30	512	322	0.242	0.636	0.692
40	580	344	0.075	0.422	0.549	40	511	321	0.245	0.640	0.695
50	579	344	0.078	0.426	0.551	50	510	321	0.247	0.643	0.698
27 00	578	343	0.081	0.430	0.553	37 00	509	320	0.250	0.647	0.700
10	577	343	0.084	0.433	0.555	10	507	320	0.253	0.650	0.703
20	576	343	0.087	0.437	0.557	20	506	320	0.255	0.654	0.706
30	575	342	0.090	0.441	0.559	30	505	319	0.258	0.657	0.709
40	574	342	0.093	0.445	0.562	40	504	319	0.260	0.661	0.712
50	573	342	0.096	0.448	0.564	50	503	318	0.263	0.665	0.715
28 00	571	341	0.099	0.452	0.566	38 00	501	318	0.266	0.668	0.717
10	570	341	0.102	0.456	0.568	10	500	317	0.268	0.672	0.720
20	569	341	0.105	0.460	0.570	20	499	317	0.271	0.675	0.723
30	568	340	0.108	0.463	0.573	30	498	317	0.273	0.679	0.726
40	567	340	0.111	0.467	0.575	40	496	316	0.276	0.683	0.729
50	566	340	0.114	0.471	0.577	50	495	316	0.278	0.686	0.732
29 00	565	339	0.117	0.474	0.579	39 00	494	315	0.281	0.690	0.735
10	564	339	0.120	0.478	0.582	10	492	315	0.284	0.693	0.738
20	563	338	0.123	0.482	0.584	20	491	315	0.286	0.697	0.741
30	562	338	0.126	0.485	0.586	30	490	314	0.289	0.701	0.744
40	561	338	0.129	0.489	0.588	40	489	314	0.291	0.704	0.747
50	560	337	0.132	0.493	0.591	50	487	313	0.294	0.708	0.750
30 00	558	337	0.135	0.496	0.593	40 00	486	313	0.296	0.711	0.753

TABLE 15.

LOGARITHMS OF FACTORS FOR COMPUTING DIFFERENCES OF LATITUDE, LONGITUDE, AND AZIMUTH IN SECONDARY TRIANGULATION.

UNIT = THE ENGLISH FOOT.

[Derivation and use of table explained on p. lx.]

ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2	ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2
40°00′	7.99486	7.99313	0.296	0.711	0.752	50°00′	7.99409	7.99287	0.448	0.939	0.955
10	485	312	0.299	0.715	0.755	10	408	287	0.450	0.944	0.958
20	484	312	0.301	0.719	0.759	20	407	287	0.453	0.948	0.962
30	482	312	0.304	0.722	0.762	30	406	286	0.455	0.952	0.966
40	481	311	0.307	0.726	0.765	40	404	286	0.458	0.956	0.970
50	480	311	0.309	0.730	0.768	50	403	285	0.460	0.960	0.974
41 00	479	310	0.312	0.733	0.771	51 00	402	285	0.463	0.964	0.978
10	477	310	0.314	0.737	0.774	10	401	284	0.466	0.968	0.982
20	476	309	0.317	0.740	0.777	20	399	284	0.468	0.972	0.985
30	475	309	0.319	0.744	0.780	30	398	284	0.471	0.976	0.989
40	473	309	0.322	0.748	0.783	40	397	283	0.473	0.981	0.993
50	472	308	0.324	0.751	0.786	50	396	283	0.476	0.985	0.997
42 00	471	308	0.327	0.755	0.789	52 00	394	282	0.478	0.989	1.001
10	470	307	0.329	0.759	0.792	10	393	282	0.481	0.993	1.005
20	468	307	0.332	0.762	0.796	20	392	281	0.484	0.998	1.009
30	467	306	0.334	0.766	0.799	30	391	281	0.486	1.002	1.013
40	466	306	0.337	0.770	0.802	40	389	281	0.489	1.006	1.017
50	464	306	0.339	0.774	0.805	50	388	280	0.491	1.010	1.021
43 00	463	305	0.342	0.777	0.808	53 00	387	280	0.494	1.015	1.025
10	462	305	0.344	0.781	0.812	10	386	279	0.497	1.019	1.030
20	461	304	0.347	0.785	0.815	20	384	279	0.499	1.023	1.034
30	459	304	0.349	0.788	0.818	30	383	279	0.502	1.028	1.038
40	458	303	0.352	0.792	0.821	40	382	278	0.505	1.032	1.042
50	457	303	0.354	0.796	0.824	50	381	278	0.507	1.036	1.046
44 00	455	303	0.357	0.800	0.828	54 00	379	277	0.510	1.041	1.050
10	454	302	0.359	0.803	0.831	10	378	277	0.512	1.045	1.055
20	453	302	0.362	0.807	0.834	20	377	277	0.515	1.049	1.059
30	452	301	0.364	0.811	0.838	30	376	276	0.518	1.054	1.063
40	450	301	0.367	0.815	0.841	40	375	276	0.520	1.058	1.067
50	449	300	0.370	0.818	0.844	50	373	275	0.523	1.063	1.072
45 00	448	300	0.372	0.822	0.848	55 00	372	275	0.526	1.067	1.076
10	446	300	0.375	0.826	0.851	10	371	275	0.528	1.072	1.080
20	445	299	0.377	0.830	0.854	20	370	274	0.531	1.076	1.084
30	444	299	0.380	0.833	0.858	30	369	274	0.534	1.081	1.089
40	443	298	0.382	0.837	0.861	40	367	273	0.537	1.085	1.093
50	441	298	0.385	0.841	0.865	50	366	273	0.539	1.090	1.098
46 00	440	297	0.387	0.845	0.868	56 00	365	273	0.542	1.094	1.102
10	439	297	0.390	0.849	0.872	10	364	272	0.545	1.099	1.106
20	437	297	0.392	0.853	0.875	20	363	272	0.547	1.104	1.111
30	436	296	0.395	0.856	0.878	30	361	271	0.550	1.108	1.115
40	435	296	0.397	0.860	0.882	40	360	271	0.553	1.113	1.120
50	434	295	0.400	0.864	0.885	50	359	271	0.556	1.118	1.124
47 00	432	295	0.402	0.868	0.889	57 00	358	270	0.558	1.122	1.129
10	431	294	0.405	0.872	0.892	10	357	270	0.561	1.127	1.134
20	430	294	0.407	0.876	0.896	20	356	269	0.564	1.132	1.138
30	428	294	0.410	0.880	0.900	30	354	269	0.567	1.137	1.143
40	427	293	0.412	0.884	0.903	40	353	269	0.569	1.141	1.147
50	426	293	0.415	0.888	0.907	50	352	268	0.572	1.146	1.152
48 00	425	292	0.417	0.891	0.910	58 00	351	268	0.575	1.151	1.157
10	423	292	0.420	0.895	0.914	10	350	267	0.578	1.156	1.162
20	422	291	0.422	0.899	0.918	20	349	267	0.581	1.161	1.166
30	421	291	0.425	0.903	0.921	30	347	267	0.583	1.166	1.171
40	420	291	0.427	0.907	0.925	40	346	266	0.586	1.170	1.176
50	418	290	0.430	0.911	0.929	50	345	266	0.589	1.175	1.181
49 00	417	290	0.432	0.915	0.932	59 00	344	266	0.592	1.180	1.185
10	416	289	0.435	0.919	0.936	10	343	265	0.595	1.185	1.190
20	414	289	0.438	0.923	0.940	20	342	265	0.598	1.190	1.195
30	413	289	0.440	0.927	0.943	30	341	264	0.600	1.195	1.200
40	412	288	0.443	0.931	0.947	40	339	264	0.603	1.200	1.205
50	411	288	0.445	0.935	0.951	50	338	264	0.606	1.205	1.210
50 00	409	287	0.448	0.939	0.955	60 00	337	263	0.609	1.210	1.215

LOGARITHMS OF FACTORS FOR COMPUTING DIFFERENCES OF LATITUDE, LONGITUDE, AND AZIMUTH IN SECONDARY TRIANGULATION.

UNIT = THE ENGLISH FOOT.

[Derivation and use of table explained on p. lx.]

φ	a_1	$b_1 = c_1$	a_2	b_2	c_2	ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2
60°00′	7.99337	7.99263	0.609	1.210	1.215	70°00′	7.99278	7.99244	0.809	1.575	1.576
10	336	263	0.612	1.216	1.220	10	277	243	0.813	1.583	1.584
20	335	263	0.615	1.221	1.225	20	277	243	0.817	1.590	1.591
30	334	262	0.618	1.226	1.230	30	276	243	0.821	1.598	1.599
40	333	262	0.621	1.231	1.235	40	275	242	0.825	1.605	1.606
50	332	261	0.624	1.236	1.240	50	274	242	0.829	1.613	1.614
61 00	331	261	0.627	1.241	1.245	71 00	273	242	0.833	1.621	1.621
10	329	261	0.630	1.247	1.251	10	273	242	0.837	1.629	1.629
20	328	260	0.633	1.252	1.256	20	272	241	0.841	1.636	1.637
30	327	260	0.636	1.257	1.261	30	271	241	0.845	1.644	1.645
40	326	260	0.639	1.263	1.266	40	270	241	0.849	1.652	1.653
50	325	259	0.642	1.268	1.272	50	269	241	0.854	1.660	1.661
62 00	324	259	0.645	1.273	1.277	72 00	269	240	0.858	1.669	1.669
10	323	259	0.648	1.279	1.282	10	268	240	0.862	1.677	1.677
20	322	258	0.651	1.284	1.288	20	267	240	0.866	1.685	1.686
30	321	258	0.654	1.290	1.293	30	266	240	0.871	1.694	1.694
40	320	257	0.657	1.295	1.298	40	266	239	0.875	1.702	1.702
50	319	257	0.660	1.301	1.304	50	265	239	0.880	1.710	1.711
63 00	318	257	0.663	1.306	1.309	73 00	264	239	0.884	1.719	1.720
10	317	256	0.666	1.312	1.315	10	264	239	0.889	1.728	1.728
20	316	256	0.669	1.318	1.320	20	263	238	0.893	1.737	1.737
30	315	256	0.672	1.323	1.326	30	262	238	0.898	1.745	1.746
40	314	255	0.676	1.329	1.332	40	261	238	0.903	1.754	1.755
50	313	255	0.679	1.335	1.337	50	261	238	0.907	1.763	1.764
64 00	312	255	0.682	1.341	1.343	74 00	260	238	0.912	1.772	1.773
10	311	254	0.685	1.346	1.349	10	259	237	0.917	1.782	1.782
20	310	254	0.688	1.352	1.355	20	259	237	0.922	1.791	1 791
30	309	254	0.692	1.358	1.360	30	258	237	0.927	1.800	1.801
40	308	253	0.695	1.363	1.366	40	257	237	0.931	1.810	1.810
50	307	253	0.698	1.370	1.372	50	257	236	0.936	1.820	1.820
65 00	306	253	0.701	1.376	1.378	75 00	256	236	0.941	1.829	1.830
10	305	252	0.705	1.382	1.384	10	255	236	0.946	1.839	1.839
20	304	252	0.708	1.388	1.390	20	255	236	0.952	1.849	1.849
30	303	252	0.711	1.394	1.396	30	254	236	0.957	1.859	1.859
40	302	251	0.715	1.400	1.402	40	254	235	0.962	1.869	1.869
50	301	251	0.718	1.406	1.408	50	253	235	0.967	1.879	1.880
66 00	300	251	0.721	1.413	1.414	76 00	252	235	0.973	1.890	1.890
10	299	250	0.725	1.419	1.421	10	252	235	0.978	1.900	1.901
20	298	250	0.728	1.425	1.427	20	251	235	0.984	1.911	1.911
30	297	250	0.732	1.432	1.433	30	250	234	0.989	1.922	1.922
40	296	249	0.735	1.438	1.440	40	250	234	0.995	1.933	1.933
50	295	249	0.739	1.444	1.446	50	249	234	1.000	1.944	1.944
67 00	294	249	0.742	1.451	1.452	77 00	249	234	1.006	1.955	1.955
10	293	249	0.746	1.457	1.459	10	248	234	1.012	1.966	1.966
20	292	248	0.749	1.464	1.465	20	248	233	1.018	1.978	1.978
30	291	248	0.753	1.470	1.472	30	247	233	1.024	1.989	1.989
40	290	248	0.756	1.477	1.478	40	247	233	1.030	2.001	2.001
50	289	247	0.760	1.484	1.485	50	246	233	1.036	2.013	2.013
68 00	289	247	0.763	1.491	1.492	78 00	245	233	1.042	2.025	2.025
10	288	247	0.767	1.497	1.499	10	245	233	1.048	2.037	2.037
20	287	246	0.771	1.504	1.505	20	244	232	1.054	2.050	2.050
30	286	246	0.774	1.511	1.512	30	244	232	1.061	2.062	2.062
40	285	246	0.778	1.518	1.519	40	243	232	1.067	2.075	2.075
50	284	246	0.782	1.525	1.526	50	243	232	1.074	2.088	2.088
69 00	283	245	0.786	1.532	1.533	79 00	242	232	1.081	2.101	2.101
10	282	245	0.789	1.539	1.540	10	242	232	1.087	2.114	2.114
20	282	245	0.793	1.546	1.547	20	242	231	1.094	2.128	2.128
30	281	244	0.797	1.553	1.554	30	241	231	1.101	2.142	2.142
40	280	244	0.801	1.561	1.562	40	241	231	1.108	2.156	2.156
50	279	244	0.805	1.568	1.569	50	240	231	1.116	2.170	2.170
70 00	278	244	0.809	1.575	1.576	80 00	240	231	1.123	2.184	2.184

Table 16.

LOGARITHMS OF FACTORS FOR COMPUTING DIFFERENCES OF LATITUDE, LONGITUDE, AND AZIMUTH IN SECONDARY TRIANGULATION.

UNIT = THE METRE.

[Derivation and use of table explained on p. lx.]

ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2	ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2
0°00′	8.51268	8.50973	— ∞	— ∞	1.404	10°00′	8.51254	8.50968	0.653	0.958	1.430
10	268	973	8.871	9.169	1.404	10	254	968	0.660	0.965	1.431
20	268	973	9.172	9.470	1.404	20	253	968	0.668	0.973	1.432
30	268	973	9.348	9.646	1.404	30	253	968	0.675	0.980	1.433
40	268	973	9.473	9.771	1.404	40	253	968	0.682	0.987	1.434
50	268	973	9.570	9.868	1.404	50	252	967	0.689	0.995	1.435
1 00	267	973	9.649	9.947	1.404	11 00	252	967	0.695	1.002	1.436
10	267	973	9.716	0.014	1.404	10	251	967	0.702	1.009	1.436
20	267	973	9.774	0.072	1.404	20	251	967	0.709	1.015	1.437
30	267	973	9.825	0.123	1.405	30	250	967	0.715	1.022	1.438
40	267	973	9.871	0.169	1.405	40	250	967	0.722	1.029	1.439
50	267	973	9.912	0.211	1.405	50	249	966	0.728	1.035	1.440
2 00	267	972	9.950	0.248	1.405	12 00	249	966	0.734	1.042	1.441
10	267	972	9.985	0.283	1.405	10	248	966	0.740	1.048	1.442
20	267	972	0.017	0.315	1.405	20	248	966	0.746	1.055	1.444
30	266	972	0.047	0.346	1.406	30	247	966	0.752	1.061	1.445
40	266	972	0.075	0.374	1.406	40	246	966	0.758	1.067	1.446
50	266	972	0.101	0.400	1.406	50	246	965	0.764	1.073	1.447
3 00	266	972	0.126	0.425	1.406	13 00	245	965	0.770	1.080	1.448
10	266	972	0.150	0.449	1.407	10	245	965	0.776	1.086	1.449
20	266	972	0.172	0.471	1.407	20	244	965	0.781	1.092	1.450
30	266	972	0.193	0.492	1.407	30	244	965	0.787	1.097	1.451
40	266	972	0.214	0.513	1.408	40	243	964	0.792	1.103	1.452
50	266	972	0.233	0.532	1.408	50	242	964	0.798	1.109	1.454
4 00	265	972	0.252	0.551	1.408	14 00	242	964	0.803	1.115	1.455
10	265	972	0.269	0.569	1.409	10	241	964	0.809	1.120	1.456
20	265	972	0.286	0.586	1.409	20	241	964	0.814	1.126	1.457
30	265	972	0.303	0.602	1.409	30	240	963	0.819	1.132	1.458
40	265	972	0.319	0.618	1.410	40	239	963	0.824	1.137	1.460
50	264	972	0.334	0.634	1.410	50	239	963	0.830	1.143	1.461
5 00	264	972	0.349	0.649	1.411	15 00	238	963	0.835	1.148	1.462
10	264	971	0.363	0.663	1.411	10	237	963	0.840	1.153	1.463
20	264	971	0.377	0.677	1.411	20	237	962	0.845	1.159	1.465
30	264	971	0.390	0.691	1.412	30	236	962	0.850	1.164	1.466
40	263	971	0.404	0.704	1.412	40	235	962	0.854	1.169	1.467
50	263	971	0.416	0.717	1.413	50	235	962	0.859	1.174	1.469
6 00	263	971	0.428	0.729	1.413	16 00	234	961	0.864	1.179	1.470
10	263	971	0.440	0.741	1.414	10	233	961	0.869	1.185	1.471
20	262	971	0.452	0.753	1.415	20	233	961	0.873	1.190	1.473
30	262	971	0.464	0.764	1.415	30	232	961	0.878	1.195	1.474
40	262	971	0.475	0.776	1.416	40	231	961	0.883	1.200	1.475
50	261	971	0.485	0.787	1.416	50	231	960	0.887	1.205	1.477
7 00	261	970	0.496	0.797	1.417	17 00	230	960	0.892	1.210	1.478
10	261	970	0.506	0.808	1.417	10	229	960	0.896	1.214	1.480
20	260	970	0.516	0.818	1.418	20	228	960	0.901	1.219	1.481
30	260	970	0.526	0.828	1.419	30	228	959	0.905	1.224	1.482
40	260	970	0.536	0.838	1.419	40	227	959	0.910	1.229	1.484
50	259	970	0.545	0.848	1.420	50	226	959	0.914	1.234	1.485
8 00	259	970	0.555	0.857	1.421	18 00	225	959	0.918	1.238	1.487
10	259	970	0.564	0.866	1.421	10	225	958	0.922	1.243	1.489
20	258	970	0.573	0.875	1.422	20	224	958	0.927	1.248	1.490
30	258	969	0.581	0.884	1.423	30	223	958	0.931	1.252	1.491
40	258	969	0.590	0.893	1.424	40	223	958	0.935	1.257	1.493
50	257	969	0.598	0.902	1.424	50	222	957	0.939	1.261	1.495
9 00	257	969	0.607	0.910	1.425	19 00	221	957	0.943	1.266	1.496
10	256	969	0.615	0.918	1.426	10	220	957	0.947	1.271	1.498
20	256	969	0.623	0.927	1.427	20	219	957	0.951	1.275	1.499
30	256	969	0.630	0.935	1.428	30	218	956	0.955	1.279	1.501
40	255	969	0.638	0.942	1.428	40	218	956	0.959	1.284	1.502
50	255	968	0.646	0.950	1.429	50	217	956	0.963	1.288	1.504
10 00	254	968	0.653	0.958	1.430	20 00	216	955	0.967	1.293	1.506

LOGARITHMS OF FACTORS FOR COMPUTING DIFFERENCES OF LATITUDE, LONGITUDE, AND AZIMUTH IN SECONDARY TRIANGULATION.

UNIT = THE METRE.

[Derivation and use of table explained on p. lx.]

ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2	ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2
20°00′	8.51216	8.50955	0.967	1.293	1.506	30°00′	8.51157	8.50936	1.167	1.528	1.625
10	215	955	0.971	1.297	1.507	10	156	936	1.170	1.532	1.627
20	214	955	0.975	1.301	1.509	20	155	935	1.173	1.535	1.630
30	214	955	0.979	1.306	1.511	30	154	935	1.176	1.539	1.632
40	213	954	0.983	1.310	1.512	40	153	934	1.178	1.543	1.635
50	212	954	0.987	1.314	1.514	50	152	934	1.181	1.546	1.637
21 00	211	954	0.990	1.319	1.516	31 00	151	934	1.184	1.550	1.639
10	210	953	0.994	1.323	1.518	10	149	933	1.187	1.554	1.642
20	209	953	0.998	1.327	1.519	20	148	933	1.190	1.557	1.644
30	208	953	1.002	1.331	1.521	30	147	933	1.193	1.561	1.646
40	207	953	1.005	1.336	1.523	40	146	932	1.195	1.564	1.649
50	207	952	1.009	1.340	1.524	50	145	932	1.198	1.568	1.651
22 00	206	952	1.013	1.344	1.526	32 00	144	931	1.201	1.572	1.654
10	205	952	1.016	1.348	1.528	10	143	931	1.204	1.575	1.656
20	204	951	1.020	1.352	1.530	20	141	931	1.207	1.579	1.659
30	203	951	1.023	1.356	1.532	30	140	930	1.209	1.582	1.661
40	202	951	1.027	1.360	1.534	40	139	930	1.212	1.586	1.664
50	201	951	1.030	1.364	1.535	50	138	929	1.215	1.590	1.666
23 00	200	950	1.034	1.368	1.537	33 00	137	929	1.218	1.593	1.669
10	199	950	1.037	1.372	1.539	10	136	929	1.220	1.597	1.671
20	198	950	1.041	1.376	1.541	20	134	928	1.223	1.600	1.674
30	197	949	1.044	1.380	1.543	30	133	928	1.226	1.604	1.676
40	197	949	1.048	1.384	1.545	40	132	927	1.229	1.607	1.679
50	196	949	1.051	1.388	1.547	50	131	927	1.231	1.611	1.682
24 00	195	948	1.055	1.392	1.549	34 00	130	927	1.234	1.615	1.684
10	194	948	1.058	1.396	1.550	10	128	926	1.237	1.618	1.687
20	193	948	1.061	1.400	1.552	20	127	926	1.239	1.622	1.689
30	192	947	1.065	1.404	1.554	30	126	925	1.242	1.625	1.692
40	191	947	1.068	1.408	1.556	40	125	925	1.245	1.629	1.695
50	190	947	1.071	1.412	1.558	50	124	925	1.248	1.632	1.697
25 00	189	946	1.075	1.416	1.560	35 00	122	924	1.250	1.636	1.700
10	188	946	1.078	1.420	1.562	10	121	924	1.253	1.639	1.702
20	187	946	1.081	1.424	1.564	20	120	923	1.256	1.643	1.705
30	186	945	1.084	1.427	1.566	30	119	923	1.258	1.647	1.708
40	185	945	1.088	1.431	1.568	40	118	923	1.261	1.650	1.711
50	184	945	1.091	1.435	1.570	50	116	922	1.264	1.654	1.713
26 00	183	944	1.094	1.439	1.572	36 00	115	922	1.266	1.657	1.716
10	182	944	1.097	1.443	1.575	10	114	921	1.269	1.661	1.719
20	181	944	1.100	1.447	1.577	20	113	921	1.271	1.664	1.721
30	180	943	1.104	1.450	1.579	30	111	921	1.274	1.668	1.724
40	179	943	1.107	1.454	1.581	40	110	920	1.277	1.672	1.727
50	178	943	1.110	1.458	1.583	50	109	920	1.279	1.675	1.730
27 00	177	942	1.113	1.462	1.585	37 00	108	919	1.282	1.679	1.732
10	176	942	1.116	1.465	1.587	10	106	919	1.285	1.682	1.735
20	175	942	1.119	1.469	1.589	20	105	919	1.287	1.686	1.738
30	174	941	1.122	1.473	1.591	30	104	918	1.290	1.689	1.741
40	172	941	1.125	1.477	1.594	40	103	918	1.292	1.693	1.744
50	171	941	1.128	1.480	1.596	50	102	917	1.295	1.697	1.747
28 00	170	940	1.131	1.484	1.598	38 00	100	917	1.298	1.700	1.749
10	169	940	1.134	1.488	1.600	10	099	916	1.300	1.704	1.752
20	168	940	1.137	1.492	1.602	20	098	916	1.303	1.707	1.755
30	167	939	1.140	1.495	1.605	30	097	916	1.305	1.711	1.758
40	166	939	1.143	1.499	1.607	40	095	915	1.308	1.715	1.761
50	165	938	1.146	1.503	1.609	50	094	915	1.310	1.718	1.764
29 00	164	938	1.149	1.506	1.611	39 00	093	914	1.313	1.722	1.767
10	163	938	1.152	1.510	1.614	10	092	914	1.316	1.725	1.770
20	162	937	1.155	1.514	1.616	20	090	914	1.318	1.729	1.773
30	161	937	1.158	1.517	1.618	30	089	913	1.321	1.733	1.776
40	160	937	1.161	1.521	1.620	40	088	913	1.323	1.736	1.779
50	158	936	1.164	1.525	1.623	50	086	912	1.326	1.740	1.781
30 00	157	936	1.167	1.528	1.625	40 00	085	912	1.328	1.743	1.784

LOGARITHMS OF FACTORS FOR COMPUTING DIFFERENCES OF LATITUDE, LONGITUDE, AND AZIMUTH IN SECONDARY TRIANGULATION.

UNIT = THE METRE.

[Derivation and use of table explained on p. lx.]

ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2
40°00′	8.51085	8.50912	1.328	1.743	1.784
10	084	911	1.331	1.747	1.787
20	083	911	1.333	1.751	1.790
30	081	911	1.336	1.754	1.793
40	080	910	1.338	1.758	1.797
50	079	910	1.341	1.762	1.800
41 00	078	909	1.344	1.765	1.803
10	076	909	1.346	1.769	1.806
20	075	908	1.349	1.772	1.809
30	074	908	1.351	1.776	1.812
40	072	908	1.354	1.780	1.815
50	071	907	1.356	1.783	1.818
42 00	070	907	1.359	1.787	1.821
10	069	906	1.361	1.791	1.824
20	067	906	1.364	1.794	1.828
30	066	905	1.366	1.798	1.831
40	065	905	1.369	1.802	1.834
50	063	905	1.371	1.805	1.837
43 00	062	904	1.374	1.809	1.840
10	061	904	1.376	1.813	1.843
20	060	903	1.379	1.817	1.847
30	058	903	1.381	1.820	1.850
40	057	902	1.384	1.824	1.853
50	056	902	1.386	1.828	1.856
44 00	054	902	1.389	1.832	1.860
10	053	901	1.391	1.835	1.863
20	052	901	1.394	1.839	1.866
30	051	900	1.396	1.843	1.870
40	049	900	1.399	1.847	1.873
50	048	899	1.401	1.850	1.876
45 00	047	899	1.404	1.854	1.880
10	045	899	1.407	1.858	1.883
20	044	898	1.409	1.862	1.886
30	043	898	1.412	1.865	1.890
40	042	897	1.414	1.869	1.893
50	040	897	1.417	1.873	1.897
46 00	039	896	1.419	1.877	1.900
10	038	896	1.422	1.881	1.903
20	036	896	1.424	1.885	1.907
30	035	895	1.427	1.888	1.910
40	034	895	1.429	1.892	1.914
50	033	894	1.432	1.896	1.917
47 00	031	894	1.434	1.900	1.921
10	030	893	1.437	1.904	1.924
20	029	893	1.439	1.908	1.928
30	027	893	1.442	1.912	1.932
40	026	892	1.444	1.916	1.935
50	025	892	1.447	1.920	1.939
48 00	024	891	1.449	1.923	1.942
10	022	891	1.452	1.927	1.946
20	021	890	1.454	1.931	1.950
30	020	890	1.457	1.935	1.953
40	019	890	1.459	1.939	1.957
50	017	889	1.462	1.943	1.961
49 00	016	889	1.464	1.947	1.964
10	015	888	1.467	1.951	1.968
20	013	888	1.469	1.955	1.972
30	012	888	1.472	1.959	1.975
40	011	887	1.475	1.963	1.979
50	010	887	1.477	1.967	1.983
50 00	008	886	1.480	1.971	1.987

ϕ	a_1	$b_1 = c_1$	a_2	b_2	c_2
50°00′	8.51008	8.50886	1.480	1.971	1.987
10	007	886	1.482	1.975	1.990
20	006	885	1.485	1.980	1.994
30	005	885	1.487	1.984	1.998
40	003	885	1.490	1.988	2.002
50	002	884	1.492	1.992	2.006
51 00	001	884	1.495	1.996	2.010
10	000	883	1.498	2.000	2.014
20	8.50998	883	1.500	2.004	2.017
30	997	882	1.503	2.008	2.021
40	996	882	1.505	2.013	2.025
50	994	882	1.508	2.017	2.029
52 00	993	881	1.510	2.021	2.033
10	992	881	1.513	2.025	2.037
20	991	880	1.516	2.030	2.041
30	990	880	1.518	2.034	2.045
40	988	880	1.521	2.038	2.049
50	987	879	1.523	2.042	2.053
53 00	986	879	1.526	2.047	2.057
10	985	878	1.529	2.051	2.062
20	983	878	1.531	2.055	2.066
30	982	877	1.534	2.060	2.070
40	981	877	1.537	2.064	2.074
50	980	877	1.539	2.068	2.078
54 00	978	876	1.542	2.073	2.082
10	977	876	1.544	2.077	2.086
20	976	875	1.547	2.081	2.091
30	975	875	1.550	2.086	2.095
40	973	875	1.552	2.090	2.099
50	972	874	1.555	2.095	2.104
55 00	971	874	1.558	2.099	2.108
10	970	873	1.560	2.104	2.112
20	969	873	1.563	2.108	2.116
30	967	873	1.566	2.113	2.121
40	966	872	1.568	2.117	2.125
50	965	872	1.571	2.122	2.130
56 00	964	871	1.574	2.126	2.134
10	963	871	1.577	2.131	2.138
20	961	871	1.579	2.136	2.143
30	960	870	1.582	2.140	2.147
40	959	870	1.585	2.145	2.152
50	958	869	1.588	2.150	2.156
57 00	957	869	1.590	2.154	2.161
10	956	869	1.593	2.159	2.166
20	954	868	1.596	2.164	2.170
30	953	868	1.599	2.169	2.175
40	952	867	1.601	2.173	2.179
50	951	867	1.604	2.178	2.184
58 00	950	867	1.607	2.183	2.189
10	949	866	1.610	2.188	2.193
20	947	866	1.613	2.193	2.198
30	946	866	1.615	2.197	2.203
40	945	865	1.618	2.202	2.208
50	944	865	1.621	2.207	2.213
59 00	943	864	1.624	2.212	2.217
10	942	864	1.627	2.217	2.222
20	941	864	1.630	2.222	2.227
30	939	863	1.632	2.227	2.232
40	938	863	1.635	2.232	2.237
50	937	863	1.638	2.237	2.242
60 00	936	862	1.641	2.242	2.247

LOGARITHMS OF FACTORS FOR COMPUTING DIFFERENCES OF LATITUDE, LONGITUDE, AND AZIMUTH IN SECONDARY TRIANGULATION.

UNIT = THE METRE.

[Derivation and use of table explained on p. lx.]

φ	a_1	$b_1 = c_1$	a_2	b_2	c_2	φ	a_1	$b_1 = c_1$	a_2	b_2	c_2
60°00′	8.50936	8.50862	1.641	2.242	2.247	70°00′	8.50877	8.50842	1.841	2.607	2.608
10	935	862	1.644	2.247	2.252	10	876	842	1.845	2.615	2.616
20	934	861	1.647	2.253	2.257	20	875	842	1.849	2.622	2.623
30	933	861	1.650	2.258	2.262	30	875	842	1.853	2.630	2.631
40	932	861	1.653	2.263	2.267	40	874	841	1.857	2.637	2.638
50	931	860	1.656	2.268	2.272	50	873	841	1.861	2.645	2.646
61 00	929	860	1.659	2.273	2.277	71 00	872	841	1.865	2.653	2.653
10	928	860	1.662	2.279	2.283	10	871	841	1.869	2.661	2.661
20	927	859	1.665	2.284	2.288	20	871	840	1.873	2.668	2.669
30	926	859	1.668	2.289	2.293	30	870	840	1.877	2.676	2.677
40	925	858	1.671	2.295	2.298	40	869	840	1.881	2.684	2.685
50	924	858	1.674	2.300	2.303	50	868	840	1.886	2.692	2.693
62 00	923	858	1.677	2.305	2.309	72 00	868	839	1.890	2.701	2.701
10	922	857	1.680	2.311	2.314	10	867	839	1.894	2.709	2.709
20	921	857	1.683	2.316	2.320	20	866	839	1.898	2.717	2.718
30	920	857	1.686	2.322	2.325	30	865	839	1.903	2.725	2.726
40	919	856	1.689	2.327	2.330	40	865	838	1.907	2.734	2.734
50	918	856	1.692	2.333	2.336	50	864	838	1.912	2.742	2.742
63 00	917	856	1.695	2.338	2.341	73 00	863	838	1.916	2.751	2.751
10	916	855	1.698	2.344	2.347	10	862	838	1.921	2.760	2.760
20	915	855	1.701	2.350	2.352	20	862	837	1.925	2.769	2.769
30	913	855	1.704	2.355	2.358	30	861	837	1.930	2.777	2.778
40	912	854	1.708	2.361	2.364	40	860	837	1.935	2.786	2.787
50	911	854	1.711	2.367	2.369	50	860	837	1.939	2.795	2.796
64 00	910	854	1.714	2.373	2.375	74 00	859	836	1.944	2.804	2.805
10	909	853	1.717	2.378	2.381	10	858	836	1.949	2.814	2.814
20	908	853	1.720	2.384	2.387	20	858	836	1.954	2.823	2.823
30	907	853	1.724	2.390	2.392	30	857	836	1.958	2.832	2.833
40	906	852	1.727	2.396	2.398	40	856	836	1.963	2.842	2.842
50	905	852	1.730	2.402	2.404	50	856	835	1.968	2.851	2.852
65 00	904	852	1.733	2.408	2.410	75 00	855	835	1.973	2.861	2.861
10	903	851	1.737	2.414	2.416	10	854	835	1.978	2.871	2.871
20	902	851	1.740	2.420	2.422	20	854	835	1.984	2.881	2.881
30	901	851	1.743	2.426	2.428	30	853	834	1.989	2.891	2.891
40	900	850	1.747	2.432	2.434	40	852	834	1.994	2.901	2.901
50	900	850	1.750	2.438	2.440	50	852	834	1.999	2.911	2.912
66 00	899	850	1.753	2.445	2.446	76 00	851	834	2.005	2.922	2.922
10	898	849	1.757	2.451	2.453	10	851	834	2.010	2.932	2.933
20	897	849	1.760	2.457	2.459	20	850	833	2.015	2.943	2.943
30	896	849	1.764	2.464	2.465	30	849	833	2.021	2.954	2.954
40	895	848	1.767	2.470	2.472	40	849	833	2.027	2.965	2.965
50	894	848	1.771	2.476	2.478	50	848	833	2.032	2.976	2.976
67 00	893	848	1.774	2.483	2.484	77 00	848	833	2.038	2.987	2.987
10	892	847	1.778	2.489	2.491	10	847	832	2.044	2.998	2.998
20	891	847	1.781	2.496	2.497	20	847	832	2.050	3.010	3.010
30	890	847	1.785	2.502	2.504	30	846	832	2.056	3.021	3.021
40	889	847	1.788	2.509	2.510	40	845	832	2.062	3.033	3.033
50	888	846	1.792	2.516	2.517	50	845	832	2.068	3.045	3.045
68 00	887	846	1.795	2.522	2.524	78 00	844	832	2.074	3.057	3.057
10	887	846	1.799	2.529	2.531	10	844	831	2.080	3.069	3.069
20	886	845	1.803	2.536	2.537	20	843	831	2.086	3.082	3.082
30	885	845	1.806	2.543	2.544	30	843	831	2.093	3.094	3.094
40	884	845	1.810	2.550	2.551	40	842	831	2.099	3.107	3.107
50	883	844	1.814	2.557	2.558	50	842	831	2.106	3.120	3.120
69 00	882	844	1.818	2.564	2.565	79 00	841	831	2.113	3.133	3.133
10	881	844	1.821	2.571	2.572	10	841	830	2.119	3.146	3.146
20	880	844	1.825	2.578	2.579	20	840	830	2.126	3.160	3.160
30	880	843	1.829	2.585	2.586	30	840	830	2.133	3.174	3.174
40	879	843	1.833	2.593	2.594	40	839	830	2.140	3.188	3.188
50	878	843	1.837	2.600	2.601	50	839	830	2.148	3.202	3.202
70 00	877	842	1.841	2.607	2.608	80 00	839	830	2.155	3.216	3.216

TABLE 17.

LENGTHS OF TERRESTRIAL ARCS OF MERIDIAN.

[Derivation of table explained on p. xlvi.]

Latitude Interval.	Latitude. 0°	Latitude. 1°	Latitude. 2°	Latitude. 3°	Latitude. 4°
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
10″	1007.66	1007.66	1007.67	1007.68	1007.71
20	2015.31	2015.32	2015.34	2015.37	2015.41
30	3022.97	3022.98	3023.01	3023.06	3023.12
40	4030.63	4030.64	4030.68	4030.74	4030.83
50	5038.28	5038.30	5038.35	5038.42	5038.54
60	6045.94	6045.96	6046.02	6046.11	6046.24
10′	60459.4	60459.6	60460.2	60461.1	60462.4
20	120918.8	120919.2	120920.4	120922.2	120924.8
30	181378.3	181378.8	181380.6	181383.3	181387.3
40	241837.7	241838.4	241840.8	241844.4	241849.7
50	302297.1	302298.0	302301.0	302305.5	302312.1
60	362756.5	362757.6	362761.2	362766.6	362774.5
	5°	6°	7°	8°	9°
10″	1007.73	1007.77	1007.81	1007.86	1007.91
20	2015.47	2015.54	2015.62	2015.71	2015.82
30	3023.20	3023.31	3023.43	3023.56	3023.72
40	4030.94	4031.08	4031.24	4031.42	4031.63
50	5038.67	5038.84	5039.04	5039.28	5039.54
60	6046.41	6046.61	6046.85	6047.15	6047.45
10′	60464.1	60466.1	60468.5	60471.3	60474.5
20	120928.2	120932.3	120937.1	120942.6	120949.0
30	181392.3	181398.4	181405.6	181413.9	181423.4
40	241856.4	241864.6	241874.2	241885.2	241897.9
50	302320.5	302330.7	302342.7	302356.5	302372.4
60	362784.6	362796.8	362811.2	362827.8	362846.9
	10°	11°	12°	13°	14°
10″	1007.97	1008.03	1008.10	1008.18	1008.26
20	2015.93	2016.06	2016.20	2016.35	2016.51
30	3023.90	3024.09	3024.30	3024.52	3024.77
40	4031.86	4032.12	4032.40	4032.70	4033.02
50	5039.83	5040.15	5040.50	5040.88	5041.28
60	6047.80	6048.18	6048.60	6049.05	6049.54
10′	60478.0	60481.8	60486.0	60490.5	60495.4
20	120955.9	120963.6	120972.0	120981.0	120990.7
30	181433.9	181445.4	181458.0	181471.5	181486.1
40	241911.8	241927.2	241944.0	241962.0	241981.4
50	302389.8	302409.0	302430.0	302452.5	302476.8
60	362867.8	362890.8	362916.0	362943.0	362972.2
	15°	16°	17°	18°	19°
10″	1008.34	1008.44	1008.53	1008.63	1008.74
20	2016.69	2016.87	2017.06	2017.27	2017.48
30	3025.03	3025.30	3025.60	3025.90	3026.23
40	4033.37	4033.74	4034.13	4034.54	4034.97
50	5041.72	5042.18	5042.66	5043.18	5043.71
60	6050.06	6050.61	6051.19	6051.81	6052.45
10′	60500.6	60506.1	60511.9	60518.1	60524.5
20	121001.2	121012.2	121023.8	121036.2	121049.0
30	181501.7	181518.3	181535.8	181554.3	181573.6
40	242002.3	242024.4	242047.7	242072.4	242098.1
50	302502.9	302530.5	302559.6	302590.5	302622.6
60	363003.5	363036.6	363071.5	363108.6	363147.1
	20°	21°	22°	23°	24°
10″	1008.86	1008.97	1009.10	1009.22	1009.35
20	2017.71	2017.95	2018.19	2018.44	2018.70
30	3026.56	3026.92	3027.28	3027.66	3028.06
40	4035.42	4035.89	4036.38	4036.88	4037.41
50	5044.28	5044.86	5045.48	5046.10	5046.76
60	6053.13	6053.84	6054.57	6055.33	6056.11
10′	60531.3	60538.4	60545.7	60553.3	60561.1
20	121062.6	121076.8	121091.4	121106.5	121122.2
30	181593.9	181615.1	181637.1	181659.8	181683.4
40	242125.2	242153.5	242182.8	242213.0	242244.5
50	302656.5	302691.9	302728.5	302766.3	302805.6
60	363187.8	363230.3	363274.2	363319.6	363366.7

LENGTHS OF TERRESTRIAL ARCS OF MERIDIAN.

[Derivation of table explained on p. xlvi.]

Latitude Interval.	Latitude. 25°	Latitude. 26°	Latitude. 27°	Latitude. 28°	Latitude. 29°
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
10″	1009.49	1009.63	1009.77	1009.92	1010.07
20	2018.97	2019.25	2019.54	2019.83	2020.13
30	3028.46	3028.88	3029.31	3029.75	3030.20
40	4037.95	4038.51	4039.08	4039.67	4040.27
50	5047.44	5048.13	5048.85	5049.58	5050.33
60	6056.92	6057.76	6058.62	6059.50	6060.40
10′	60569.2	60577.6	60586.2	60595.0	60604.0
20	121138.5	121155.2	121172.3	121190.0	121208.0
30	181707.7	181732.7	181758.5	181785.0	181812.0
40	242276.9	242310.3	242344.7	242379.9	242416.0
50	302846.1	302887.9	302930.9	302974.9	303019.9
60	363415.4	363465.5	363517.1	363569.9	363623.9
	30°	31°	32°	33°	34°
10″	1010.22	1010.38	1010.54	1010.70	1010.86
20	2020.44	2020.75	2021.07	2021.40	2021.73
30	3030.66	3031.13	3031.61	3032.10	3032.59
40	4040.88	4041.51	4042.15	4042.80	4043.46
50	5051.10	5051.89	5052.68	5053.50	5054.32
60	6061.32	6062.26	6063.22	6064.20	6065.19
10′	60613.2	60622.6	60632.2	60642.0	60651.9
20	121226.4	121245.3	121264.4	121283.9	121303.8
30	181839.7	181867.9	181896.6	181925.9	181955.7
40	242452.9	242490.5	242528.8	242567.9	242607.6
50	303066.1	303113.2	303161.1	303209.9	303259.4
60	363679.3	363735.8	363793.3	363851.8	363911.3
	35°	36°	37°	38°	39°
10″	1011.03	1011.20	1011.37	1011.55	1011.72
20	2022.06	2022.40	2022.75	2023.09	2023.44
30	3033.10	3033.61	3034.12	3034.64	3035.17
40	4044.13	4044.81	4045.50	4046.19	4046.89
50	5055.16	5056.01	5056.87	5057.74	5058.61
60	6066.19	6067.21	6068.24	6069.29	6070.34
10′	60661.9	60672.1	60682.4	60692.9	60703.4
20	121323.9	121344.3	121364.9	121385.7	121406.7
30	181985.8	182016.4	182047.3	182078.6	182110.1
40	242647.8	242688.5	242729.7	242771.4	242813.4
50	303309.7	303360.6	303412.2	303464.3	303516.8
60	363971.7	364032.8	364094.6	364157.1	364220.2
	40°	41°	42°	43°	44°
10″	1011.90	1012.08	1012.25	1012.43	1012.61
20	2023.80	2024.15	2024.51	2024.87	2025.23
30	3035.70	3036.23	3036.77	3037.30	3037.84
40	4047.60	4048.31	4049.02	4049.74	4050.46
50	5059.50	5060.38	5061.28	5062.17	5063.07
60	6071.39	6072.46	6073.53	6074.61	6075.69
10′	60713.9	60724.6	60735.3	60746.1	60756.9
20	121427.9	121449.2	121470.6	121492.2	121513.7
30	182141.8	182173.8	182206.0	182238.2	182270.6
40	242855.8	242898.4	242941.3	242984.3	243027.4
50	303569.7	303623.0	303676.6	303730.4	303784.3
60	364283.7	364347.6	364411.9	364476.5	364541.2
	45°	46°	47°	48°	49°
10″	1012.79	1012.97	1013.15	1013.33	1013.51
20	2025.59	2025.95	2026.31	2026.67	2027.02
30	3038.38	3038.92	3039.46	3040.00	3040.54
40	4051.18	4051.90	4052.62	4053.34	4054.05
50	5063.97	5064.87	5065.77	5066.67	5067.56
60	6076.77	6077.85	6078.93	6080.00	6081.08
10′	60767.7	60778.5	60789.3	60800.0	60810.8
20	121535.3	121556.9	121578.5	121600.1	121621.5
30	182303.0	182335.4	182367.8	182400.1	182432.3
40	243070.6	243113.9	243157.0	243200.1	243243.0
50	303838.3	303892.4	303946.3	304000.1	304053.8
60	364606.0	364670.8	364735.5	364800.2	364864.5

LENGTHS OF TERRESTRIAL ARCS OF MERIDIAN.

[Derivation of table explained on p. xlvi.]

Latitude Interval.	Latitude. 50°	Latitude. 51°	Latitude. 52°	Latitude. 53°	Latitude. 54°	Latitude. 55°
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
10″	1013.69	1013.87	1014.04	1014.22	1014.39	1014.56
20	2027.38	2027.74	2028.09	2028.44	2028.78	2029.12
30	3041.07	3041.60	3042.13	3042.65	3043.17	3043.68
40	4054.76	4055.47	4056.17	4056.87	4057.56	4058.24
50	5068.46	5069.34	5070.22	5071.09	5071.96	5072.80
60	6082.15	6083.21	6084.26	6085.31	6086.35	6087.37
10′	60821.5	60832.1	60842.6	60853.1	60863.5	60873.7
20	121642.9	121664.2	121685.2	121706.2	121726.9	121747.3
30	182464.4	182496.2	182527.7	182559.2	182590.4	182621.0
40	243285.8	243328.3	243370.3	243412.3	243453.8	243494.6
50	304107.3	304160.4	304212.9	304265.4	304317.3	304368.3
60	364928.8	364992.5	365055.5	365118.5	365180.8	365242.0
	56°	57°	58°	59°	60°	61°
10″	1014.73	1014.90	1015.06	1015.22	1015.38	1015.53
20	2029.46	2029.79	2030.12	2030.44	2030.76	2031.07
30	3044.19	3044.69	3045.18	3045.66	3046.14	3046.60
40	4058.92	4059.58	4060.24	4060.88	4061.52	4062.14
50	5073.65	5074.48	5075.30	5076.10	5076.90	5077.67
60	6088.38	6089.38	6090.36	6091.33	6092.27	6093.20
10′	60883.8	60893.8	60903.6	60913.3	60922.7	60932.0
20	121767.6	121787.5	121807.2	121826.5	121845.5	121864.1
30	182651.4	182681.3	182710.8	182739.8	182768.2	182796.1
40	243535.2	243575.0	243614.4	243653.0	243691.0	243728.2
50	304419.0	304468.8	304518.0	304566.3	304613.7	304660.2
60	365302.8	365362.6	365421.6	365479.6	365536.4	365592.2
	62°	63°	64°	65°	66°	67°
10″	1015.69	1015.83	1015.98	1016.12	1016.26	1016.39
20	2031.37	2031.67	2031.96	2032.24	2032.51	2032.78
30	3047.06	3047.50	3047.94	3048.36	3048.77	3049.16
40	4062.74	4063.34	4063.92	4064.48	4065.02	4065.55
50	5078.43	5079.17	5079.90	5080.60	5081.28	5081.94
60	6094.12	6095.00	6095.87	6096.71	6097.54	6098.33
10′	60941.2	60950.0	60958.7	60967.1	60975.4	60983.3
20	121882.3	121900.1	121917.5	121934.3	121950.7	121966.6
30	182823.5	182850.1	182876.2	182901.4	182926.1	182949.8
40	243764.6	243800.2	243835.0	243868.6	243901.4	243933.1
50	304705.8	304750.2	304793.7	304835.7	304876.8	304916.4
60	365647.0	365700.2	365752.4	365802.8	365852.2	365899.7
	68°	69°	70°	71°	72°	73°
10″	1016.52	1016.64	1016.76	1016.87	1016.98	1017.09
20	2033.03	2033.28	2033.52	2033.75	2033.96	2034.17
30	3049.55	3049.92	3050.28	3050.62	3050.95	3051.26
40	4066.07	4066.56	4067 04	4067.49	4067.93	4068.34
50	5082.58	5083.20	5083.80	5084.36	5084.91	5085.43
60	6099.10	6199.84	6100.55	6101.24	6101.89	6102.52
10′	60991.0	61998.4	61005.5	61012.4	61018.9	61025.2
20	121982.0	121996.8	122011.1	122024.8	122037.8	122050.3
30	182973.1	182995.2	183016.6	183037.1	183056.8	183075.5
40	243964.1	243993.6	244022.2	244049.5	244075.7	244100.6
50	304955.1	304992.0	305027.7	305061.9	305094.6	305125.8
60	365946.1	365990.4	366033.2	366074.3	366113.5	366151.0
	74°	75°	76°	77°	78°	79°
10″	1017.18	1017.28	1017.37	1017.45	1017.53	1017.60
20	2034.37	2034.56	2034.73	2034.90	2035.05	2035.19
30	3051.56	3051.84	3052.10	3052.35	3052.58	3052.79
40	4068.74	4069.12	4069.46	4069.80	4070.10	4070.38
50	5085.92	5086.40	5086.83	5087.24	5087.63	5087.98
60	6103.11	6103.67	6104.20	6104.69	6105.16	6105.58
10′	61031.1	61036.7	61042.0	61046.9	61051.6	61055.8
20	122062.2	122073.5	122083.9	122093.9	122103.1	122111.5
30	183093.3	183110.2	183125.9	183140.8	183154.7	183167.3
40	244124.4	244147.0	244167.8	244187.8	244206.2	244223.0
50	305155.5	305183.7	305209.8	305234.7	305257.8	305278.8
60	366186.6	366220.4	366251.8	366281.6	366309.4	366334.6

LENGTHS OF TERRESTRIAL ARCS OF PARALLEL.

[Derivation of table explained on p. xlix.]

Longitude Interval.	Latitude. 0°	Latitude. 1°	Latitude. 2°	Latitude. 3°	Latitude. 4°
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
10″	1014.52	1014.37	1013.91	1013.14	1012.07
20	2029.05	2028.74	2027.82	2026.29	2024.14
30	3043.57	3043.11	3041.73	3039.43	3036.21
40	4058.10	4057.48	4055.64	4052.57	4048.28
50	5072.62	5071.86	5069.55	5065.72	5060.35
60	6087.14	6086.23	6083.46	6078.86	6072.42
10′	60871.4	60862.3	60834.6	60788.6	60724.2
20	121742.9	121724.5	121669.2	121577.2	121448.4
30	182614.3	182586.8	182503.8	182365.7	182172.6
40	243485.8	243449.0	243338.4	243154.3	242896.8
50	304357.2	304311.3	304173.0	303942.9	303621.0
60	365228.6	365173.6	365007.6	364731.5	364345.2
	5°	6°	7°	8°	9°
10″	1010.69	1009.00	1007.01	1004.72	1002.12
20	2021.38	2018.01	2014.03	2009.43	2004.23
30	3032.07	3027.01	3021.04	3014.15	3006.35
40	4042.76	4036.02	4028.05	4018.87	4008.47
50	5053.45	5045.02	5035.06	5023.58	5010.58
60	6064.14	6054.02	6042.08	6028.30	6012.70
10′	60641.4	60540.2	60420.8	60283.0	60127.0
20	121282.8	121080.5	120841.6	120566.0	120254.0
30	181924.2	181620.7	181262.3	180849.1	180381.1
40	242565.6	242161.0	241683.1	241132.1	240508.1
50	303207.0	302701.2	302103.9	301415.1	300635.1
60	363848.4	363241.4	362524.7	361698.1	360762.1
	10°	11°	12°	13°	14°
10″	999.21	996.01	992.50	988.69	984.58
20	1998.43	1992.01	1985.00	1977.38	1969.17
30	2997.64	2988.02	2977.50	2966.07	2953.75
40	3996.85	3984.03	3970.00	3954.76	3938.34
50	4996.06	4980.04	4962.50	4943.46	4922.92
60	5995.28	5976.04	5955.00	5932.15	5907.50
10′	59952.8	59760.4	59550.0	59321.5	59075.0
20	119905.6	119520.8	119100.0	118642.9	118150.1
30	179858.3	179281.3	178650.0	177964.4	177225.1
40	239811.1	239041.7	238200.0	237285.8	236300.2
50	299763.9	298802.1	297750.0	296607.3	295375.2
60	359716.7	358562.5	357300.0	355928.8	354450.2
	15°	16°	17°	18°	19°
10″	980.18	975.47	970.48	965.18	959.60
20	1960.35	1950.95	1940.95	1930.36	1919.19
30	2940.53	2926.42	2911.42	2895.55	2878.79
40	3920.71	3901.90	3881.90	3860.73	3838.38
50	4900.88	4877.37	4852.38	4825.91	4797.98
60	5881.06	5852.84	5822.85	5791.09	5757.58
10′	58810.6	58528.4	58228.5	57910.9	57575.8
20	117621.2	117056.9	116457.0	115821.8	115151.5
30	176431.9	175585.3	174685.5	173732.8	172727.3
40	235242.5	234113.8	232914.0	231643.7	230303.0
50	294053.1	292642.2	291142.5	289554.6	287878.8
60	352863.7	351170.6	349371.0	347465.5	345454.6
	20°	21°	22°	23°	24°
10″	953.72	947.55	941.10	934.36	927.33
20	1907.44	1895.10	1882.19	1868.71	1854.67
30	2861.15	2842.66	2823.29	2803.07	2782.00
40	3814.87	3790.21	3764.38	3737.43	3709.33
50	4768.59	4737.76	4705.48	4671.78	4636.66
60	5722.31	5685.31	5646.58	5606.14	5564.00
10′	57223.1	56853.1	56465.8	56061.4	55640.0
20	114446.2	113706.2	112931.5	112122.8	111280.0
30	171669.2	170559.4	169397.3	168184.3	166919.9
40	228892.3	227412.5	225863.0	224245.7	222559.9
50	286115.4	284265.6	282328.8	280307.1	278199.9
60	343338.5	341118.7	338794.6	336368.5	333839.9

TABLE 18.

LENGTHS OF TERRESTRIAL ARCS OF PARALLEL.

[Derivation of table explained on p. xlix.]

Longitude Interval.	Latitude. 25°	Latitude. 26°	Latitude. 27°	Latitude. 28°	Latitude. 29°
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
10″	920.03	912.44	904.58	896.44	888.03
20	1840.05	1824.88	1809.16	1792.88	1776.06
30	2760.08	2737.33	2713.74	2689.32	2664.09
40	3680.11	3649.77	3618.32	3585.76	3552.12
50	4600.14	4562.21	4522.89	4482.20	4440.15
60	5520.17	5474.65	5427.47	5378.64	5328.18
10′	55201.7	54746.5	54274.7	53786.4	53281.8
20	110403.3	109493.0	108549.5	107572.9	106563.5
30	165605.0	164239.5	162824.2	161359.3	159845.3
40	220806.6	218986.1	217099.0	215145.7	213127.1
50	276008.3	273732.6	271373.7	268932.2	266408.8
60	331209.9	328479.1	325648.4	322718.6	319690.6
	30°	31°	32°	33°	34°
10″	879.35	870.40	861.18	851.71	841.97
20	1758.70	1740.80	1722.37	1703.41	1683.94
30	2638.04	2611.20	2583.55	2555.12	2525.91
40	3517.39	3481.59	3444.74	3406.83	3367.88
50	4396.74	4351.99	4305.92	4258.53	4209.85
60	5276.09	5222.39	5167.10	5110.24	5051.82
10′	52760.9	52223.9	51671.0	51102.4	50518.2
20	105521.8	104447.8	103342.1	102204.8	101036.4
30	158282.6	156671.8	155013.1	153307.3	151554.6
40	211043.5	208895.7	206684.2	204409.7	202072.8
50	263804.4	261119.6	258355.2	255512.1	252591.0
60	316565.3	313343.5	310026.3	306614.5	303109.2
	35°	36°	37°	38°	39°
10″	831.98	821.73	811.23	800.48	789.49
20	1663.95	1643.46	1622.46	1600.97	1578.98
30	2495.93	2465.19	2433.69	2401.45	2368.48
40	3327.91	3286.91	3244.92	3201.93	3157.97
50	4159.88	4108.64	4056.15	4002.42	3947.46
60	4991.86	4930.37	4867.38	4802.90	4736.95
10′	49918.6	49303.7	48673.8	48029.0	47369.5
20	99837.2	98607.4	97347.6	96058.0	94739.1
30	149755.8	147911.2	146021.4	144087.0	142108.6
40	199674.3	197214.9	194695.2	192116.0	189478.2
50	249592.9	246518.6	243369.0	240145.0	236847.7
60	299511.5	295822.3	292042.8	288174.0	284217.2
	40°	41°	42°	43°	44°
10″	778.26	766.79	755.08	743.15	730.98
20	1556.52	1533.58	1510.17	1486.29	1461.96
30	2334.78	2300.37	2265.25	2229.44	2192.95
40	3113.04	3067.16	3020.33	2972.59	2923.93
50	3891.30	3833.94	3775.42	3715.73	3654.91
60	4669.56	4600.73	4530.50	4458.88	4385.89
10′	46695.6	46007.3	45305.0	44588.8	43858.9
20	93391.2	92014.7	90610.0	89177.6	87717.9
30	140086.7	138022.0	135915.0	133766.4	131576.8
40	186782.3	184029.3	181220.0	178355.2	175435.8
50	233477.9	230036.7	226525.0	222944.0	219294.7
60	280173.5	276044.0	271830.1	267532.8	263153.6
	45°	46°	47°	48°	49°
10″	718.59	705.99	693.16	680.12	666.87
20	1437.19	1411.97	1386.32	1360.24	1333.75
30	2155.78	2117.96	2079.48	2040.36	2000.62
40	2874.38	2823.94	2772.64	2720.49	2667.50
50	3592.97	3529.93	3465.80	3400.61	3334.37
60	4311.56	4235.91	4158.96	4080.73	4001.25
10′	43115.6	42359.1	41589.6	40807.3	40012.5
20	86231.3	84718.2	83179.2	81614.6	80024.9
30	129346.9	127077.3	124768.7	122421.9	120037.4
40	172462.5	169436.5	166358.3	163229.2	160049.9
50	215578.2	211795.6	207947.9	204036.4	200062.3
60	258693.8	254154.7	249537.5	244843.7	240074.8

LENGTHS OF TERRESTRIAL ARCS OF PARALLEL.

[Derivation of table explained on p. xlix.]

Longitude Interval.	Latitude. 50°	Latitude. 51°	Latitude. 52°	Latitude. 53°	Latitude. 54°	Latitude. 55°
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
10″	653.42	639.77	625.92	611.88	597.65	583.23
20	1306.85	1279.54	1251.84	1223.76	1195.30	1166.47
30	1960.27	1919.31	1877.76	1835.63	1792.94	1749.70
40	2613.69	2559.08	2503.68	2447.51	2390.59	2332.93
50	3267.12	3198.85	3129.60	3059.39	2988.28	2916.16
60	3920.54	3838.62	3755.52	3671.27	3585.89	3499.40
10′	39205.4	38386.2	37555.2	36712.7	35858.9	34994.0
20	78410.8	76772.4	75110.4	73425.4	71717.8	69988.0
30	117616.1	115158.6	112665.6	110138.0	107576.6	104981.9
40	156821.5	153544.8	150220.8	146850.7	143435.5	139975.9
50	196026.9	191931.0	187776.0	183563.4	179294.4	174969.9
60	235232.3	230317.2	225331.2	220276.1	215153.3	209963.9
	56°	57°	58°	59°	60°	61°
10″	568.64	553.87	538.93	523.82	508.55	493.13
20	1137.28	1107.74	1077.86	1047.65	1017.11	986.26
30	1705.92	1661.61	1616.79	1571.47	1525.66	1479.38
40	2274.56	2215.48	2155.72	2095.29	2034.22	1972.52
50	2843.20	2769.35	2694.64	2619.12	2542.77	2465.64
60	3411.83	3323.22	3233.57	3142.94	3051.33	2958.77
10′	34118.3	33232.2	32335.7	31429.4	30513.3	29587.7
20	68236.7	66464.4	64671.5	62858.8	61026.6	59175.5
30	102355.0	99696.6	97007.2	94288.1	91539.9	88763.2
40	136473.4	132928.8	129343.0	125717.5	122053.2	118351.0
50	170591.7	166161.0	161678.7	157146.9	152566.5	147938.7
60	204710.0	199393.2	194014.4	188576.3	183079.8	177526.4
	62°	63°	64°	65°	66°	67°
10″	477.55	461.83	445.96	429.95	413.82	397.55
20	955.10	923.65	891.92	859.91	827.63	795.10
30	1432.66	1385.48	1337.88	1289.86	1241.44	1192.64
40	1910.21	1847.31	1783.84	1719.81	1655.26	1590.19
50	2387.76	2309.14	2229.80	2149.76	2069.08	1987.74
60	2865.31	2770.96	2675.75	2579.72	2482.89	2385.29
10′	28653.1	27709.6	26757.5	25797.2	24828.9	23852.9
20	57306.2	55419.2	53515.1	51594.4	49657.8	47705.8
30	85959.4	83128.9	80272.6	77391.5	74486.7	71558.6
40	114612.5	110838.5	107030.2	103188.7	99315.6	95411.5
50	143265.6	138548.1	133787.7	128985.9	124144.5	119264.4
60	171918.7	166257.7	160545.2	154783.1	148973.4	143117.3
	68°	69°	70°	71°	72°	73°
10″	381.16	364.65	348.03	331.30	314.47	297.54
20	762.32	729.30	696.06	662.60	628.94	595.08
30	1143.47	1093.95	1044.09	993.90	943.41	892.62
40	1524.63	1458.60	1392.12	1325.20	1257.88	1190.16
50	1905.79	1823.25	1740.14	1656.50	1572.34	1487.70
60	2286.95	2187.90	2088.17	1987.81	1886.81	1785.23
10′	22869.5	21879.0	20881.7	19878.1	18868.1	17852.3
20	45739.0	43758.0	41763.5	39756.1	37736.3	35704.7
30	68608.4	65637.0	62645.2	59634.2	56604.4	53557.0
40	91477.9	87516.0	83527.0	79512.2	75472.6	71409.4
50	114347.4	109395.0	104408.7	99390.3	94340.7	89261.7
60	137216.9	131274.0	125290.4	119268.4	113208.8	107114.0
	74°	75°	76°	77°	78°	79°
10″	280.52	263.41	246.22	228.96	211.62	194.22
20	561.04	526.82	492.44	457.91	423.24	388.43
30	841.56	790.23	738.66	686.86	634.85	582.64
40	1122.08	1053.64	984.88	915.82	846.47	776.86
50	1402.60	1317.06	1231.10	1144.78	1058.09	971.08
60	1683.11	1580.47	1477.33	1373.73	1269.71	1165.29
10′	16831.1	15804.7	14773.3	13737.3	12697.1	11652.9
20	33662.3	31609.3	29546.5	27474.6	25394.2	23305.8
30	50493.4	47414.0	44319.8	41211.9	38091.2	34958.7
40	67324.6	63218.6	59093.0	54949.2	50788.3	46611.6
50	84155.7	79023.3	73866.3	68686.5	63485.4	58264.5
60	100986.8	94828.0	88639.6	82423.8	76182.5	69917.4

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{250000}$.

[Derivation of table explained on pp. liii — lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
0°00′	....	4.383	.000	8.766	.000	13.148	.000	17.531	.000
15	4.353	4.383	.000	8.766	.000	13.148	.000	17.531	.001
30	8.706	4.383	.000	8.765	.000	13.148	.001	17.530	.001
45	13.059	4.382	.000	8.765	.001	13.147	.001	17.530	.002
1 00	17.412	4.382	.000	8.764	.001	13.146	.001	17.528	.003
15	4.353	4.382	.000	8.764	.001	13.145	.002	17.527	.003
30	8.706	4.381	.000	8.763	.001	13.144	.002	17.525	.004
45	13.059	4.381	.000	8.762	.001	13.142	.003	17.523	.005
2 00	17.412	4.380	.000	8.760	.001	13.141	.003	17.521	.005
15	4.353	4.379	.000	8.759	.001	13.138	.003	17.518	.006
30	8.706	4.379	.000	8.757	.001	13.136	.004	17.514	.007
45	13.059	4.378	.000	8.755	.002	13.133	.004	17.511	.007
3 00	17.413	4.377	.001	8.753	.002	13.130	.004	17.507	.008
15	4.353	4.376	.001	8.751	.002	13.127	.005	17.503	.008
30	8.706	4.375	.001	8.749	.002	13.124	.005	17.498	.009
45	13.060	4.373	.001	8.747	.002	13.120	.006	17.494	.009
4 00	17.413	4.372	.001	8.744	.003	13.116	.006	17.488	.010
15	4.353	4.371	.001	8.742	.003	13.112	.006	17.483	.011
30	8.707	4.369	.001	8.739	.003	13.108	.007	17.478	.012
45	13.060	4.368	.001	8.736	.003	13.104	.007	17.472	.013
5 00	17.413	4.366	.001	8.732	.003	13.099	.007	17.465	.013
15	4.353	4.364	.001	8.729	.003	13.094	.008	17.458	.014
30	8.707	4.363	.001	8.725	.004	13.088	.008	17.451	.014
45	13.060	4.361	.001	8.722	.004	13.082	.008	17.443	.015
6 00	17.414	4.359	.001	8.718	.004	13.076	.009	17.435	.016
15	4.354	4.357	.001	8.714	.004	13.071	.009	17.428	.017
30	8.707	4.355	.001	8.710	.004	13.064	.010	17.419	.017
45	13.061	4.353	.001	8.705	.004	13.058	.010	17.410	.018
7 00	17.414	4.350	.001	8.701	.005	13.051	.010	17.401	.019
15	4.354	4.348	.001	8.696	.005	13.044	.011	17.392	.019
30	8.707	4.346	.001	8.691	.005	13.036	.011	17.382	.020
45	13.061	4.343	.001	8.686	.005	13.029	.011	17.372	.020
8 00	17.415	4.340	.001	8.681	.005	13.021	.012	17.362	.021
15	4.354	4.338	.001	8.675	.005	13.013	.012	17.351	.022
30	8.708	4.335	.001	8.670	.006	13.005	.013	17.340	.022
45	13.062	4.332	.002	8.664	.006	12.996	.013	17.328	.023
9 00	17.416	4.329	.002	8.658	.006	12.987	.013	17.316	.024
15	4.354	4.326	.002	8.652	.006	12.979	.014	17.305	.024
30	8.708	4.323	.002	8.646	.006	12.969	.014	17.292	.025
45	13.062	4.320	.002	8.640	.006	12.960	.014	17.280	.026
10 00	17.417	4.317	.002	8.633	.006	12.950	.015	17.266	.026

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{250000}$.

[Derivation of table explained on pp. liii — lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
10°00′	....	4.317	.002	8.633	.006	12.950	.015	17.266	.026
15	4.354	4.313	.002	8.626	.007	12.940	.015	17.253	.027
30	8.709	4.310	.002	8.620	.007	12.930	.015	17.240	.027
45	13.063	4.306	.002	8.613	.007	12.919	.016	17.226	.028
11 00	17.418	4.303	.002	8.606	.007	12.908	.016	17.211	.029
15	4.355	4.299	.002	8.598	.007	12.897	.016	17.196	.029
30	8.709	4.295	.002	8.591	.007	12.886	.017	17.182	.030
45	13.064	4.292	.002	8.583	.008	12.875	.017	17.166	.031
12 00	17.419	4.288	.002	8.575	.008	12.863	.017	17.150	.031
15	4.355	4.284	.002	8.567	.008	12.851	.018	17.134	.032
30	8.710	4.280	.002	8.559	.008	12.839	.018	17.118	.032
45	13.065	4.275	.002	8.551	.008	12.826	.019	17.102	.033
13 00	17.420	4.271	.002	8.542	.008	12.813	.019	17.084	.034
15	4.355	4.267	.002	8.534	.009	12.800	.019	17.067	.034
30	8.711	4.262	.002	8.525	.009	12.787	.020	17.050	.035
45	13.066	4.258	.002	8.516	.009	12.774	.020	17.032	.035
14 00	17.421	4.253	.002	8.507	.009	12.760	.020	17.013	.036
15	4.356	4.249	.002	8.498	.009	12.746	.021	16.995	.036
30	8.711	4.244	.002	8.488	.009	12.732	.021	16.976	.037
45	13.067	4.239	.002	8.479	.009	12.718	.021	16.957	.038
15 00	17.423	4.234	.002	8.469	.010	12.703	.022	16.938	.038
15	4.356	4.229	.002	8.459	.010	12.688	.022	16.918	.039
30	8.712	4.224	.002	8.449	.010	12.673	.022	16.898	.039
45	13.068	4.219	.002	8.439	.010	12.658	.022	16.877	.040
16 00	17.424	4.214	.003	8.428	.010	12.642	.023	16.856	.041
15	4.356	4.209	.003	8.417	.010	12.626	.023	16.835	.041
30	8.713	4.204	.003	8.407	.010	12.610	.023	16.814	.042
45	13.069	4.198	.003	8.396	.011	12.594	.024	16.792	.042
17 00	17.426	4.192	.003	8.385	.011	12.577	.024	16.770	.043
15	4.357	4.187	.003	8.374	.011	12.561	.024	16.748	.043
30	8.714	4.181	.003	8.362	.011	12.544	.025	16.725	.044
45	13.071	4.175	.003	8.351	.011	12.526	.025	16.702	.044
18 00	17.427	4.170	.003	8.339	.011	12.509	.025	16.679	.045
15	4.357	4.164	.003	8.327	.011	12.491	.026	16.655	.045
30	8.715	4.158	.003	8.316	.012	12.473	.026	16.631	.046
45	13.072	4.152	.003	8.303	.012	12.455	.026	16.606	.046
19 00	17.429	4.145	.003	8.291	.012	12.436	.026	16.582	.047
15	4.358	4.139	.003	8.278	.012	12.418	.027	16.557	.048
30	8.716	4.133	.003	8.266	.012	12.399	.027	16.532	.048
45	13.073	4.127	.003	8.253	.012	12.380	.027	16.506	.048
20 00	17.431	4.120	.003	8.240	.012	12.360	.028	16.480	.049

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{250000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
20°00′	....	4.120	.003	8.240	.012	12.360	.028	16.480	.049
15	4.358	4.114	.003	8.227	.012	12.340	.028	16.454	.050
30	8.717	4.107	.003	8.214	.013	12.321	.028	16.428	.050
45	13.075	4.100	.003	8.200	.013	12.301	.029	16.401	.051
21 00	17.433	4.094	.003	8.187	.013	12.280	.029	16.374	.051
15	4.359	4.087	.003	8.173	.013	12.260	.029	16.346	.052
30	8.718	4.080	.003	8.159	.013	12.239	.029	16.318	.052
45	13.076	4.073	.003	8.145	.013	12.218	.030	16.291	.053
22 00	17.435	4.066	.003	8.131	.013	12.197	.030	16.262	.053
15	4.359	4.058	.003	8.117	.013	12.175	.030	16.234	.054
30	8.719	4.051	.003	8.102	.014	12.154	.030	16.205	.054
45	13.078	4.044	.003	8.088	.014	12.132	.031	16.176	.055
23 00	17.437	4.036	.003	8.073	.014	12.109	.031	16.146	.055
15	4.360	4.029	.003	8.058	.014	12.087	.031	16.116	.055
30	8.720	4.021	.003	8.043	.014	12.064	.031	16.086	.056
45	13.080	4.014	.004	8.028	.014	12.041	.032	16.055	.056
24 00	17.439	4.006	.004	8.012	.014	12.018	.032	16.024	.057
15	4.360	3.998	.004	7.997	.014	11.995	.032	15.993	.057
30	8.721	3.990	.004	7.981	.014	11.971	.032	15.962	.058
45	13.081	3.982	.004	7.965	.015	11.948	.033	15.930	.058
25 00	17.442	3.974	.004	7.949	.015	11.923	.033	15.898	.059
15	4.361	3.966	.004	7.933	.015	11.899	.033	15.865	.059
30	8.722	3.958	.004	7.916	.015	11.874	.033	15.832	.059
45	13.083	3.950	.004	7.900	.015	11.850	.034	15.800	.060
26 00	17.444	3.942	.004	7.883	.015	11.825	.034	15.767	.060
15	4.362	3.933	.004	7.866	.015	11.800	.034	15.733	.061
30	8.723	3.925	.004	7.849	.015	11.774	.034	15.699	.061
45	13.085	3.916	.004	7.833	.015	11.749	.035	15.665	.061
27 00	17.446	3.908	.004	7.816	.015	11.723	.035	15.631	.062
15	4.362	3.899	.004	7.798	.016	11.697	.035	15.596	.062
30	8.724	3.890	.004	7.780	.016	11.671	.035	15.561	.063
45	13.087	3.881	.004	7.763	.016	11.644	.036	15.526	.063
28 00	17.449	3.873	.004	7.745	.016	11.618	.036	15.490	.064
15	4.363	3.863	.004	7.727	.016	11.591	.036	15.454	.064
30	8.726	3.854	.004	7.709	.016	11.563	.036	15.418	.064
45	13.088	3.845	.004	7.691	.016	11.536	.036	15.382	.065
29 00	17.451	3.836	.004	7.673	.016	11.509	.036	15.345	.065
15	4.363	3.827	.004	7.654	.016	11.481	.037	15.308	.065
30	8.727	3.817	.004	7.635	.016	11.453	.037	15.270	.066
45	13.091	3.808	.004	7.616	.016	11.425	.037	15.233	.066
30 00	17.454	3.799	.004	7.598	.017	11.396	.037	15.195	.066

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{250000}$.

[Derivation of table explained on pp. liii-lvi.]

Latitude of parallel	Meridional distances from even degree parallels.	Co-ordinates of developed parallel for—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches*	*Inches.*	*Inches.*	*Inches.*
30°00′	....	3.799	.004	7.598	.017	11.396	.037	15.195	.066
15	4.364	3.789	.004	7.578	.017	11.367	.037	15.156	.067
30	8.728	3.779	.004	7.559	.017	11.338	.038	15.118	.067
45	13.092	3.770	.004	7.540	.017	11.309	.038	15.079	.067
31 00	17.457	3.760	.004	7.520	.017	11.280	.038	15.040	.068
15	4.365	3.750	.004	7.500	.017	11.250	.038	15.001	.068
30	8.730	3.740	.004	7.480	.017	11.221	.038	14.961	.068
45	13.095	3.730	.004	7.460	.017	11.191	.038	14.921	.068
32 00	17.460	3.720	.004	7.441	.017	11.161	.039	14.881	.069
15	4.366	3.710	.004	7.420	.017	11.130	.039	14.840	.069
30	8.731	3.700	.004	7.400	.017	11.100	.039	14.799	.069
45	13.097	3.690	.004	7.379	.017	11.069	.039	14.758	.070
33 00	17.462	3.679	.004	7.359	.017	11.038	.039	14.718	.070
15	4.366	3.669	.004	7.338	.018	11.007	.039	14.676	.070
30	8.733	3.658	.004	7.317	.018	10.975	.040	14.633	.070
45	13.099	3.648	.004	7.296	.018	10.943	.040	14.591	.071
34 00	17.465	3.637	.004	7.275	.018	10.912	.040	14.549	.071
15	4.367	3.626	.004	7.253	.018	10.879	.040	14.506	.071
30	8.734	3.616	.004	7.231	.018	10.847	.040	14.463	.071
45	13.101	3.605	.004	7.210	.018	10.815	.040	14.420	.072
35 00	17.468	3.594	.004	7.188	.018	10.782	.040	14.376	.072
15	4.368	3.583	.004	7.166	.018	10.749	.041	14.332	.072
30	8.735	3.572	.004	7.144	.018	10.716	.041	14.288	.072
45	13.103	3.561	.005	7.122	.018	10.683	.041	14.244	.073
36 00	17.471	3.550	.005	7.100	.018	10.650	.041	14.200	.073
15	4.368	3.539	.005	7.077	.018	10.616	.041	14.154	.073
30	8.736	3.527	.005	7.054	.018	10.582	.041	14.109	.073
45	13.105	3.516	.005	7.032	.018	10.547	.041	14.063	.073
37 00	17.473	3.504	.005	7.009	.018	10.513	.041	14.018	.074
15	4.369	3.493	.005	6.986	.018	10.479	.041	13.972	.074
30	8.738	3.481	.005	6.963	.018	10.444	.042	13.925	.074
45	13.108	3.470	.005	6.939	.018	10.409	.042	13.879	.074
38 00	17.477	3.458	.005	6.916	.019	10.374	.042	13.832	.074
15	4.370	3.446	.005	6.892	.019	10.339	.042	13.785	.074
30	8.740	3.434	.005	6.869	.019	10.303	.042	13.737	.075
45	13.110	3.422	.005	6.845	.019	10.267	.042	13.690	.075
39 00	17.480	3.411	.005	6.821	.019	10.232	.042	13.642	.075
15	4.371	3.398	.005	6.797	.019	10.195	.042	13.594	.075
30	8.741	3.386	.005	6.773	.019	10.159	.042	13.545	.075
45	13.112	3.374	.005	6.748	.019	10.123	.042	13.497	.075
40 00	17.483	3.362	.005	6.724	.019	10.086	.042	13.448	.075

Table 19.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{250000}$.

[Derivation of table explained on p. liii-lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
40°00′	....	3.362	.005	6.724	.019	10.086	.042	13.448	.075
15	4.371	3.350	.005	6.699	.019	10.049	.042	13.399	.075
30	8.743	3.337	.005	6.675	.019	10.012	.043	13.349	.076
45	13.114	3.325	.005	6.650	.019	9.975	.043	13.300	.076
41 00	17.486	3.312	.005	6.625	.019	9.937	.043	13.250	.076
15	4.372	3.300	.005	6.600	.019	9.900	.043	13.200	.076
30	8.744	3.287	.005	6.575	.019	9.862	.043	13.149	.076
45	13.117	3.275	.005	6.549	.019	9.824	.043	13.098	.076
42 00	17.489	3.262	.005	6.524	.019	9.786	.043	13.048	.076
15	4.373	3.249	.005	6.498	.019	9.747	.043	12.996	.076
30	8.746	3.236	.005	6.472	.019	9.709	.043	12.945	.076
45	13.119	3.223	.005	6.447	.019	9.670	.043	12.893	.076
43 00	17.492	3.210	.005	6.421	.019	9.631	.043	12.842	.076
15	4.374	3.197	.005	6.394	.019	9.592	.043	12.789	.076
30	8.747	3.184	.005	6.368	.019	9.552	.043	12.736	.076
45	13.121	3.170	.005	6.342	.019	9.513	.043	12.684	.076
44 00	17.495	3.158	.005	6.316	.019	9.473	.043	12.631	.077
15	4.375	3.144	.005	6.289	.019	9.433	.043	12.578	.077
30	8.749	3.131	.005	6.262	.019	9.393	.043	12.524	.077
45	13.124	3.118	.005	6.235	.019	9.353	.043	12.471	.077
45 00	17.498	3.104	.005	6.209	.019	9.313	.043	12.417	.077
15	4.375	3.091	.005	6.181	.019	9.272	.043	12.363	.077
30	8.751	3.077	.005	6.154	.019	9.231	.043	12.308	.077
45	13.126	3.063	.005	6.127	.019	9.190	.043	12.254	.077
46 00	17.501	3.050	.005	6.100	.019	9.150	.043	12.200	.077
15	4.376	3.036	.005	6.072	.019	9.108	.043	12.144	.077
30	8.752	3.022	.005	6.044	.019	9.067	.043	12.089	.077
45	13.128	3.008	.005	6.017	.019	9.025	.043	12.033	.077
47 00	17.504	2.994	.005	5.989	.019	8.983	.043	11.978	.076
15	4.377	2.980	.005	5.961	.019	8.941	.043	11.922	.076
30	8.754	2.966	.005	5.933	.019	8.899	.043	11.865	.076
45	13.131	2.952	.005	5.904	.019	8.857	.043	11.809	.076
48 00	17.508	2.938	.005	5.876	.019	8.814	.043	11.752	.076
15	4.378	2.924	.005	5.848	.019	8.771	.043	11.695	.076
30	8.755	2.909	.005	5.819	.019	8.728	.043	11.638	.076
45	13.133	2.895	.005	5.790	.019	8.686	.043	11.581	.076
49 00	17.511	2.881	.005	5.762	.019	8.643	.043	11.524	.076
15	4.378	2.866	.005	5.733	.019	8.599	.043	11.465	.076
30	8.757	2.852	.005	5.704	.019	8.555	.043	11.407	.076
45	13.135	2.837	.005	5.675	.019	8.512	.042	11.349	.076
50 00	17.514	2.823	.005	5.646	.019	8.468	.042	11.291	.076

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{250000}$.

[Derivation of table explained on p. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
50°00′	....	2.823	.005	5.646	.019	8.468	.042	11.291	.076
15	4.379	2.808	.005	5.616	.019	8.424	.042	11.232	.075
30	8.758	2.793	.005	5.587	.019	8.380	.042	11.174	.075
45	13.137	2.779	.005	5.557	.019	8.336	.042	11.114	.075
51 00	17.517	2.764	.005	5.528	.019	8.291	.042	11.055	.075
15	4.380	2.749	.005	5.498	.019	8.247	.042	10.996	.075
30	8.760	2.734	.005	5.468	.019	8.202	.042	10.936	.075
45	13.140	2.719	.005	5.438	.019	8.157	.042	10.876	.075
52 00	17.520	2.704	.005	5.408	.019	8.112	.042	10.816	.074
15	4.381	2.689	.005	5.378	.019	8.067	.042	10.756	.074
30	8.761	2.674	.005	5.347	.019	8.021	.041	10.695	.074
45	13.142	2.659	.005	5.317	.018	7.976	.041	10.634	.074
53 00	17.523	2.643	.005	5.287	.018	7.930	.041	10.573	.074
15	4.381	2.628	.005	5.256	.018	7.884	.041	10.512	.074
30	8.763	2.613	.005	5.225	.018	7.838	.041	10.451	.073
45	13.144	2.597	.005	5.195	.018	7.792	.041	10.389	.073
54 00	17.526	2.582	.005	5.164	.018	7.745	.041	10.327	.073
15	4.382	2.566	.005	5.133	.018	7.699	.041	10.266	.073
30	8.764	2.551	.005	5.102	.018	7.652	.041	10.203	.073
45	13.147	2.535	.005	5.070	.018	7.606	.041	10.141	.072
55 00	17.529	2.520	.005	5.039	.018	7.559	.041	10.078	.072
15	4.383	2.504	.004	5.008	.018	7.512	.040	10.016	.072
30	8.766	2.488	.004	4.976	.018	7.465	.040	9.953	.072
45	13.149	2.472	.004	4.945	.018	7.417	.040	9.890	.071
56 00	17.532	2.456	.004	4.913	.018	7.370	.040	9.826	.071
15	4.384	2.441	.004	4.881	.018	7.322	.040	9.763	.071
30	8.767	2.425	.004	4.849	.018	7.274	.040	9.699	.071
45	13.151	2.409	.004	4.817	.018	7.226	.040	9.635	.070
57 00	17.535	2.393	.004	4.785	.018	7.178	.039	9.571	.070
15	4.384	2.377	.004	4.753	.017	7.130	.039	9.507	.070
30	8.769	2.361	.004	4.721	.017	7.082	.039	9.442	.070
45	13.153	2.344	.004	4.689	.017	7.033	.039	9.378	.069
58 00	17.537	2.328	.004	4.656	.017	6.985	.039	9.313	.069
15	4.385	2.312	.004	4.624	.017	6.936	.039	9.248	.069
30	8.770	2.296	.004	4.591	.017	6.887	.038	9.183	.068
45	13.155	2.279	.004	4.559	.017	6.838	.038	9.117	.068
59 00	17.540	2.263	.004	4.526	.017	6.789	.038	9.052	.068
15	4.386	2.246	.004	4.493	.017	6.740	.038	8.986	.068
30	8.772	2.230	.004	4.460	.017	6.690	.038	8.920	.067
45	13.157	2.214	.004	4.427	.017	6.641	.038	8.854	.067
60 00	17.543	2.197	.004	4.394	.017	6.591	.037	8.788	.067

TABLE 19.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{250000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
60°00′	....	2.197	.004	4.394	.017	6.591	.037	8.788	.067
15	4.386	2.180	.004	4.361	.017	6.541	.037	8.722	.066
30	8.773	2.164	.004	4.327	.016	6.491	.037	8.655	.066
45	13.159	2.147	.004	4.294	.016	6.441	.037	8.588	.066
61 00	17.546	2.130	.004	4.261	.016	6.391	.037	8.521	.065
15	4.387	2.114	.004	4.227	.016	6.340	.036	8.454	.065
30	8.774	2.097	.004	4.194	.016	6.290	.036	8.387	.064
45	13.161	2.080	.004	4.160	.016	6.240	.036	8.320	.064
62 00	17.548	2.063	.004	4.126	.016	6.189	.036	8.252	.064
15	4.388	2.046	.004	4.092	.016	6.138	.036	8.184	.063
30	8.776	2.029	.004	4.058	.016	6.088	.035	8.117	.063
45	13.163	2.012	.004	4.024	.016	6.036	.035	8.048	.063
63 00	17.551	1.995	.004	3.990	.015	5.985	.035	7.980	.062
15	4.388	1.978	.004	3.956	.015	5.934	.035	7.912	.062
30	8.777	1.961	.004	3.922	.015	5.883	.034	7.844	.061
45	13.165	1.944	.004	3.887	.015	5.831	.034	7.775	.061
64 00	17.554	1.926	.004	3.853	.015	5.780	.034	7.706	.060
15	4.389	1.909	.004	3.819	.015	5.728	.034	7.637	.060
30	8.778	1.892	.004	3.784	.015	5.676	.034	7.568	.060
45	13.167	1.875	.004	3.749	.015	5.624	.033	7.499	.059
65 00	17.556	1.857	.004	3.715	.015	5.572	.033	7.430	.059
15	4.390	1.840	.004	3.680	.015	5.520	.033	7.360	.059
30	8.779	1.823	.004	3.645	.014	5.468	.033	7.290	.058
45	13.169	1.805	.004	3.610	.014	5.415	.032	7.220	.058
66 00	17.559	1.788	.004	3.575	.014	5.363	.032	7.151	.057
15	4.390	1.770	.004	3.540	.014	5.310	.032	7.080	.057
30	8.780	1.753	.004	3.505	.014	5.258	.032	7.010	.056
45	13.171	1.735	.003	3.470	.014	5.205	.031	6.940	.056
67 00	17.561	1.717	.003	3.435	.014	5.152	.031	6.870	.055
15	4.391	1.700	.003	3.400	.014	5.099	.031	6.799	.055
30	8.782	1.682	.003	3.364	.014	5.046	.031	6.728	.054
45	13.172	1.664	.003	3.329	.013	4.993	.030	6.658	.054
68 00	17.563	1.647	.003	3.293	.013	4.940	.030	6.586	.053
15	4.391	1.629	.003	3.258	.013	4.886	.030	6.515	.053
30	8.783	1.611	.003	3.222	.013	4.833	.029	6.444	.052
45	13.174	1.593	.003	3.186	.013	4.780	.029	6.373	.052
69 00	17.565	1.575	.003	3.151	.013	4.726	.029	6.301	.051
15	4.392	1.557	.003	3.115	.013	4.672	.029	6.230	.051
30	8.784	1.540	.003	3.079	.013	4.618	.028	6.158	.051
45	13.176	1.522	.003	3.043	.012	4.564	.028	6.086	.050
70 00	17.568	1.504	.003	3.007	.012	4.510	.028	6.014	.049

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{250000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
70°00′	....	1.504	.003	3.007	.012	4.510	.028	6.014	.049
15	4.392	1.486	.003	2.971	.012	4.456	.028	5.942	.049
30	8.785	1.467	.003	2.935	.012	4.402	.027	5.870	.048
45	13.177	1.449	.003	2.899	.012	4.348	.027	5.797	.048
71 00	17.570	1.431	.003	2.862	.012	4.294	.027	5.725	.047
15	4.393	1.413	.003	2.826	.012	4.239	.026	5.652	.047
30	8.786	1.395	.003	2.790	.011	4.185	.026	5.580	.046
45	13.179	1.377	.003	2.753	.011	4.130	.026	5.507	.046
72 00	17.572	1.358	.003	2.717	.011	4.075	.025	5.434	.045
15	4.393	1.340	.003	2.681	.011	4.021	.025	5.361	.045
30	8.787	1.322	.003	2.644	.011	3.966	.025	5.288	.044
45	13.180	1.304	.003	2.607	.011	3.911	.024	5.215	.044
73 00	17.573	1.285	.003	2.571	.011	3.856	.024	5.142	.043
15	4.394	1.267	.003	2.534	.011	3.801	.024	5.068	.043
30	8.788	1.249	.003	2.497	.010	3.746	.024	4.994	.042
45	13.181	1.230	.003	2.461	.010	3.691	.023	4.921	.041
74 00	17.575	1.212	.003	2.424	.010	3.636	.023	4.848	.041
15	4.394	1.193	.003	2.387	.010	3.580	.023	4.774	.040
30	8.788	1.175	.002	2.350	.010	3.525	.022	4.700	.040
45	13.183	1.156	.002	2.313	.010	3.470	.022	4.626	.039
75 00	17.577	1.138	.002	2.276	.010	3.414	.022	4.552	.038
15	4.395	1.119	.002	2.239	.009	3.358	.021	4.478	.038
30	8.789	1.101	.002	2.202	.009	3.303	.021	4.404	.037
45	13.184	1.082	.002	2.165	.009	3.247	.021	4.329	.037
76 00	17.579	1.064	.002	2.127	.009	3.191	.020	4.255	.036
15	4.395	1.045	.002	2.090	.009	3.135	.020	4.180	.036
30	8.790	1.026	.002	2.053	.009	3.079	.020	4.106	.035
45	13.185	1.008	.002	2.016	.009	3.023	.019	4.031	.034
77 00	17.580	0.989	.002	1.978	.008	2.967	.019	3.956	.034
15	4.395	0.970	.002	1.941	.008	2.911	.019	3.882	.033
30	8.791	0.952	.002	1.903	.008	2.855	.018	3.807	.033
45	13.186	0.933	.002	1.866	.008	2.799	.018	3.732	.032
78 00	17.582	0.914	.002	1.828	.008	2.743	.018	3.657	.031
15	4.396	0.895	.002	1.791	.008	2.686	.017	3.582	.031
30	8.791	0.877	.002	1.753	.008	2.630	.017	3.506	.030
45	13.187	0.858	.002	1.716	.008	2.573	.017	3.431	.030
79 00	17.583	0.839	.002	1.678	.007	2.517	.016	3.356	.029
15	4.396	0.820	.002	1.640	.007	2.461	.016	3.281	.028
30	8.792	0.801	.002	1.603	.007	2.404	.016	3.205	.028
45	13.188	0.782	.002	1.565	.007	2.348	.015	3.130	.027
80 00	17.584	0.764	.002	1.527	.007	2.291	.015	3.054	.026

TABLE 20.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii — lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
0°00′	....	2.922	5.844	8.765	11.687	14.609	17.531
10	5.804	2.922	5.843	8.765	11.687	14.608	17.530
20	11.608	2.922	5.843	8.765	11.686	14.608	17.530
30	17.412	2.922	5.843	8.765	11.686	14.608	17.530
40	23.216	2.922	5.843	8.764	11.686	14.608	17.529
50	29.020	2.921	5.843	8.764	11.686	14.607	17.528
1 00	....	2.921	5.843	8.764	11.685	14.606	17.528
10	5.840	2.921	5.842	8.763	11.684	14.606	17.527
20	11.608	2.921	5.842	8.763	11.684	14.604	17.525
30	17.412	2.921	5.841	8.762	11.683	14.604	17.524
40	23.216	2.920	5.841	8.761	11.682	14.602	17.522
50	29.020	2.920	5.840	8.761	11.681	14.601	17.521
2 00	....	2.920	5.840	8.760	11.680	14.600	17.520
10	5.804	2.920	5.839	8.759	11.678	14.598	17.518
20	11.608	2.919	5.839	8.758	11.677	14.596	17.516
30	17.412	2.919	5.838	8.757	11.676	14.594	17.513
40	23.216	2.918	5.837	8.756	11.674	14.592	17.511
50	29.020	2.918	5.836	8.755	11.673	14.591	17.509
3 00	....	2.918	5.836	8.753	11.671	14.589	17.507
10	5.804	2.917	5.835	8.752	11.669	14.586	17.504
20	11.608	2.917	5.834	8.750	11.667	14.584	17.501
30	17.413	2.916	5.832	8.749	11.665	14.581	17.497
40	23.217	2.916	5.831	8.747	11.663	14.578	17.494
50	29.021	2.915	5.830	8.746	11.661	14.576	17.491
4 00	....	2.915	5.829	8.744	11.659	14.574	17.488
10	5.804	2.914	5.828	8.742	11.656	14.570	17.484
20	11.609	2.913	5.827	8.740	11.654	14.567	17.480
30	17.413	2.913	5.825	8.738	11.651	14.564	17.476
40	23.217	2.912	5.824	8.736	11.648	14.560	17.473
50	29.022	2.911	5.823	8.734	11.646	14.557	17.468
5 00	....	2.911	5.822	8.732	11.643	14.554	17.465
10	5.804	2.910	5.820	8.730	11.640	14.550	17.459
20	11.609	2.909	5.818	8.727	11.636	14.546	17.455
30	17.414	2.908	5.817	8.725	11.633	14.542	17.450
40	23.218	2.908	5.815	8.722	11.630	14.538	17.445
50	29.022	2.907	5.813	8.720	11.627	14.534	17.440
6 00	....	2.906	5.812	8.718	11.624	14.530	17.435
10	5.805	2.905	5.810	8.715	11.620	14.524	17.429
20	11.609	2.904	5.808	8.712	11.616	14.520	17.424
30	17.414	2.903	5.806	8.709	11.612	14.515	17.418
40	23.219	2.902	5.804	8.706	11.608	14.510	17.413
50	29.024	2.901	5.802	8.703	11.604	14.506	17.407
7 00	....	2.900	5.800	8.701	11.601	14.501	17.401
10	5.805	2.899	5.798	8.697	11.596	14.496	17.395
20	11.610	2.898	5.796	8.694	11.592	14.490	17.387
30	17.415	2.897	5.794	8.690	11.587	14.484	17.381
40	23.220	2.896	5.791	8.687	11.583	14.478	17.374
50	29.025	2.895	5.789	8.684	11.578	14.473	17.368
8 00	....	2.894	5.787	8.680	11.574	14.468	17.361

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	0°	1°
	Inches.	*Inches.*
5′	0.000	0.000
10	.000	.000
15	.000	.000
20	.000	.001
25	.000	.001
30	.000	.001
	2°	**3°**
5	0.000	0.000
10	.000	.000
15	.001	.001
20	.001	.002
25	.002	.003
30	.003	.004
	4°	**5°**
5	0.000	0.000
10	.001	.001
15	.001	.002
20	.002	.003
25	.004	.005
30	.005	.007
	6°	**7°**
5	0.000	0.000
10	.001	.001
15	.002	.002
20	.004	.004
25	.006	.006
30	.008	.009
	8°	
5	0.000	
10	.001	
15	.003	
20	.005	
25	.007	
30	010	

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii — lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
8°00′	....	2.894	5.787	8.680	11.574	14.468	17.361
10	5.805	2.892	5.784	8.677	11.569	14.461	17.353
20	11.610	2.891	5.782	8.673	11.564	14.455	17.346
30	17.416	2.890	5.779	8.669	11.559	14.448	17.338
40	23.221	2.888	5.777	8.666	11.554	14.442	17.331
50	29.026	2.887	5.775	8.662	11.549	14.436	17.324
9 00	....	2.886	5.772	8.658	11.544	14.430	17.317
10	5.806	2.885	5.769	8.654	11.539	14.424	17.308
20	11.611	2.883	5.767	8.650	11.533	14.416	17.300
30	17.417	2.882	5.764	8.646	11.528	14.410	17.291
40	23.222	2.881	5.761	8.642	11.522	14.402	17.283
50	29.028	2.879	5.758	8.637	11.516	14.396	17.275
10 00	....	2.878	5.755	8.633	11.511	14.388	17.266
10	5.806	2.876	5.752	8.628	11.504	14.380	17.257
20	11.612	2.875	5.749	8.624	11.498	14.373	17.248
30	17.417	2.873	5.746	8.619	11.492	14.366	17.239
40	23.223	2.872	5.743	8.614	11.486	14.358	17.229
50	29.029	2.870	5.740	8.610	11.480	14.350	17.220
11 00	....	2.869	5.737	8.606	11.474	14.342	17.211
10	5.806	2.867	5.734	8.601	11.468	14.334	17.201
20	11.612	2.865	5.730	8.596	11.461	14.326	17.191
30	17.419	2.864	5.727	8.590	11.454	14.318	17.181
40	23.225	2.862	5.724	8.585	11.447	14.309	17.171
50	29.031	2.860	5.720	8.580	11.440	14.300	17.161
12 00	....	2.858	5.717	8.575	11.434	14.292	17.150
10	5.807	2.857	5.713	8.570	11.426	14.282	17.139
20	11.613	2.855	5.709	8.564	11.419	14.274	17.128
30	17.420	2.853	5.706	8.559	11.412	14.264	17.117
40	23.226	2.851	5.702	8.553	11.404	14.256	17.107
50	29.033	2.849	5.698	8.548	11.397	14.246	17.095
13 00	....	2.847	5.695	8.542	11.390	14.237	17.084
10	5.807	2.846	5.691	8.536	11.382	14.228	17.073
20	11.614	2.844	5.687	8.530	11.374	14.218	17.061
30	17.421	2.842	5.683	8.524	11.366	14.208	17.049
40	23.228	2.840	5.679	8.519	11.358	14.198	17.038
50	29.035	2.838	5.675	8.513	11.350	14.188	17.026
14 00	....	2.836	5.671	8.507	11.342	14.178	17.014
10	5.808	2.834	5.667	8.500	11.334	14.168	17.001
20	11.615	2.831	5.663	8.494	11.326	14.157	16.988
30	17.422	2.829	5.658	8.488	11.317	14.146	16.975
40	23.230	2.827	5.654	8.481	11.308	14.136	16.963
50	29.038	2.825	5.650	8.475	11.300	14.125	16.950
15 00	....	2.823	5.646	8.469	11.292	14.114	16.937
10	5.808	2.821	5.641	8.462	11.282	14.103	16.924
20	11.616	2.818	5.637	8.455	11.274	14.092	16.910
30	17.424	2.816	5.632	8.448	11.264	14.080	16.897
40	23.232	2.814	5.628	8.441	11.255	14.069	16.883
50	29.040	2.812	5.623	8.435	11.246	14.058	16.870
16 00	....	2.809	5.619	8.428	11.237	14.046	16.856

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	8°	9°
	Inches.	*Inches.*
5′	0.000	0.000
10	.001	.001
15	.003	.003
20	.005	.005
25	.007	.008
30	.010	.012
	10°	**11°**
5	0.000	0.000
10	.001	.002
15	.003	.004
20	.006	.006
25	.009	.010
30	.013	.014
	12°	**13°**
5	0.000	0.000
10	.002	.002
15	.004	.004
20	.007	.007
25	.011	.012
30	.016	.017
	14°	**15°**
5	0.000	0.001
10	.002	.002
15	.004	.005
20	.008	.009
25	.012	.013
30	.018	.019
	16°	
5	0.001	
10	.002	
15	.005	
20	.009	
25	.014	
30	.020	

Table 20.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	Abscissas of developed parallel. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
16°00′	....	2.809	5.619	8.428	11.237	14.046	16.856
10	5.809	2.807	5.614	8.421	11.228	14.034	16.841
20	11.617	2.804	5.609	8.414	11.218	14.022	16.827
30	17.426	2.802	5.604	8.406	11.208	14.010	16.813
40	23.234	2.800	5.599	8.399	11.199	13.998	16.798
50	29.043	2.797	5.595	8.392	11.189	13.986	16.784
17 00	....	2.795	5.590	8.385	11.180	13.974	16.769
10	5.809	2.792	5.585	8.377	11.170	13.962	16.754
20	11.618	2.790	5.580	8.369	11.159	13.949	16.739
30	17.427	2.787	5.575	8.362	11.149	13.936	16.724
40	23.236	2.785	5.570	8.354	11.139	13.924	16.709
50	29.046	2.782	5.564	8.347	11.129	13.911	16.693
18 00	....	2.780	5.559	8.339	11.119	13.898	16.678
10	5.810	2.777	5.554	8.331	11.108	13.885	16.662
20	11.619	2.774	5.549	8.323	11.097	13.872	16.646
30	17.429	2.772	5.543	8.315	11.087	13.859	16.630
40	23.239	2.769	5.538	8.307	11.076	13.845	16.614
50	29.049	2.766	5.533	8.299	11.065	13.832	16.598
19 00	....	2.764	5.527	8.291	11.054	13.818	16.582
10	5.810	2.761	5.522	8.282	11.043	13.804	16.565
20	11.621	2.758	5.516	8.274	11.032	13.790	16.548
30	17.431	2.755	5.510	8.266	11.021	13.776	16.531
40	23.242	2.752	5.505	8.257	11.009	13.762	16.514
50	29.052	2.750	5.499	8.249	10.998	13.748	16.497
20 00	....	2.747	5.493	8.240	10.987	13.734	16.480
10	5.811	2.743	5.487	8.231	10.975	13.719	16.462
20	11.622	2.741	5.482	8.222	10.963	13.704	16.445
30	17.433	2.738	5.476	8.213	10.951	13.689	16.427
40	23.244	2.735	5.470	8.204	10.939	13.674	16.409
50	29.055	2.732	5.464	8.196	10.928	13.660	16.391
21 00	....	2.729	5.458	8.187	10.916	13.645	16.373
10	5.812	2.726	5.452	8.177	10.903	13.629	16.355
20	11.623	2.723	5.445	8.168	10.891	13.614	16.336
30	17.435	2.720	5.439	8.159	10.878	13.598	16.318
40	23.247	2.717	5.433	8.150	10.866	13.583	16.300
50	29.058	2.714	5.427	8.141	10.854	13.568	16.281
22 00	....	2.710	5.421	8.131	10.842	13.552	16.262
10	5.812	2.707	5.414	8.122	10.829	13.536	16.243
20	11.625	2.704	5.408	8.112	10.816	13.520	16.223
30	17.437	2.701	5.401	8.102	10.802	13.503	16.204
40	23.250	2.697	5.395	8.092	10.790	13.487	16.184
50	29.062	2.694	5.388	8.083	10.777	13.471	16.165
23 00	....	2.691	5.382	8.073	10.764	13.455	16.145
10	5.813	2.688	5.375	8.063	10.750	13.438	16.125
20	11.626	2.684	5.368	8.053	10.737	13.421	16.105
30	17.439	2.681	5.362	8.042	10.723	13.404	16.085
40	23.252	2.677	5.355	8.032	10.710	13.387	16.064
50	29.066	2.674	5.348	8.022	10.696	13.371	16.045
24 00	....	2.671	5.341	8.012	10.683	13.354	16.024

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	16°	17°
	Inches.	*Inches.*
5′	0.001	0.001
10	.002	.002
15	.005	.005
20	.009	.010
25	.014	.015
30	.020	.021
	18°	**19°**
5	0.001	0.001
10	.002	.003
15	.006	.006
20	.010	.010
25	.016	.016
30	.022	.024
	20°	**21°**
5	0.001	0.001
10	.003	.003
15	.006	.006
20	.011	.011
25	.017	.018
30	.025	.026
	22°	**23°**
5	0.001	0.001
10	.003	.003
15	.007	.007
20	.012	.012
25	.018	.019
30	.027	.028
	24°	
5	0.001	
10	.003	
15	.007	
20	.013	
25	.020	
30	.028	

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii-lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
24°00′	....	2.671	5.341	8.012	10.683	13.354	16.024
10	5.814	2.667	5.334	8.002	10.669	13.336	16.003
20	11.628	2.664	5.327	7.991	10.655	13.319	15.982
30	17.442	2.660	5.320	7.981	10.641	13.301	15.961
40	23.256	2.657	5.313	7.970	10.627	13.284	15.940
50	29.069	2.653	5.306	7.960	10.613	13.266	15.919
25 00	....	2.650	5.299	7.949	10.599	13.249	15.898
10	5.815	2.646	5.292	7.938	10.584	13.231	15.877
20	11.629	2.642	5.285	7.927	10.570	13.212	15.854
30	17.444	2.639	5.278	7.916	10.555	13.194	15.833
40	23.259	2.635	5.270	7.905	10.540	13.176	15.811
50	29.074	2.631	5.263	7.894	10.526	13.157	15.788
26 00	....	2.628	5.256	7.883	10.511	13.139	15.767
10	5.816	2.624	5.248	7.872	10.496	13.120	15.744
20	11.631	2.620	5.240	7.861	10.481	13.101	15.721
30	17.446	2.616	5.233	7.849	10.466	13.082	15.698
40	23.262	2.613	5.225	7.838	10.451	13.063	15.676
50	29.077	2.609	5.218	7.827	10.436	13.045	15.654
27 00	....	2.605	5.210	7.816	10.421	13.026	15.631
10	5.816	2.601	5.203	7.804	10.405	13.006	15.608
20	11.633	2.597	5.195	7.792	10.390	12.987	15.584
30	17.449	2.593	5.187	7.780	10.374	12.967	15.560
40	23.265	2.589	5.179	7.768	10.358	12.947	15.537
50	29.082	2.586	5.171	7.757	10.342	12.928	15.514
28 00	....	2.582	5.163	7.745	10.327	12.909	15.490
10	5.817	2.578	5.155	7.733	10.311	12.889	15.466
20	11.634	2.574	5.147	7.721	10.294	12.868	15.442
30	17.451	2.570	5.139	7.709	10.278	12.848	15.418
40	23.268	2.566	5.131	7.697	10.262	12.828	15.394
50	29.086	2.562	5.123	7.685	10.246	12.808	15.369
29 00	....	2.558	5.115	7.673	10.230	12.788	15.345
10	5.818	2.553	5.107	7.660	10.213	12.767	15.320
20	11.636	2.549	5.098	7.648	10.197	12.746	15.295
30	17.454	2.545	5.090	7.635	10.180	12.725	15.270
40	23.272	2.541	5.082	7.622	10.163	12.704	15.245
50	29.090	2.537	5.073	7.610	10.146	12.683	15.220
30 00	....	2.533	5.065	7.598	10.130	12.662	15.195
10	5.819	2.528	5.056	7.585	10.113	12.641	15.169
20	11.638	2.524	5.048	7.572	10.096	12.620	15.143
30	17.457	2.520	5.039	7.559	10.078	12.598	15.118
40	23.276	2.515	5.031	7.546	10.061	12.577	15.092
50	29.094	2.511	5.022	7.533	10.044	12.555	15.066
31 00	....	2.507	5.014	7.520	10.027	12.534	15.040
10	5.820	2.502	5.005	7.507	10.009	12.512	15.014
20	11.640	2.498	4.996	7.494	9.992	12.490	14.987
30	17.460	2.493	4.987	7.480	9.974	12.467	14.960
40	23.280	2.489	4.978	7.467	9.956	12.445	14.934
50	29.100	2.485	4.969	7.454	9.938	12.423	14.908
32 00	....	2.480	4.960	7.441	9.921	12.401	14.881

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	24°	25°
	Inches.	*Inches.*
5′	0.001	0.001
10	.003	.003
15	.007	.007
20	.013	.013
25	.020	.020
30	.028	.029
	26°	**27°**
5	0.001	0.001
10	.003	.003
15	.008	.008
20	.013	.014
25	.021	.022
30	.030	.031
	28°	**29°**
5	0.001	0.001
10	.004	.004
15	.008	.008
20	.014	.014
25	.022	.023
30	.032	.032
	30°	**31°**
5	0.001	0.001
10	.004	.004
15	.008	.008
20	.015	.015
25	.023	.023
30	.033	.034
	32°	
5	0.001	
10	.004	
15	.009	
20	.015	
25	.024	
30	.034	

TABLE 20.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
32°00′	....	2.480	4.960	7.441	9.921	12.401	14.881
10	5.821	2.476	4.951	7.427	9.903	12.379	14.854
20	11.642	2.471	4.942	7.413	9.884	12.355	14.827
30	17.462	2.467	4.933	7.400	9.866	12.333	14.800
40	23.283	2.462	4.924	7.386	9.848	12.310	14.772
50	29.104	2.458	4.915	7.373	9.830	12.288	14.745
33 00	....	2.453	4.906	7.359	9.812	12.265	14.717
10	5.822	2.448	4.896	7.345	9.793	12.241	14.689
20	11.643	2.444	4.887	7.331	9.774	12.218	14.661
30	17.465	2.439	4.878	7.316	9.755	12.194	14.633
40	23.287	2.434	4.868	7.302	9.736	12.171	14.605
50	29.109	2.429	4.859	7.288	9.718	12.147	14.576
34 00	....	2.425	4.850	7.274	9.699	12.124	14.549
10	5.823	2.420	4.840	7.260	9.680	12.100	14.520
20	11.645	2.415	4.830	7.246	9.661	12.076	14.491
30	17.468	2.410	4.821	7.231	9.642	12.052	14.462
40	23.291	2.406	4.811	7.217	9.622	12.028	14.434
50	29.113	2.401	4.802	7.203	9.604	12.004	14.405
35 00	....	2.396	4.792	7.188	9.584	11.980	14.376
10	5.824	2.391	4.782	7.174	9.565	11.956	14.347
20	11.647	2.386	4.773	7.159	9.545	11.932	14.318
30	17.471	2.381	4.763	7.144	9.526	11.907	14.288
40	23.294	2.377	4.753	7.130	9.506	11.883	14.259
50	29.118	2.372	4.743	7.115	9.486	11.858	14.230
36 00	....	2.367	4.733	7.099	9.466	11.833	14.200
10	5.824	2.362	4.723	7.085	9.446	11.808	14.170
20	11.649	2.357	4.713	7.070	9.426	11.783	14.139
30	17.473	2.351	4.703	7.055	9.406	11.757	14.109
40	23.297	2.346	4.693	7.039	9.386	11.732	14.078
50	29.122	2.341	4.683	7.024	9.366	11.707	14.048
37 00	....	2.336	4.673	7.009	9.345	11.682	14.018
10	5.826	2.331	4.662	6.994	9.325	11.656	13.987
20	11.651	2.326	4.652	6.978	9.304	11.630	13.956
30	17.477	2.321	4.642	6.963	9.284	11.605	13.925
40	23.302	2.316	4.631	6.947	9.263	11.579	13.894
50	29.128	2.311	4.621	6.932	9.242	11.553	13.864
38 00	....	2.305	4.611	6.916	9.222	11.527	13.832
10	5.827	2.300	4.600	6.900	9.200	11.501	13.801
20	11.653	2.295	4.590	6.884	9.179	11.474	13.769
30	17.480	2.290	4.579	6.869	9.158	11.448	13.737
40	23.306	2.284	4.568	6.853	9.137	11.421	13.705
50	29.133	2.279	4.558	6.837	9.116	11.395	13.673
39 00	....	2.274	4.548	6.821	9.095	11.369	13.642
10	5.828	2.268	4.537	6.805	9.073	11.342	13.610
20	11.655	2.263	4.526	6.789	9.052	11.315	13.577
30	17.483	2.258	4.515	6.773	9.030	11.288	13.545
40	23.310	2.252	4.504	6.756	9.008	11.261	13.513
50	29.138	2.247	4.493	6.740	8.987	11.234	13.480
40 00	....	2.241	4.483	6.724	8.965	11.207	13.448

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	32°	33°
	Inches.	*Inches.*
5′	0.001	0.001
10	.004	.004
15	.009	.009
20	.015	.016
25	.024	.024
30	.034	.035

Longitude interval.	34°	35°
5	0.001	0.001
10	.004	.004
15	.009	.009
20	.016	.016
25	.025	.025
30	.036	.036

Longitude interval.	36°	37°
5	0.001	0.001
10	.004	.004
15	.009	.009
20	.016	.016
25	.025	.026
30	.036	.037

Longitude interval.	38°	39°
5	0.001	0.001
10	.004	.004
15	.009	.009
20	.017	.017
25	.026	.026
30	.037	.037

Longitude interval.	40°
5	0.001
10	.004
15	.009
20	.017
25	.026
30	.038

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii-lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
40°00′	....	2.241	4.483	6.724	8.965	11.207	13.448
10	5.829	2.236	4.472	6.707	8.943	11.179	13.415
20	11.657	2.230	4.461	6.691	8.921	11.152	13.382
30	17.486	2.225	4.450	6.674	8.899	11.124	13.349
40	23.314	2.219	4.439	6.658	8.877	11.097	13.316
50	29.143	2.214	4.428	6.641	8.855	11.069	13.283
41 00	....	2.208	4.417	6.625	8.834	11.042	13.250
10	5.830	2.203	4.406	6.608	8.811	11.014	13.217
20	11.659	2.197	4.394	6.591	8.788	10.985	13.183
30	17.489	2.192	4.383	6.575	8.766	10.958	13.149
40	23.319	2.186	4.372	6.558	8.744	10.929	13.115
50	29.149	2.180	4.360	6.541	8.721	10.901	13.081
42 00	....	2.175	4.349	6.524	8.698	10.873	13.048
10	5.831	2.169	4.338	6.507	8.676	10.844	13.013
20	11.661	2.163	4.326	6.490	8.653	10.816	12.979
30	17.492	2.157	4.315	6.472	8.630	10.787	12.945
40	23.323	2.152	4.303	6.455	8.607	10.759	12.910
50	29.154	2.146	4.292	6.438	8.584	10.730	12.876
43 00	....	2.140	4.281	6.421	8.561	10.702	12.842
10	5.832	2.135	4.269	6.403	8.538	10.672	12.807
20	11.663	2.129	4.257	6.386	8.514	10.643	12.772
30	17.495	2.123	4.246	6.368	8.491	10.614	12.737
40	23.327	2.117	4.234	6.351	8.468	10.585	12.701
50	29.159	2.111	4.222	6.333	8.444	10.556	12.667
44 00	....	2.105	4.210	6.316	8.421	10.526	12.631
10	5.833	2.099	4.199	6.298	8.397	10.496	12.596
20	11.666	2.093	4.187	6.280	8.373	10.467	12.560
30	17.498	2.087	4.175	6.262	8.350	10.437	12.524
40	23.331	2.081	4.163	6.244	8.326	10.407	12.489
50	29.164	2.076	4.151	6.227	8.302	10.378	12.453
45 00	....	2.070	4.139	6.209	8.278	10.348	12.417
10	5.834	2.064	4.127	6.191	8.254	10.317	12.381
20	11.668	2.057	4.115	6.172	8.230	10.288	12.345
30	17.501	2.051	4.103	6.154	8.206	10.257	12.308
40	23.335	2.045	4.091	6.136	8.181	10.226	12.272
50	29.169	2.039	4.079	6.118	8.157	10.197	12.236
46 00	....	2.033	4.067	6.100	8.133	10.166	12.199
10	5.835	2.027	4.054	6.081	8.108	10.136	12.163
20	11.670	2.021	4.042	6.063	8.084	10.104	12.125
30	17.504	2.015	4.030	6.044	8.059	10.074	12.089
40	23.339	2.009	4.017	6.026	8.034	10.043	12.052
50	29.174	2.003	4.005	6.008	8.010	10.013	12.015
47 00	....	1.996	3.992	5.989	7.985	9.981	11.978
10	5.836	1.990	3.980	5.970	7.960	9.951	11.941
20	11.672	1.984	3.968	5.951	7.935	9.919	11.903
30	17.508	1.978	3.955	5.933	7.910	9.888	11.866
40	23.344	1.971	3.943	5.914	7.885	9.857	11.828
50	29.180	1.965	3.930	5.895	7.860	9.826	11.791
48 00	....	1.959	3.917	5.876	7.835	9.794	11.752

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	40°	41°	42°	43°	44°	45°	46°	47°	48°
	Inches.	*Inches.*							
5′	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
10	.004	.004	.004	.004	.004	.004	.004	.004	.004
15	.009	.009	.010	.010	.010	.010	.010	.010	.010
20	.017	.017	.017	.017	.017	.017	.017	.017	.017
25	.026	.026	.026	.027	.027	.027	.027	.027	.026
30	.038	.038	.038	.038	.038	.038	.038	.038	.038

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	Abscissas of developed parallel. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
48°00′	....	1.959	3.917	5.876	7.835	9.794	11.752
10	5.837	1.952	3.905	5.857	7.810	9.762	11.714
20	11.674	1.946	3.892	5.838	7.784	9.730	11.677
30	17.511	1.940	3.879	5.819	7.759	9.699	11.638
40	23.348	1.933	3.867	5.800	7.733	9.667	11.600
50	29.185	1.927	3.854	5.781	7.708	9.635	11.562
49 00	....	1.921	3.841	5.762	7.682	9.603	11.523
10	5.838	1.914	3.828	5.743	7.657	9.571	11.485
20	11.676	1.908	3.815	5.723	7.631	9.539	11.446
30	17.514	1.901	3.803	5.704	7.605	9.507	11.408
40	23.352	1.895	3.790	5.684	7.579	9.474	11.369
50	29.190	1.888	3.777	5.665	7.553	9.442	11.330
50 00	....	1.882	3.764	5.646	7.527	9.409	11.291
10	5.839	1.875	3.750	5.626	7.501	9.376	11.251
20	11.678	1.869	3.737	5.606	7.475	9.344	11.212
30	17.517	1.862	3.724	5.587	7.449	9.311	11.173
40	23.356	1.856	3.711	5.567	7.422	9.278	11.134
50	29.194	1.849	3.698	5.547	7.396	9.245	11.094
51 00	....	1.842	3.685	5.528	7.370	9.212	11.055
10	5.840	1.836	3.672	5.507	7.343	9.179	11.015
20	11.680	1.829	3.658	5.488	7.317	9.146	10.975
30	17.520	1.823	3.645	5.468	7.290	9.113	10.936
40	23.360	1.816	3.632	5.448	7.264	9.080	10 895
50	29.200	1.809	3.618	5.428	7.237	9.046	10.855
52 00	....	1.803	3.605	5.408	7.210	9.013	10.816
10	5.841	1.796	3.592	5.388	7.184	8.980	10.775
20	11.682	1.789	3.578	5.367	7.156	8.946	10.734
30	17.523	1.782	3.565	5.347	7.130	8.912	10.694
40	23.364	1.776	3.551	5.327	7.103	8.878	10.654
50	29.204	1.769	3.538	5.307	7.076	8.844	10.613
53 00	....	1.762	3.524	5.287	7.049	8.811	10.573
10	5.842	1.755	3.511	5.266	7.022	8.777	10.532
20	11.684	1.748	3.497	5.246	6.994	8.742	10.491
30	17.526	1.742	3.483	5.225	6.967	8.708	10.450
40	23.368	1.735	3.470	5.205	6.940	8.674	10.409
50	29.210	1.728	3.456	5.184	6.912	8.640	10.368
54 00	....	1.721	3.442	5.164	6.885	8.606	10.327
10	5.843	1.714	3.429	5.143	6.857	8.572	10.286
20	11.686	1.707	3.415	5.122	6.830	8.537	10.244
30	17.529	1.700	3.401	5.101	6.802	8.502	10.202
40	23.372	1.694	3.387	5.080	6.774	8.468	10.161
50	29.214	1.687	3.373	5.060	6.746	8.433	10.120
55 00	....	1.680	3.359	5.039	6.719	8.398	10.078
10	5.844	1.673	3.345	5.018	6.691	8.364	10.036
20	11.688	1.666	3.331	4.997	6.663	8.328	9.994
30	17.532	1.659	3.317	4.976	6.635	8.294	9.952
40	23.376	1.652	3.303	4.955	6.607	8.258	9.910
50	29.220	1.645	3.289	4.934	6.579	8.224	9.868
56 00	....	1.638	3.275	4.913	6.551	8.188	9.826

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	48°	49°
	Inches.	*Inches.*
5′	0.001	0.001
10	.004	.004
15	.010	.010
20	.017	.017
25	.026	.026
30	.038	.038
	50°	**51°**
5	0.001	0.001
10	.004	.004
15	.009	.009
20	.017	017
25	.026	.026
30	.038	.037
	52°	**53°**
5	0.001	0.001
10	.004	.004
15	.009	.009
20	.017	.016
25	.026	.026
30	.037	.037
	54°	**55°**
5	0.001	0.001
10	.004	.004
15	.009	.009
20	.016	.016
25	.025	.025
30	.036	.036
	56°	
5	0.001	
10	.004	
15	.009	
20	.016	
25	.025	
30	.036	

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude	25′ longitude	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
56°00′	....	1.638	3.275	4.913	6.551	8.188	9.826
10	5.845	1.631	3.261	4.892	6.522	8.153	9.784
20	11.690	1.624	3.247	4.870	6.494	8.118	9.741
30	17.535	1.616	3.233	4.849	6.466	8.082	9.698
40	23.380	1.609	3.219	4.828	6.437	8.046	9.656
50	29.224	1.602	3.204	4.807	6.409	8.011	9.613
57 00	....	1.595	3.190	4.785	6.380	7.976	9.571
10	5.846	1.588	3.176	4.764	6.352	7.940	9.527
20	11.692	1.581	3.162	4.742	6.323	7.904	9.485
30	17.537	1.574	3.147	4.721	6.294	7.868	9.442
40	23.383	1.566	3.133	4.699	6.266	7.832	9.398
50	29.229	1.559	3.119	4.678	6.237	7.796	9.356
58 00	....	1.552	3.104	4.656	6.208	7.760	9.313
10	5.847	1.545	3.090	4.634	6.179	7.724	9.269
20	11.694	1.538	3.075	4.613	6.150	7.688	9.226
30	17.540	1.530	3.061	4.591	6.122	7.652	9.182
40	23.387	1.523	3.046	4.569	6.092	7.616	9.139
50	29.234	1.516	3.032	4.547	6.063	7.579	9.095
59 00	......	1.509	3.017	4.526	6.034	7.543	9.052
10	5.848	1.501	3.003	4.504	6.005	7.506	9.008
20	11.695	1.494	2.988	4.482	5.976	7.470	8.963
30	17.543	1.487	2.973	4.460	5.946	7.433	8.920
40	23.391	1.479	2.959	4.438	5.917	7.396	8.876
50	29.238	1.472	2.944	4.416	5.888	7.360	8.831
60 00	....	1.465	2.929	4.394	5.858	7.323	8.788
10	5.849	1.457	2.914	4.372	5.829	7.286	8.743
20	11.697	1.450	2.900	4.349	5.799	7.249	8.699
30	17.546	1.442	2.885	4.327	5.770	7.212	8.654
40	23.394	1.435	2.870	4.305	5.740	7.175	8.610
50	29.243	1.428	2.855	4.283	5.710	7.138	8.566
61 00	....	1.420	2.840	4.261	5.681	7.101	8.521
10	5.850	1.413	2.825	4.238	5.651	7.064	8.476
20	11.699	1.405	2.810	4.216	5.621	7.026	8.431
30	17.549	1.398	2.795	4.193	5.591	6.988	8.386
40	23.398	1.390	2.781	4.171	5.561	6.952	8.342
50	29.248	1.383	2.766	4.148	5.531	6.914	8.297
62 00	....	1.375	2.751	4.126	5.501	6.877	8.252
10	5.850	1.368	2.736	4.103	5.471	6.839	8.207
20	11.701	1.360	2.720	4.081	5.441	6.801	8.161
30	17.551	1.353	2.705	4.058	5.410	6.763	8.116
40	23.402	1.345	2.690	4.035	5.380	6.726	8.071
50	29.252	1.338	2.675	4.013	5.350	6.688	8.026
63 00	....	1.330	2.660	3.990	5.320	6.650	7.980
10	5.851	1.322	2.645	3.967	5.290	6.612	7.934
20	11.702	1.315	2.630	3.944	5.259	6.574	7.889
30	17.554	1.307	2.614	3.921	5.228	6.536	7.843
40	23.405	1.300	2.599	3.899	5.198	6.498	7.797
50	29.256	1.292	2.584	3.876	5.168	6.460	7.751
64 00	....	1.284	2.569	3.853	5.137	6.422	7.706

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	56°	57°
	Inches.	*Inches.*
5′	0.001	0.001
10	.004	.004
15	.009	.009
20	.016	.016
25	.025	.024
30	.036	.035
	58°	**59°**
5	0.001	0.001
10	.004	.004
15	.009	.008
20	.015	.015
25	.024	.024
30	.034	.034
	60°	**61°**
5	0.001	0.001
10	.004	.004
15	.008	.008
20	.015	.014
25	.023	.023
30	.033	.033
	62°	**63°**
5	0.001	0.001
10	.004	.003
15	.008	.008
20	.014	.014
25	.022	.022
30	.032	.031
	64°	
5	0.001	
10	.003	
15	.008	
20	.013	
25	.021	
30	.030	

TABLE 20.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
64°00′	....	1.284	2.569	3.853	5.137	6.422	7.706
10	5.852	1.277	2.553	3.830	5.106	6.383	7.660
20	11.704	1.269	2.538	3.807	5.076	6.345	7.614
30	17.556	1.261	2.523	3.784	5.045	6.307	7.568
40	23.408	1.254	2.507	3.761	5.014	6.268	7.522
50	29.260	1.246	2.492	3.738	4.984	6.230	7.476
65 00	....	1.238	2.477	3.715	4.953	6.192	7.430
10	5.853	1.231	2.461	3.692	4.922	6.153	7.384
20	11.706	1.223	2.446	3.668	4.891	6.114	7.337
30	17.558	1.215	2.430	3.645	4.860	6.075	7.290
40	23.411	1.207	2.415	3.622	4.829	6.037	7.244
50	29.264	1.200	2.399	3.599	4.798	5.998	7.198
66 00	....	1.192	2.384	3.575	4.767	5.959	7.151
10	5.854	1.184	2.368	3.552	4.736	5.920	7.104
20	11.707	1.176	2.352	3.529	4.705	5.881	7.057
30	17.561	1.168	2.337	3.505	4.673	5.842	7.010
40	23.414	1.161	2.321	3.482	4.642	5.803	6.963
50	29.268	1.153	2.305	3.458	4.611	5.764	6.916
67 00	....	1.145	2.290	3.435	4.580	5.725	6.869
10	5.854	1.137	2.274	3.411	4.548	5.685	6.822
20	11.709	1.129	2.258	3.388	4.517	5.646	6.775
30	17.563	1.121	2.243	3.364	4.485	5.607	6.728
40	23.418	1.113	2.227	3.340	4.454	5.567	6.680
50	29.272	1.106	2.211	3.317	4.422	5.528	6.634
68 00	....	1.098	2.195	3.293	4.391	5.489	6.586
10	5.855	1.090	2.180	3.269	4.359	5.449	6.539
20	11.710	1.082	2.164	3.246	4.328	5.410	6.491
30	17.565	1.074	2.148	3.222	4.296	5.370	6.443
40	23.420	1.066	2.132	3.198	4.264	5.330	6.396
50	29.276	1.058	2.116	3.174	4.232	5.291	6.349
69 00	....	1.050	2.100	3.151	4.201	5.251	6.301
10	5.856	1.042	2.084	3.127	4.169	5.211	6.253
20	11.712	1.034	2.068	3.103	4.137	5.171	6.205
30	17.567	1.026	2.052	3.079	4.105	5.131	6.157
40	23.423	1.018	2.037	3.055	4.073	5.092	6.110
50	29.279	1.010	2.021	3.031	4.041	5.052	6.062
70 00	....	1.002	2.005	3.007	4.009	5.012	6.014
10	5.856	.994	1.989	2.983	3.977	4.972	5.966
20	11.713	.986	1.972	2.959	3.945	4.931	5.917
30	17.570	.978	1.956	2.935	3.913	4.891	5.869
40	23.426	.970	1.940	2.911	3.881	4.851	5.821
50	29.282	.962	1.924	2.886	3.848	4.811	5.773
71 00	....	.954	1.908	2.862	3.816	4.771	5.725
10	5.857	.946	1.892	2.838	3.784	4.730	5.676
20	11.714	.938	1.876	2.814	3.752	4.690	5.628
30	17.572	.930	1.860	2.790	3.720	4.650	5.579
40	23.429	.922	1.844	2.765	3.687	4.609	5.531
50	29.286	.914	1.828	2.741	3.655	4.569	5.483
72 00	....	.906	1.811	2.717	3.623	4.529	5.434

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	64°	65°
	Inches.	*Inches.*
5′	0.001	0.001
10	.003	.003
15	.008	.007
20	.013	.013
25	.021	.020
30	.030	.029
	66°	67°
5	0.001	0.001
10	.003	.003
15	.007	.007
20	.013	.012
25	.020	.019
30	.029	.028
	68°	69°
5	0.001	0.001
10	.003	.003
15	.007	.006
20	.012	.011
25	.019	.018
30	.027	.026
	70°	71°
5	0.001	0.001
10	.003	.003
15	.006	.006
20	.011	.010
25	.017	.016
30	.024	.024
	72°	
5	0.001	
10	.003	
15	.006	
20	.010	
25	.016	
30	.023	

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{125000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
72°00′	....	.906	1.811	2.717	3.623	4.529	5.434
10	5.858	.898	1.795	2.693	3.590	4.488	5.386
20	11.716	.889	1.779	2.668	3.558	4.447	5.336
30	17.573	.881	1.763	2.644	3.525	4.407	5.288
40	23.431	.873	1.746	2.620	3.493	4.366	5.239
50	29.289	.865	1.730	2.595	3.460	4.325	5.190
73 00	....	.857	1.714	2.571	3.428	4.285	5.141
10	5.858	.849	1.697	2.546	3.395	4.244	5.092
20	11.717	.841	1.681	2.522	3.362	4.203	5.044
30	17.575	.832	1.665	2.497	3.330	4.162	4.994
40	23.434	.824	1.648	2.473	3.297	4.121	4.945
50	29.292	.816	1.632	2.448	3.264	4.081	4.897
74 00	....	.808	1.616	2.424	3.232	4.040	4.847
10	5.859	.800	1.599	2.399	3.199	3.999	4.798
20	11.718	.791	1.583	2.374	3.160	3.957	4.748
30	17.577	.783	1.566	2.350	3.133	3.916	4.699
40	23.436	.775	1.550	2.325	3.100	3.875	4.650
50	29.295	.767	1.534	2.300	3.067	3.834	4.601
75 00	....	.759	1.517	2.276	3.034	3.793	4.552
10	5.860	.750	1.501	2.251	3.002	3.752	4.502
20	11.719	.742	1.484	2.226	2.968	3.711	4.453
30	17.578	.734	1.468	2.201	2.935	3.669	4.403
40	23.438	.726	1.451	2.177	2.902	3.628	4.354
50	29.298	.717	1.435	2.152	2.870	3.587	4.304
76 00	....	.709	1.418	2.127	2.836	3.546	4.255
10	5.860	.701	1.402	2.102	2.803	3.504	4.205
20	11.720	.692	1.385	2.078	2.770	3.463	4.155
30	17.580	.684	1.368	2.053	2.737	3.421	4.105
40	23.440	.676	1.352	2.028	2.704	3.380	4.056
50	29.300	.668	1.335	2.003	2.671	3.339	4.006
77 00	....	.659	1.319	1.978	2.638	3.297	3.956
10	5.860	.651	1.302	1.953	2.604	3.256	3.907
20	11.721	.643	1.285	1.928	2.571	3.214	3.856
30	17.582	.634	1.269	1.903	2.538	3.172	3.806
40	23.442	.626	1.252	1.878	2.504	3.131	3.757
50	29.302	.618	1.235	1.853	2.471	3.089	3.706
78 00	....	.609	1.219	1.828	2.438	3.047	3.656
10	5.861	.601	1.202	1.803	2.404	3.005	3.606
20	11.722	.593	1.185	1.778	2.371	2.964	3.556
30	17.583	.584	1.169	1.753	2.338	2.922	3.506
40	23.444	.576	1.152	1.728	2.304	2.880	3.456
50	29.304	.568	1.135	1.703	2.270	2.838	3.406
79 00	....	.559	1.119	1.678	2.237	2.797	3.356
10	5.861	.551	1.102	1.653	2.204	2.755	3.305
20	11.723	.542	1.085	1.628	2.170	2.713	3.255
30	17.584	.534	1.068	1.602	2.136	2.671	3.205
40	23.445	.526	1.052	1.577	2.103	2.629	3.155
50	29.306	.517	1.035	1.552	2.070	2.587	3.104
80 00	....	.509	1.018	1.527	2.036	2.545	3.054

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	72°	73°
	Inches.	*Inches.*
5′	0.001	0.001
10	.003	.002
15	.006	.005
20	.010	.010
25	.016	.015
30	.023	.021
	74°	**75°**
5	0.001	0.001
10	.002	.002
15	.005	.005
20	.009	.009
25	.014	.013
30	.020	.019
	76°	**77°**
5	0.001	0.000
10	.002	.002
15	.005	.004
20	.008	.007
25	.013	.012
30	.018	.017
	78°	**79°**
5	0.000	0.000
10	.002	.002
15	.004	.004
20	.007	.006
25	.011	.010
30	.016	.014

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{126720}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR— 15′ longitude. x	15′ longitude. y	30′ longitude. x	30′ longitude. y	45′ longitude. x	45′ longitude. y	1° longitude. x	1° longitude. y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
0°00′	....	8.647	.000	17.293	.000	25.940	.000	34.586	.000
15	8.588	8.646	.000	17.293	.001	25.939	.001	34.585	.001
30	17.176	8.646	.000	17.292	.001	25.938	.001	34.584	.003
45	25.764	8.646	.000	17.291	.001	25.937	.002	34.582	.004
1 00	34.352	8.645	.000	17.291	.001	25.936	.003	34.581	.005
15	8.588	8.644	.000	17.289	.002	25.933	.003	34.577	.007
30	17.176	8.643	.000	17.287	.002	25.930	.004	34.573	.008
45	25.764	8.642	.001	17.285	.002	25.927	.005	34.569	.009
2 00	34.352	8.641	.001	17.283	.003	25.924	.006	34.565	.011
15	8.588	8.640	.001	17.279	.003	25.919	.007	34.559	.012
30	17.176	8.638	.001	17.276	.003	25.914	.007	34.552	.014
45	25.765	8.636	.001	17.273	.004	25.909	.008	34.546	.015
3 00	34.353	8.635	.001	17.270	.004	25.904	.009	34.539	.016
15	8.588	8.633	.001	17.265	.004	25.898	.009	34.530	.018
30	17.177	8.630	.001	17.260	.005	25.891	.010	34.521	.019
45	25.765	8.628	.001	17.256	.005	25.884	.011	34.512	.020
4 00	34.353	8.626	.001	17.251	.005	25.877	.012	34.502	.021
15	8.589	8.623	.001	17.245	.006	25.868	.012	34.491	.023
30	17.177	8.620	.001	17.240	.006	25.859	.013	34.479	.024
45	25.766	8.617	.002	17.234	.006	25.850	.014	34.467	.025
5 00	34.354	8.614	.002	17.228	.007	25.842	.015	34.456	.026
15	8.589	8.610	.002	17.221	.007	25.831	.016	34.441	.028
30	17.177	8.607	.002	17.213	.007	25.820	.016	34.427	.029
45	25.766	8.603	.002	17.206	.008	25.809	.017	34.412	.030
6 00	34.355	8.600	.002	17.199	.008	25.799	.018	34.398	.031
15	8.589	8.595	.002	17.191	.008	25.786	.019	34.381	.033
30	17.178	8.591	.002	17.182	.008	25.773	.020	34.364	.034
45	25.767	8.587	.002	17.174	.009	25.760	.021	34.347	.035
7 00	34.356	8.583	.002	17.165	.009	25.748	.021	34.330	.037
15	8.589	8.578	.002	17.155	.009	25.733	.022	34.310	.038
30	17.179	8.573	.003	17.145	.009	25.718	.022	34.291	.040
45	25.768	8.568	.003	17.136	.010	25.704	.023	34.272	.041
8 00	34.358	8.563	.003	17.126	.010	25.689	.023	34.252	.042
15	8.590	8.558	.003	17.115	.010	25.673	.024	34.230	.044
30	17.180	8.552	.003	17.104	.011	25.656	.024	34.208	.045
45	25.769	8.546	.003	17.093	.011	25.639	.025	34.186	.046
9 00	34.359	8.541	.003	17.082	.012	25.622	.026	34.163	.047
15	8.590	8.535	.003	17.069	.012	25.604	.027	34.138	.048
30	17.180	8.528	.003	17.057	.012	25.585	.027	34.114	.050
45	25.771	8.522	.003	17.045	.013	25.567	.028	34.089	.051
10 00	34.361	8.516	.003	17.032	.013	25.548	.029	34.064	.052

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{126720}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR — 15′ longitude. x	15′ longitude. y	30′ longitude. x	30′ longitude. y	45′ longitude. x	45′ longitude. y	1° longitude. x	1° longitude. y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
10°00′	....	8.516	.003	17.032	.013	25.548	.029	34.064	.052
15	8.591	8.509	.003	17.019	.013	25.528	.030	34.037	.054
30	17.181	8.502	.003	17.005	.013	25.507	.031	34.010	.055
45	25.772	8.496	.003	16.991	.014	25.487	.032	33.982	.056
11 00	34.363	8.489	.004	16.977	.014	25.466	.032	33.955	.057
15	8.591	8.481	.004	16.962	.014	25.444	.033	33.925	.058
30	17.183	8.474	.004	16.947	.015	25.421	.033	33.895	.059
45	25.774	8.466	.004	16.933	.015	25.399	.034	33.865	.060
12 00	34.365	8.459	.004	16.918	.015	25.376	.035	33.835	.061
15	8.592	8.451	.004	16.901	.016	25.352	.035	33.803	.063
30	17.184	8.443	.004	16.885	.016	25.328	.036	33.770	.064
45	25.776	8.434	.004	16.869	.016	25.304	.036	33.738	.065
13 00	34.368	8.426	.004	16.853	.017	25.279	.037	33.706	.066
15	8.592	8.418	.004	16.835	.017	25.253	.038	33.671	.067
30	17.185	8.409	.004	16.818	.017	25.227	.039	33.636	.069
45	25.778	8.400	.004	16.800	.018	25.201	.040	33.601	.070
14 00	34.370	8.391	.004	16.783	.018	25.174	.040	33.566	.071
15	8.593	8.382	.005	16.764	.018	25.146	.041	33.528	.072
30	17.186	8.373	.005	16.745	.018	25.118	.041	33.490	.073
45	25.780	8.363	.005	16.726	.019	25.090	.042	33.453	.074
15 00	34.373	8.354	.005	16.708	.019	25.061	.042	33.415	.075
15	8.594	8.344	.005	16.688	.019	25.031	.043	33.375	.077
30	17.188	8.334	.005	16.668	.019	25.001	.044	33.335	.078
45	25.782	8.324	.005	16.647	.020	24.971	.045	33.295	.079
16 00	34.376	8.314	.005	16.627	.020	24.941	.045	33.255	.080
15	8.595	8.303	.005	16.606	.020	24.909	.045	33.212	.081
30	17.190	8.292	.005	16.585	.020	24.877	.046	33.170	.082
45	25.784	8.282	.005	16.564	.021	24.845	.046	33.127	.083
17 00	34.379	8.271	.005	16.542	.021	24.813	.047	33.084	.084
15	8.596	8.260	.005	16.520	.021	24.779	.048	33.039	.085
30	17.191	8.249	.005	16.497	.021	24.746	.049	32.994	.087
45	25.787	8.237	.006	16.475	.022	24.712	.050	32.949	.088
18 00	34.382	8.226	.006	16.452	.022	24.678	.050	32.904	.089
15	8.596	8.214	.006	16.428	.022	24.642	.051	32.856	.090
30	17.193	8.202	.006	16.404	.023	24.607	.051	32.809	.091
45	25.790	8.190	.006	16.381	.023	24.571	.052	32.761	.092
19 00	34.386	8.178	.006	16.357	.023	24.535	.052	32.714	.093
15	8.597	8.166	.006	16.332	.023	24.498	.053	32.664	.094
30	17.195	8.153	.006	16.307	.024	24.460	.054	32.614	.095
45	25.792	8.141	.006	16.282	.024	24.422	.055	32.563	.096
20 00	34.390	8.128	.006	16.257	.024	24.385	.055	32.513	.097

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{126720}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
20°00′	....	8.128	.006	16.257	.024	24.385	.055	32.513	.097
15	8.598	8.115	.006	16.230	.024	24.346	.056	32.461	.098
30	17.197	8.102	.006	16.204	.025	24.306	.056	32.408	.099
45	25.795	8.089	.006	16.178	.025	24.267	.057	32.356	.100
21 00	34.394	8.076	.006	16.152	.025	24.227	.057	32.303	.101
15	8.599	8.062	.006	16.124	.025	24.186	.058	32.248	.102
30	17.199	8.048	.006	16.097	.026	24.145	.058	32.193	.103
45	25.798	8.035	.007	16.069	.026	24.104	.059	32.138	.104
22 00	34.398	8.021	.007	16.042	.026	24.062	.059	32.083	.105
15	8.600	8.006	.007	16.013	.026	24.019	.060	32.026	.106
30	17.201	7.992	.007	15.984	.027	23.976	.060	31.968	.107
45	25.801	7.978	.007	15.955	.027	23.933	.061	31.911	.108
23 00	34.402	7.963	.007	15.927	.027	23.890	.061	31.853	.109
15	8.602	7.948	.007	15.897	.027	23.845	.062	31.794	.109
30	17.203	7.933	.007	15.867	.028	23.800	.062	31.734	.110
45	25.804	7.918	.007	15.837	.028	23.756	.063	31.674	.111
24 00	34.406	7.904	.007	15.807	.028	23.711	.063	31.614	.112
15	8.603	7.888	.007	15.776	.028	23.664	.064	31.552	.113
30	17.205	7.872	.007	15.745	.029	23.617	.064	31.489	.114
45	25.808	7.857	.007	15.713	.029	23.570	.065	31.427	.115
25 00	34.410	7.841	.007	15.682	.029	23.524	.065	31.365	.116
15	8.604	7.825	.007	15.650	.029	23.475	.065	31.300	.117
30	17.207	7.809	.007	15.617	.029	23.426	.066	31.235	.117
45	25.811	7.793	.007	15.585	.030	23.378	.067	31.170	.118
26 00	34.415	7.776	.007	15.553	.030	23.329	.067	31.106	.119
15	8.605	7.760	.007	15.519	.030	23.279	.067	31.039	.120
30	17.210	7.743	.008	15.486	.030	23.229	.068	30.972	.121
45	25.814	7.726	.008	15.452	.030	23.179	.068	30.905	.121
27 00	34.419	7.709	.008	15.419	.031	23.128	.069	30.838	.122
15	8.606	7.692	.008	15.384	.031	23.076	.069	30.769	.123
30	17.212	7.675	.008	15.350	.031	23.024	.070	30.699	.124
45	25.818	7.657	.008	15.315	.031	22.972	.070	30.630	.124
28 00	34.424	7.640	.008	15.280	.031	22.920	.070	30.560	.125
15	8.607	7.622	.008	15.244	.031	22.866	.071	30.489	.126
30	17.215	7.604	.008	15.208	.032	22.813	.071	30.417	.127
45	25.822	7.586	.008	15.173	.032	22.759	.072	30.345	.127
29 00	34.430	7.568	.008	15.137	.032	22.705	.072	30.274	.128
15	8.609	7.550	.008	15.100	.032	22.650	.072	30.200	.129
30	17.217	7.531	.008	15.063	.032	22.594	.073	30.125	.130
45	25.826	7.513	.008	15.026	.033	22.539	.073	30.051	.130
30 00	34.435	7.494	.008	14.989	.033	22.483	.074	29.978	131

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{126720}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
30°00′	....	7.494	.008	14.989	.033	22.483	.074	29.978	.131
15	8.610	7.475	.008	14.951	.033	22.426	.074	29.902	.131
30	17.220	7.456	.008	14.913	.033	22.369	.074	29.825	.132
45	25.830	7.437	.008	14.874	.033	22.312	.075	29.749	.133
31 00	34.440	7.418	.008	14.836	.033	22.254	.075	29.672	.133
15	8.611	7.398	.008	14.797	.033	22.195	.075	29.594	.134
30	17.213	7.379	.008	14.758	.034	22.137	.076	29.515	.135
45	25.834	7.359	.008	14.718	.034	22.078	.076	29.437	.135
32 00	34.446	7.340	.008	14.679	.034	22.019	.076	29.358	.136
15	8.613	7.319	.008	14.639	.034	21.958	.077	29.278	.136
30	17.225	7.299	.009	14.598	.034	21.898	.077	29.197	.137
45	25.838	7.279	.009	14.558	.034	21.837	.077	29.116	.137
33 00	34.451	7.259	.009	14.518	.034	21.777	.078	29.036	.138
15	8.614	7.238	.009	14.476	.035	21.714	.078	28.953	.138
30	17.228	7.217	.009	14.435	.035	21.652	.078	28.869	.139
45	25.842	7.197	.009	14.393	.035	21.590	.078	28.786	.139
34 00	34.456	7.176	.009	14.352	.035	21.527	.079	28.703	.140
15	8.615	7.154	.009	14.309	.035	21.464	.079	28.618	.141
30	17.231	7.133	.009	14.266	.035	21.400	.079	28.533	.141
45	25.846	7.112	.009	14.224	.035	21.336	.080	28.448	.142
35 00	34.462	7.091	.009	14.181	.035	21.272	.080	28.362	.142
15	8.617	7.069	.009	14.138	.036	21.207	.080	28.275	.142
30	17.234	7.047	.009	14.094	.036	21.141	.080	28.188	.143
45	25.851	7.025	.009	14.050	.036	21.076	.080	28.101	.143
36 00	34.468	7.003	.009	14.007	.036	21.010	.081	28.014	.144
15	8.618	6.981	.009	13.962	.036	20.943	.081	27.924	.144
30	17.237	6.959	.009	13.917	.036	20.876	.081	27.835	.144
45	25.855	6.936	.009	13.873	.036	20.809	.081	27.745	.145
37 00	34.474	6.914	.009	13.828	.036	20.742	.082	27.655	.145
15	8.620	6.891	.009	13.782	.036	20.673	.082	27.564	.145
30	17.240	6.868	.009	13.736	.036	20.604	.082	27.472	.146
45	25.860	6.845	.009	13.690	.037	20.536	.082	27.381	.146
38 00	34.480	6.822	.009	13.645	.037	20.467	.082	27.289	.147
15	8.621	6.799	.009	13.598	.037	20.397	.083	27.196	.147
30	17.243	6.775	.009	13.551	.037	20.326	.083	27.102	.147
45	25.864	6.752	.009	13.504	.037	20.256	.083	27.008	.147
39 00	34.485	6.729	.009	13.457	.037	20.186	.083	26.914	.148
15	8.623	6.705	.009	13.409	.037	20.114	.083	26.819	.148
30	17.246	6.681	.009	13.361	.037	20.042	.083	26.723	.148
45	25.868	6.657	.009	13.314	.037	19.970	.084	26.627	.148
40 00	34.491	6.633	.009	13.266	.037	19.899	.084	26.532	.149

Table 21.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{126720}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
40°00′	....	6.633	.009	13.266	.037	19.899	.084	26.532	.149
15	8.624	6.608	.009	13.217	.037	19.825	.084	26.434	.149
30	17.249	6.584	.009	13.168	.037	19.752	.084	26 336	.149
45	25.873	6.560	.009	13.119	.037	19.679	.084	26.238	.149
41 00	34.497	6.535	.009	13.070	037	19.605	.084	26.140	.150
15	8.625	6.510	.009	13.020	.037	19.530	.084	26.041	.150
30	17.250	6.485	.009	12.970	.037	19.456	.084	25.941	.150
45	25.875	6.460	.009	12.920	.037	19.381	.084	25.841	.150
42 00	34.500	6.435	.009	12.871	.037	19.306	.085	25.741	.150
15	8.627	6.410	.009	12.820	.037	19.230	.085	25.640	.150
30	17.255	6.385	.009	12.769	.038	19.154	.085	25.538	.151
45	25.882	6.359	.009	12 718	.038	19.077	.085	25.436	.151
43 00	34.510	6.334	.009	12.667	.038	19.001	.085	25.335	.151
15	8.629	6.308	.009	12.615	.038	18.923	.085	25.231	.151
30	17.257	6.282	.009	12.563	.038	18.845	.085	25.127	.151
45	25.886	6.256	.009	12.512	.038	18.767	.085	25.023	.151
44 00	34.515	6.230	.009	12.460	.038	18.689	.085	24.919	.151
15	8.630	6.203	.009	12.407	.038	18.610	.085	24.814	.151
30	17.261	6.177	.009	12.354	.038	18.531	.085	24.708	.151
45	25.891	6.151	.009	12.301	.038	18.452	.085	24.603	.151
45 00	34.522	6.124	.009	12.249	.038	18.373	.085	24.497	.151
15	8.632	6.097	.009	12.195	.038	18.292	.085	24.390	.151
30	17.264	6.071	.009	12.141	.038	18.212	.085	24.283	.151
45	25.896	6.044	.009	12 088	.038	18.131	.085	24.175	.151
46 00	34.528	6.017	.009	12.034	.038	18.051	.085	24.068	.151
15	8.633	5.990	.009	11.979	.038	17.969	.085	23.959	.151
30	17.267	5.962	.009	11 925	.038	17.887	.085	23.849	.151
45	25.901	5.935	.009	11.870	.038	17.805	.085	23.740	.151
47 00	34.534	5.908	.009	11.815	.038	17.723	.085	23.631	.151
15	8.635	5.880	.009	11.760	.038	17.640	.085	23.520	.151
30	17.270	5.852	.009	11.704	.038	17 550	.085	23.408	.151
45	25.905	5.824	.009	11.648	.038	17.473	.085	23.297	.151
48 00	34.540	5.796	.009	11.593	.038	17.389	.085	23.186	.150
15	8.637	5.768	.009	11.536	.038	17.305	.085	23.073	.150
30	17.273	5.740	.009	11.480	.038	17.220	.084	22.960	.150
45	25.910	5.712	.009	11.424	.037	17.135	.084	22.847	.150
49 00	34.546	5.684	.009	11.367	.037	17.051	.084	22.734	.150
15	8.638	5.655	.009	11.310	.037	16.965	.084	22.620	.150
30	17.276	5.626	.009	11.253	.037	16.879	.084	22.505	.150
45	25.914	5.598	.009	11.195	.037	16.793	.084	22.391	.150
50 00	34.552	5.569	.009	11.138	.037	16.707	.084	22.276	.150

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{126720}$.

[Derivation of table explained on pp. liii-lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
50°00′	....	5.569	.009	11.138	.037	16.707	.084	22.276	.150
15	8.640	5.540	.009	11.080	.037	16.620	.084	22.160	.149
30	17.279	5.511	.009	11.022	.037	16.532	.084	22.043	.149
45	25.919	5.482	.009	10.963	.037	16.445	.083	21.927	.149
51 00	34.558	5.453	.009	10.905	.037	16.358	.083	21.810	.148
15	8.641	5.423	.009	10.846	.037	16.269	.083	21.692	.148
30	17.282	5.394	.009	10.787	.037	16.181	.083	21.574	.148
45	25.924	5.364	.009	10.728	.037	16.092	.083	21.456	.147
52 00	34.565	5.334	.009	10.669	.037	16.004	.083	21.338	.147
15	8.643	5.305	.009	10.609	.036	15.914	.082	21.218	.146
30	17.285	5.275	.009	10.549	.036	15.824	.082	21.099	.146
45	25.928	5.245	.009	10.490	.036	15.734	.082	20.979	.145
53 00	34.571	5.215	.009	10.430	.036	15.645	.082	20.860	.145
15	8.644	5.185	.009	10.369	.036	15.554	.082	20.738	.145
30	17.288	5.154	.009	10.309	.036	15.463	.081	20.617	.144
45	25.932	5.124	.009	10.248	.036	15.372	.081	20.496	.144
54 00	34.576	5.094	.009	10.187	.036	15.281	.081	20.374	.144
15	8.646	5.063	.009	10.126	.036	15.189	.081	20.252	.143
30	17.291	5.032	.009	10.064	.036	15.097	.080	20.129	.143
45	25.937	5.002	.009	10.003	.036	15.004	.080	20.006	.142
55 00	34.582	4.971	.009	9.942	.036	14.912	.080	19.883	.142
15	8.647	4.940	.009	9.879	.035	14.819	.080	19.759	.141
30	17.294	4.909	.009	9.817	.035	14.726	.079	19.634	.141
45	25.941	4.878	.009	9.755	.035	14.633	.079	19.510	.140
56 00	34.588	4.846	.009	9.693	.035	14.539	.079	19.386	.140
15	8.648	4.815	.009	9.630	.035	14.445	.079	19.260	.140
30	17.297	4.784	.009	9.567	.035	14.351	.078	19.134	.139
45	25.946	4.752	.009	9.504	.035	14.256	.078	19.008	.139
57 00	34.594	4.720	.009	9.441	.035	14.162	.078	18.882	.138
15	8.650	4.689	.009	9.377	.035	14.066	.077	18.754	.138
30	17.300	4.657	.009	9.314	.034	13.970	.077	18.627	.137
45	25.950	4.625	.009	9.250	.034	13.875	.077	18.500	.137
58 00	34.600	4.593	.009	9.186	.034	13.779	.076	18.372	.136
15	8.651	4.561	.008	9.122	.034	13.683	.076	18.244	.135
30	17.303	4.529	.008	9.058	.034	13.586	.076	18.115	.135
45	25.954	4.497	.008	8.993	.034	13.490	.075	17.986	.134
59 00	34.605	4.464	.008	8.929	.033	13.393	.075	17.858	.134
15	8.653	4.432	.008	8.864	.033	13.296	.075	17.728	.133
30	17.305	4.399	.008	8.799	.033	13.198	.075	17.597	.133
45	25.958	4.367	.008	8.734	.033	13.100	.074	17.467	.132
60 00	34.611	4.334	.008	8.669	.033	13.003	.074	17.337	.131

TABLE 21.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{126720}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR —							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
60°00′	....	4.334	.008	8.669	.033	13.003	.074	17.337	.131
15	8.654	4.301	.008	8.603	.032	12.904	.074	17.206	.131
30	17.308	4.269	.008	8.537	.032	12.806	.073	17.074	.130
45	25.962	4.236	.008	8.471	.032	12.707	.073	16.943	.129
61 00	34.616	4.203	.008	8.406	.032	12.608	.072	16.811	.128
15	8.655	4.170	.008	8.339	.032	12.509	.072	16.679	.128
30	17.311	4.136	.008	8.273	.032	12.410	.072	16.546	.127
45	25.966	4.103	.008	8.207	.031	12.310	.071	16.413	.126
62 00	34.621	4.070	.008	8.140	.031	12.210	.071	16.280	.125
15	8.657	4.036	.008	8.073	.031	12.110	.071	16.146	.125
30	17.313	4.003	.008	8.006	.031	12.009	.070	16.012	.124
45	25.970	3.970	.008	7.939	.031	11.909	.070	15.878	.123
63 00	34.626	3.936	.008	7.872	.031	11.808	.069	15.744	.122
15	8.658	3.902	.008	7.804	.030	11.707	.069	15.609	.122
30	17.316	3.868	.007	7.737	.030	11.605	.068	15.474	.121
45	25.974	3.835	.007	7.669	.030	11.504	.068	15.338	.120
64 00	34.632	3.801	.007	7.602	.030	11.402	.067	15.203	.119
15	8.659	3.767	.007	7.533	.029	11.300	.067	15.067	.119
30	17.318	3.733	.007	7.465	.029	11.198	.066	14.930	.118
45	25.977	3.698	.007	7.397	.029	11.096	.066	14.794	.117
65 00	34.636	3.664	.007	7.329	.029	10.993	.065	14.658	.116
15	8.660	3.630	.007	7.260	.028	10.890	.065	14.520	.115
30	17.321	3.596	.007	7.191	.028	10.787	.064	14.383	.114
45	25.981	3.561	.007	7.123	.028	10.684	.064	14.245	.113
66 00	34.641	3.527	.007	7.054	.028	10.581	.063	14.108	.112
15	8.661	3.492	.007	6.984	.028	10.477	.063	13.969	.111
30	17.323	3.458	.007	6.915	.027	10.373	.062	13.830	.111
45	25.984	3.423	.007	6.846	.027	10.269	.062	13.692	.110
67 00	34.646	3.388	.007	6.776	.027	10.165	.061	13.553	.109
15	8.663	3.353	.007	6.706	.027	10.060	.061	13.413	.108
30	17.325	3.318	.007	6.637	.026	9.955	.060	13.273	.107
45	25.988	3.283	.007	6.567	.026	9.850	.060	13.134	.106
68 00	34.650	3.248	.007	6.497	.026	9.746	.059	12.994	.105
15	8.664	3.213	.007	6.427	.026	9.640	.059	12.854	.104
30	17.327	3.178	.006	6.356	.025	9.535	.058	12.713	.103
45	25.991	3.143	.006	6.286	.025	9.429	.058	12.572	.102
69 00	34.655	3.108	.006	6.216	.025	9.323	.057	12.431	.101
15	8.665	3.072	.006	6.145	.025	9.217	.057	12.290	.100
30	17.329	3.037	.006	6.074	.024	9.111	.056	12.148	.099
45	25.994	3.002	.006	6.003	.024	9.005	.056	12.006	.098
70 00	34.659	2.966	.006	5.932	.024	8.899	.055	11.865	.097

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{126720}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
70°00′	....	2.966	.006	5.932	.024	8.899	.055	11.865	.097
15	8.666	2.930	.006	5.861	.024	8.792	.055	11.722	.096
30	17.331	2.895	.006	5.790	.023	8.685	.054	11.580	.095
45	25.997	2.859	.006	5.718	.023	8.578	.053	11.437	.094
71 00	34.663	2.824	.006	5.647	.023	8.471	.052	11.294	.093
15	8.667	2.788	.006	5.576	.023	8.363	.052	11.151	.092
30	17.333	2.752	.006	5.504	.022	8.256	.051	11.008	.091
45	26.000	2.716	.006	5.432	.022	8.148	.051	10.864	.090
72 00	34.667	2.680	.006	5.360	.022	8.040	.050	10.720	.089
15	8.668	2.644	.006	5.288	.022	7.932	.050	10.576	.088
30	17.335	2.608	.005	5.216	.021	7.824	.049	10.432	.087
45	26.003	2.572	.005	5.144	.021	7.716	.049	10.288	.086
73 00	34.670	2.536	.005	5.072	.021	7.608	.048	10.144	.085
15	8.668	2.500	.005	4.999	.021	7.499	.048	9.998	.084
30	17.337	2.463	.005	4.927	.020	7.390	.047	9.854	.083
45	26.006	2.427	.005	4.854	.020	7.281	.046	9.708	.081
74 00	34.674	2.391	.005	4.782	.020	7.172	.045	9.563	.080
15	8.669	2.354	.005	4.709	.020	7.063	.044	9.417	.079
30	17.339	2.318	.005	4.636	.019	6.954	.044	9.272	.078
45	26.008	2.281	.005	4.563	.019	6.844	.043	9.126	.077
75 00	34.677	2.245	.005	4.490	.019	6.735	.043	8.980	.076
15	8.670	2.208	.004	4.417	.019	6.625	.042	8.834	.074
30	17.340	2.172	.004	4.343	.018	6.515	.042	8.687	.073
45	26.010	2.135	.004	4.270	.018	6.405	.041	8.540	.072
76 00	34.680	2.098	.004	4.197	.018	6.296	.040	8.394	.071
15	8.671	2.062	.004	4.123	.018	6.185	.040	8.247	.069
30	17.342	2.025	.004	4.050	.017	6.075	.039	8.100	.068
45	26.013	1.988	.004	3.976	.017	5.964	.038	7.952	.067
77 00	34.684	1.951	.004	3.903	.017	5.854	.037	7.805	.066
15	8.672	1.914	.004	3.829	.017	5.743	.037	7.658	.065
30	17.343	1.877	.004	3.755	.016	5.632	.036	7.510	.064
45	26.015	1.840	.004	3.681	.016	5.522	.036	7.362	.063
78 00	34.686	1.804	.004	3.607	.015	5.411	.035	7.214	.062
15	8.672	1.766	.004	3.533	.015	5.300	.034	7.066	.060
30	17.344	1.729	.004	3.459	.015	5.188	.034	6.918	.059
45	26.017	1.692	.004	3.385	.014	5.077	.033	6.769	.058
79 00	34.689	1.655	.004	3.310	.014	4.966	.032	6.621	.057
15	8.673	1.618	.003	3.236	.014	4.854	.031	6.472	.055
30	17.346	1.581	.003	3.162	.013	4.742	.030	6.323	.054
45	26.018	1.544	.003	3.087	.013	4.631	.030	6.174	.053
80 00	34.691	1.506	.003	3.013	.013	4.519	.029	6.026	.052

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
0°00′	....	5.764	11.529	17.293	23.058	28.822	34.586
10	11.451	5.764	11.528	17.293	23.057	28.821	34.585
20	22.901	5.764	11.528	17.292	23.056	28.821	34.585
30	34.352	5.764	11.528	17.292	23.056	28.820	34.583
40	45.803	5.764	11.528	17.291	23.055	28.819	34.583
50	57.254	5.764	11.527	17.291	23.054	28.818	34.582
1 00	68.704	5.764	11.527	17.291	23.054	28.818	34.581
10	11.451	5.763	11.526	17.289	23.052	28.816	34.579
20	22.901	5.763	11.525	17.288	23.050	28.813	34.576
30	34.352	5.762	11.524	17.287	23.049	28.811	34.573
40	45.803	5.762	11.524	17.285	23.047	28.809	34.571
50	57.254	5.761	11.523	17.284	23.045	28.807	34.568
2 00	68.704	5.761	11.522	17.283	23.044	28.805	34.565
10	11.451	5.760	11.520	17.281	23.041	28.801	34.561
20	22.902	5.759	11.519	17.278	23.038	28.797	34.556
30	34.353	5.759	11.517	17.276	23.035	28.794	34.552
40	45.804	5.758	11.516	17.274	23.032	28.790	34.548
50	57.254	5.757	11.514	17.272	23.029	28.786	34.543
3 00	68.705	5.756	11.513	17.270	23.026	28.783	34.539
10	11.451	5.756	11.511	17.267	23.022	28.778	34.533
20	22.902	5.754	11.509	17.264	23.018	28.773	34.527
30	34.353	5.753	11.507	17.260	23.014	28.767	34.520
40	45.804	5.752	11.505	17.257	23.010	28.762	34.514
50	57.255	5.751	11.503	17.254	23.006	28.757	34.508
4 00	68.706	5.750	11.501	17.251	23.002	28.752	34.502
10	11.451	5.749	11.498	17.247	22.996	28.746	34.495
20	22.903	5.748	11.496	17.243	22.991	28.739	34.487
30	34.354	5.746	11.493	17.240	22.986	28.733	34.479
40	45.805	5.745	11.490	17.236	22.981	28.726	34.471
50	57.256	5.744	11.488	17.232	22.976	28.720	34.463
5 00	68.708	5.743	11.485	17.228	22.970	28.713	34.456
10	11.452	5.741	11.482	17.223	22.964	28.705	34.446
20	22.903	5.739	11.479	17.218	22.958	28.697	34.436
30	34.355	5.738	11.476	17.213	22.951	28.689	34.427
40	45.806	5.736	11.472	17.209	22.945	28.681	34.417
50	57.258	5.735	11.469	17.204	22.938	28.673	34.408
6 00	68.710	5.733	11.466	17.199	22.932	28.665	34.398
10	11.452	5.731	11.462	17.193	22.924	28.656	34.387
20	22.904	5.729	11.458	17.188	22.917	28.646	34.375
30	34.356	5.727	11.455	17.182	22.910	28.637	34.364
40	45.808	5.726	11.451	17.177	22.902	28.628	34.353
50	57.260	5.724	11.447	17.171	22.894	28.618	34.342
7 00	68.712	5.722	11.443	17.165	22.887	28.609	34.330

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	0°	1°
	Inches.	*Inches.*
5′	0.000	0.000
10	.000	.000
15	.000	.001
20	.000	.001
25	.000	.002
30	.000	.003

Longitude interval.	2°	3°
5	0.000	0.000
10	.001	.001
15	.001	.002
20	.002	.003
25	.004	.005
30	.005	.008

Longitude interval.	4°	5°
5	0.000	0.000
10	.001	.001
15	.003	.003
20	.005	.006
25	.007	.009
30	.011	.013

Longitude interval.	6°	7°
5	0.000	0.000
10	.002	.002
15	.004	.005
20	.007	.008
25	.011	.013
30	.016	.018

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE 1/63360.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
7°00′	68.712	5.722	11.443	17.165	22.887	28.609	34.330
10	11.452	5.720	11.439	17.159	22.878	28.598	34.317
20	22.905	5.717	11.435	17.152	22.869	28.587	34.304
30	34.358	5.715	11.430	17.146	22.861	28.576	34.291
40	45.810	5.713	11.426	17.139	22.852	28.565	34.278
50	57.262	5.711	11.422	17.132	22.843	28.554	34.265
8 00	68.715	5.709	11.417	17.126	22.834	28.543	34.252
10	11.453	5.706	11.412	17.119	22.825	28.531	34.237
20	22.906	5.704	11.407	17.111	22.815	28.519	34.222
30	34.359	5.701	11.403	17.104	22.805	28.507	34.208
40	45.812	5.699	11.398	17.096	22.795	28.494	34.193
50	57.265	5.696	11.393	17.089	22.786	28.482	34.178
9 00	68.718	5.694	11.388	17.082	22.776	28.470	34.163
10	11.454	5.691	11.382	17.073	22.764	28.456	34.147
20	22.907	5.688	11.377	17.065	22.754	28.442	34.130
30	33.361	5.686	11.371	17.057	22.742	28.428	34.114
40	45.814	5.683	11.366	17.049	22.732	28.415	34.097
50	57.268	5.680	11.360	17.040	22.720	28.401	34.081
10 00	68.722	5.677	11.355	17.032	22.710	28.387	34.064
10	11.454	5.674	11.349	17.023	22.698	28.372	34.046
20	22.909	5.671	11.343	17.014	22.685	28.357	34.028
30	34.263	5.668	11.337	17.005	22.673	28.342	34.010
40	45.817	5.665	11.331	16.996	22.661	28.327	33.992
50	57.272	5.662	11.324	16.987	22.649	28.311	33.973
11 00	68.726	5.659	11.318	16.978	22.637	28.296	33.955
10	11.455	5.656	11.312	16.968	22.624	28.280	33.935
20	22.910	5.652	11.305	16.958	22.610	28.263	33.915
30	34.365	5.649	11.298	16.948	22.597	28.246	33.895
40	45.820	5.646	11.292	16.938	22.584	28.230	33.875
50	57.275	5.642	11.285	16.928	22.570	28.213	33.855
12 00	68.730	5.639	11.278	16.918	22.557	28.196	33.835
10	11.456	5.636	11.271	16.907	22.542	28.178	33.814
20	22.912	5.632	11.264	16.896	22.528	28.160	33.792
30	34.367	5.628	11.257	16.885	22.514	28.142	33.770
40	45.823	5.625	11.250	16.874	22.499	28.124	33.749
50	57.279	5.621	11.242	16.864	22.485	28.106	33.727
13 00	68.735	5.618	11.235	16.853	22.470	28.088	33.706
10	11.457	5.614	11.227	16.841	22.455	28.069	33.682
20	22.913	5.610	11.220	16.829	22.439	28.049	33.659
30	34.370	5.606	11.212	16.818	22.424	28.030	33.635
40	45.827	5.602	11.204	16.806	22.408	28.010	33.612
50	57.284	5.598	11.196	16.794	22.392	27.991	33.589
14 00	68.740	5.594	11.188	16.783	22.377	27.971	33.565

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	7°	8°
	Inches.	*Inches.*
5′	0.000	0.001
10	.002	.002
15	.005	.005
20	.008	.009
25	.013	.014
30	.018	.021
	9°	**10°**
5	0.001	0.001
10	.003	.003
15	.006	.006
20	.010	.011
25	.016	.018
30	.023	.026
	11°	**12°**
5	0.001	0.001
10	.003	.003
15	.007	.008
20	.013	.014
25	.020	.021
30	.028	.031
	13°	**14°**
5	0.001	0.001
10	.004	.004
15	.008	.009
20	.015	.016
25	.023	.025
30	.033	.035

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
14°00′	68.740	5.594	11.188	16.783	22.377	27.971	33.565
10	11.458	5.590	11.180	16.770	22.360	27.950	33.540
20	22.915	5.586	11.172	16.758	22.344	27.930	33.515
30	34.373	5.582	11.163	16.745	22.327	27.909	33.490
40	45.830	5.578	11.155	16.733	22.310	27.888	33.465
50	57.288	5.573	11.147	16.720	22.294	27.867	33.440
15 00	68.746	5.569	11.138	16.708	22.277	27.846	33.415
10	11.459	5.565	11.130	16.694	22.259	27.824	33.389
20	22.917	5.560	11.121	16.681	22.241	27.802	33.362
30	34.376	5.556	11.112	16.667	22.223	27.779	33.335
40	45.834	5.551	11.103	16.654	22.206	27.757	33.308
50	57.293	5.547	11.094	16.641	22.188	27.735	33.282
16 00	68.752	5.542	11.085	16.628	22.170	27.713	33.255
10	11.460	5.538	11.076	16.613	22.151	27.689	33.227
20	22.919	5.533	11.066	16.599	22.132	27.665	33.198
30	34.379	5.528	11.057	16.585	22.113	27.642	33.170
40	45.838	5.524	11.047	16.571	22.094	27.618	33.142
50	57.298	5.519	11.038	16.556	22.075	27.594	33.113
17 00	68.758	5.514	11.028	16.542	22.056	27.571	33.085
10	11.461	5.509	11.018	16.527	22.036	27.546	33.055
20	22.921	5.504	11.008	16.512	22.016	27.521	33.025
30	34.382	5.499	10.998	16.497	21.996	27.495	32.994
40	45.843	5.494	10.988	16.482	21.976	27.470	32.964
50	57.304	5.489	10.978	16.467	21.956	27.445	32.934
18 00	68.764	5.484	10.968	16.452	21.936	27.420	32.904
10	11.462	5.479	10.957	16.436	21.915	27.394	32.872
20	22.924	5.473	10.947	16.420	21.894	27.367	32.840
30	34.386	5.468	10.936	16.404	21.872	27.341	32.809
40	45.848	5.463	10.926	16.389	21.852	27.315	32.777
50	57.310	5.458	10.915	16.373	21.830	27.288	32.746
19 00	68.771	5.452	10.905	16.357	21.809	27.262	32.714
10	11.463	5.447	10.893	16.340	21.787	27.234	32.680
20	22.926	5.441	10.882	16.324	21.765	27.206	32.647
30	34.390	5.436	10.871	16.307	21.742	27.178	32.614
40	45.853	5.430	10.860	16.290	21.720	27.150	32.580
50	57.316	5.424	10.849	16.274	21.698	27.123	32.547
20 00	68.779	5.419	10.838	16.257	21.676	27.095	32.513
10	11.464	5.413	10.826	16.239	21.652	27.065	32.478
20	22.929	5.407	10.814	16.222	21.629	27.036	32.443
30	34.394	5.401	10.803	16.204	21.605	27.007	32.408
40	45.858	5.396	10.791	16.187	21.582	26.978	32.373
50	57.322	5.390	10.779	16.169	21.558	26.948	32.338
21 00	68.787	5.384	10.768	16.151	21.535	26.919	32.303

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	14°	15°
	Inches.	*Inches.*
5′	0.001	0.001
10	.004	.004
15	.009	.009
20	.016	.017
25	.025	.026
30	.035	.038
	16°	**17°**
5	0.001	0.001
10	.004	.005
15	.010	.011
20	.018	.019
25	.028	.029
30	.040	.042
	18°	**19°**
5	0.001	0.001
10	.005	.005
15	.011	.012
20	.020	.021
25	.031	.032
30	.044	.046
	20°	**21°**
5	0.001	0.001
10	.005	.006
15	.012	.013
20	.022	.022
25	.034	.035
30	.049	.051

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
21°00′	68.787	5.384	10.768	16.151	21.535	26.919	32.303
10	11.466	5.378	10.755	16.133	21.511	26.889	32.266
20	22.932	5.372	10.743	16.115	21.486	26.858	32.230
30	34.397	5.366	10.731	16.097	21.462	26.828	32.193
40	45.863	5.359	10.719	16.078	21.438	26.797	32.156
50	57.329	5.353	10.707	16.060	21.413	26.767	32.120
22 00	68.795	5.347	10.694	16.042	21.389	26.736	32.083
10	11.467	5.341	10.682	16.022	21.363	26.704	32.045
20	22.934	5.334	10.669	16.003	21.338	26.672	32.006
30	34.401	5.328	10.656	15.984	21.312	26.641	31.969
40	45.868	5.322	10.643	15.965	21.287	26.609	31.930
50	57.336	5.315	10.631	15.946	21.261	26.577	31.892
23 00	68.803	5.309	10.618	15.927	21.236	26.545	31.853
10	11.469	5.302	10.604	15.907	21.209	26.511	31.813
20	22.937	5.296	10.591	15.887	21.182	26.478	31.774
30	34.406	5.289	10.578	15.867	21.156	26.445	31.733
40	45.874	5.282	10.565	15.847	21.129	26.412	31.694
50	57.343	5.276	10.551	15.827	21.102	26.378	31.654
24 00	68.812	5.269	10.538	15.807	21.076	26.345	31.614
10	11.470	5.263	10.526	15.789	21.052	26.315	31.577
20	22.940	5.256	10.512	15.767	21.023	26.279	31.535
30	34.410	5.249	10.498	15.746	20.995	26.244	31.493
40	45.880	5.242	10.483	15.725	20.967	26.209	31.450
50	57.350	5.235	10.469	15.704	20.938	26.173	31.408
25 00	68.821	5.227	10.455	15.682	20.910	26.137	31.365
10	11.472	5.220	10.441	15.661	20.881	26.101	31.322
20	22.943	5.213	10.426	15.639	20.852	26.065	31.279
30	34.415	5.206	10.412	15.618	20.824	26.029	31.235
40	45.886	5.199	10.397	15.596	20.795	25.993	31.192
50	57.358	5.191	10.383	15.575	20.766	25.958	31.149
26 00	68.830	5.184	10.369	15.553	20.737	25.922	31.106
10	11.473	5.177	10.354	15.531	20.708	25.884	31.061
20	22.946	5.169	10.339	15.508	20.678	25.847	31.017
30	34.419	5.162	10.324	15.486	20.648	25.810	30.972
40	45.892	5.154	10.309	15.463	20.618	25.772	30.927
50	57.365	5.147	10.294	15.441	20.588	25.735	30.882
27 00	68.838	5.140	10.279	15.419	20.558	25.698	30.838
10	11.475	5.132	10.264	15.396	20.528	25.659	30.791
20	22.950	5.124	10.248	15.373	20.497	25.621	30.745
30	34.424	5.116	10.233	15.349	20.466	25.582	30.699
40	45.899	5.109	10.218	15.326	20.435	25.544	30.653
50	57.374	5.101	10.202	15.303	20.404	25.505	30.607
28 00	68.849	5.093	10.187	15.280	20.374	25.467	30.560

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	21°	22°
	Inches.	*Inches.*
5′	0.001	0.001
10	.006	.006
15	.013	.013
20	.022	.023
25	.035	.036
30	.051	.052
	23°	**24°**
5	0.001	0.002
10	.006	.006
15	.014	.014
20	.024	.025
25	.038	.039
30	.054	.056
	25°	**26°**
5	0.002	0.002
10	.006	.007
15	.014	.015
20	.026	.026
25	.040	.041
30	.058	.059
	27°	**28°**
5	0.002	0.002
10	.007	.007
15	.015	.016
20	.027	.028
25	.042	.043
30	.061	.063

TABLE 22.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
28°00′	68.849	5.093	10.187	15.280	20.374	25.467	30.560
10	11.476	5.085	10.171	15.256	20.342	25.427	30.513
20	22.953	5.077	10.155	15.232	20.310	25.387	30.465
30	34.430	5.069	10.139	15.208	20.278	25.347	30.417
40	45.906	5.061	10.123	15.185	20.246	25.308	30.369
50	57.383	5.054	10.107	15.161	20.214	25.268	30.321
29 00	68.859	5.046	10.091	15.137	20.182	25.228	30.274
10	11.478	5.037	10.075	15.112	20.150	25.187	30.224
20	22.957	5.029	10.058	15.087	20.117	25.146	30.175
30	34.435	5.021	10.042	15.063	20.084	25.105	30.126
40	45.913	5.013	10.025	15.038	20.051	25.064	30.076
50	57.391	5.004	10.009	15.013	20.018	25.022	30.027
30 00	68.870	4.996	9.993	14.989	19.985	24.981	29.978
10	11.480	4.988	9.976	14.963	19.951	24.939	29.927
20	22.960	4.979	9.959	14.938	19.917	24.896	29.876
30	34.440	4.971	9.942	14.912	19.883	24.854	29.825
40	45.920	4.962	9.925	14.887	19.849	24.812	29.774
50	57.400	4.954	9.908	14.862	19.815	24.769	29.723
31 00	68.880	4.945	9.891	14.836	19.782	24.727	29.672
10	11.482	4.937	9.873	14.810	19.747	24.683	29.620
20	22.964	4.928	9.856	14.784	19.712	24.640	29.568
30	34.446	4.919	9.838	14.758	19.677	24.596	29.515
40	45.927	4.910	9.821	14.731	19.642	24.552	29.463
50	57.409	4.902	9.804	14.705	19.607	24.509	29.411
32 00	68.891	4.893	9.786	14.679	19.572	24.465	29.358
10	11.484	4.884	9.768	14.652	19.536	24.420	29.305
20	22.967	4.875	9.750	14.625	19.500	24.376	29.251
30	34.451	4.866	9.732	14.598	19.465	24.331	29.197
40	45.934	4.857	9.714	14.572	19.429	24.286	29.143
50	57.418	4.848	9.696	14.545	19.393	24.241	29.089
33 00	68.902	4.839	9.679	14.518	19.357	24.196	29.036
10	11.485	4.830	9.660	14.490	19.320	24.150	28.980
20	22.971	4.821	9.642	14.462	19.283	24.104	28.925
30	34.456	4.812	9.623	14.435	19.246	24.058	28.870
40	45.942	4.802	9.605	14.407	19.210	24.012	28.814
50	57.427	4.793	9.586	14.379	19.173	23.966	28.759
34 00	68.913	4.784	9.568	14.352	19.136	23.920	28.704
10	11.487	4.774	9.549	14.323	19.098	23.872	28.647
20	22.975	4.765	9.530	14.295	19.060	23.825	28.590
30	34.462	4.755	9.511	14.267	19.022	23.778	28.533
40	45.949	4.746	9.492	14.238	18.984	23.730	28.476
50	57.437	4.737	9.473	14.210	18.946	23.683	28.420
35 00	68.924	4.727	9.454	14.181	18.908	23.636	28.363

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	28°	29°
	Inches.	*Inches.*
5′	0.002	0.002
10	.007	.007
15	.016	.016
20	.028	.028
25	.043	.044
30	.063	.064

Longitude interval.	30°	31°
5	0.002	0.002
10	.007	.007
15	.016	.017
20	.029	.030
25	.045	.046
30	.065	.067

Longitude interval.	32°	33°
5	0.002	0.002
10	.007	.008
15	.017	.017
20	.030	.031
25	.047	.048
30	.068	.069

Longitude interval.	34°	35°
5	0.002	0.002
10	.008	.008
15	.017	.018
20	.031	.031
25	.049	.049
30	.070	.071

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
35°00′	68.924	4.727	9.454	14.181	18.908	23.636	28.363
10	11.489	4.717	9.435	14.152	18.870	23.587	28.305
20	22.978	4.708	9.415	14.123	18.831	23.539	28.246
30	34.468	4.698	9.396	14.094	18.792	23.490	28.188
40	45.957	4.688	9.377	14.065	18.753	23.442	28.130
50	57.446	4.679	9.357	14.036	18.714	23.393	28.072
36 00	68.935	4.669	9.338	14.007	18.676	23.345	28.014
10	11.491	4.659	9.318	13.977	18.636	23.295	27.954
20	22.983	4.649	9.298	13.947	18.596	23.245	27.894
30	34.474	4.639	9.278	13.917	18.556	23.195	27.835
40	45.965	4.629	9.258	13.887	18.517	23.146	27.775
50	57.457	4.619	9.238	13.858	18.477	23.096	27.715
37 00	68.948	4.609	9.219	13.828	18.437	23.046	27.656
10	11.493	4.599	9.198	13.797	18.396	22.995	27.594
20	22.986	4.589	9.178	13.767	18.356	22.944	27.533
30	34.480	4.579	9.157	13.736	18.315	22.894	27.472
40	45.973	4.568	9.137	13.706	18.274	22.843	27.411
50	57.466	4.558	9.117	13.675	18.234	22.792	27.350
38 00	68.959	4.548	9.096	13.645	18.193	22.741	27.289
10	11.495	4.538	9.076	13.613	18.151	22.689	27.227
20	22.990	4.527	9.055	13.582	18.109	22.637	27.164
30	34.485	4.517	9.034	13.551	18.068	22.585	27.102
40	45.980	4.506	9.013	13.520	18.026	22.533	27.039
50	57.475	4.496	8.992	13.488	17.984	22.481	26.977
39 00	68.970	4.486	8.971	13.457	17.943	22.429	26.914
10	11.497	4.475	8.950	13.425	17.900	22.375	26.851
20	22.994	4.464	8.929	13.393	17.858	22.322	26.787
30	34.491	4.454	8.908	13.361	17.815	22.269	26.723
40	45.988	4.443	8.886	13.330	17.773	22.216	26.659
50	57.485	4.433	8.865	13.298	17.730	22.163	26.595
40 00	68.982	4.422	8.844	13.266	17.688	22.110	26.532
10	11.499	4.411	8.822	13.233	17.644	22.055	26.466
20	22.998	4.400	8.800	13.201	17.601	22.001	26.401
30	34.497	4.389	8.779	13.168	17.557	21.947	26.336
40	45.996	4.378	8.757	13.135	17.514	21.892	26.271
50	57.495	4.368	8.735	13.103	17.470	21.838	26.206
41 00	68.994	4.357	8.713	13.070	17.427	21.784	26.140
10	11.501	4.346	8.691	13.037	17.383	21.728	26.074
20	23.002	4.335	8.669	13.004	17.338	21.673	26.007
30	34.503	4.324	8.647	12.971	17.294	21.618	25.941
40	46.004	4.312	8.625	12.937	17.250	21.562	25.875
50	57.506	4.301	8.603	12.904	17.205	21.507	25.808
42 00	69.007	4.290	8.581	12.871	17.161	21.451	25.742

ORDINATES OF DEVELOPED PARALLEL. Longitude interval.	35°	36°
	Inches.	*Inches.*
5′	0.002	0.002
10	.008	.008
15	.018	.018
20	.031	.032
25	.049	.050
30	.071	.072
	37°	**38°**
5	0.002	0.002
10	.008	.008
15	.018	.018
20	.032	.033
25	.050	.051
30	.073	.073
	39°	**40°**
5	0.002	0.002
10	.008	.008
15	.018	.019
20	.033	.033
25	.051	.052
30	.074	.074
	41°	**42°**
5	0.002	0.002
10	.008	.008
15	.019	.019
20	.033	.033
25	.052	.052
30	.075	.075

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
42°00′	69.007	4.290	8.581	12.871	17.161	21.451	25.742
10	11.503	4.279	8.558	12.837	17.116	21.395	25.674
20	23.006	4.268	8.535	12.803	17.071	21.338	25.606
30	34.510	4.256	8.513	12.769	17.025	21.282	25.538
40	46.013	4.245	8.490	12.735	16.980	21.225	25.470
50	57.516	4.234	8.467	12.701	16.935	21.169	25.402
43 00	69.019	4.222	8.445	12.667	16.890	21.112	25.334
10	11.505	4.211	8.422	12.633	16.844	21.054	25.265
20	23.010	4.199	8.399	12.598	16.798	20.997	25.196
30	34.515	4.188	8.376	12.564	16.751	20.939	25.127
40	46.020	4.176	8.353	12.529	16.705	20.882	25.058
50	57.525	4.165	8.330	12.494	16.659	20.824	24.989
44 00	69.030	4.153	8.307	12.460	16.613	20.767	24.920
10	11.507	4.142	8.283	12.425	16.566	20.708	24.849
20	23.014	4.130	8.260	12.390	16.519	20.649	24.779
30	34.522	4.118	8.236	12.354	16.473	20.591	24.709
40	46.029	4.106	8.213	12.319	16.426	20.532	24.638
50	57.536	4.095	8.189	12.284	16.379	20.473	24.568
45 00	69.043	4.083	8.166	12.249	16.332	20.415	24.498
10	11.509	4.071	8.142	12.213	16.284	20.355	24.426
20	23.018	4.059	8.118	12.177	16.236	20.295	24.354
30	34.528	4.047	8.094	12.141	16.188	20.236	24.283
40	46.037	4.035	8.070	12.105	16.141	20.176	24.211
50	57.546	4.023	8.046	12.070	16.093	20.116	24.139
46 00	69.055	4.011	8.023	12.034	16.045	20.056	24.068
10	11.511	3.999	7.998	11.997	15.997	19.996	23.995
20	23 023	3.987	7.974	11.961	15.948	19.935	23.922
30	34.534	3.975	7.950	11.925	15.899	19.974	23.849
40	46.045	3.963	7.925	11.888	15.851	19.813	23.776
50	57.557	3.951	7.901	11.852	15.802	19.753	23.703
47 00	69.068	3.938	7.877	11.815	15.754	19.692	23.630
10	11.513	3.926	7.852	11.778	15.704	19.630	23.556
20	23.027	3.914	7.827	11.741	15.655	19.569	23.482
30	34.540	3.901	7.803	11.704	15.606	19.507	23.408
40	46.053	3.889	7.778	11.667	15.556	19.445	23.334
50	57.567	3.877	7.753	11.630	15.507	19.383	23.260
48 00	69.080	3.864	7.729	11.593	15.457	19.322	23.186
10	11.516	3.852	7.704	11.555	15.407	19.259	23.111
20	23.031	3.839	7.679	11.518	15.357	19.196	23.035
30	34.546	3.827	7.653	11.480	15.307	19.134	22.960
40	46.062	3.814	7.628	11.442	15.257	19.071	22.885
50	57.577	3.802	7.603	11.405	15.206	19.008	22.810
49 00	69.093	3.789	7.578	11.367	15.156	18.945	22.734

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	42°	43°
	Inches.	*Inches.*
5′	0.002	0.002
10	.008	.008
15	.019	.019
20	.033	.033
25	.052	.052
30	.075	.075
	44°	**45°**
5	0.002	0.002
10	.008	.008
15	.019	.019
20	.034	.034
25	.052	.053
30	.075	.076
	46°	**47°**
5	0.002	0.002
10	.008	.008
15	.019	.019
20	.034	.034
25	.053	.052
30	.076	.075
	48°	**49°**
5	0.002	0.002
10	.008	.008
15	.019	.019
20	.033	.033
25	.052	.052
30	.075	.075

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
49°00′	69.093	3.789	7.578	11.367	15.156	18.945	22.734
10	11.517	3.776	7.553	11.329	15.105	18.882	22.658
20	23.035	3.764	7.527	11.291	15.054	18.818	22.581
30	34.552	3.751	7.502	11.253	15.003	18.754	22.505
40	46.070	3.738	7.476	11.214	14.952	18.690	22.429
50	57.587	3.725	7.451	11.176	14.901	18.627	22.352
50 00	69.105	3.713	7.425	11.138	14.850	18.563	22.276
10	11.520	3.700	7.399	11.099	14.799	18.499	22.198
20	23.039	3.687	7.374	11.060	14.747	18.434	22.121
30	34.558	3.674	7.348	11.021	14.695	18.369	22.043
40	46.078	3.661	7.322	10.983	14.644	18.305	21.965
50	57.598	3.648	7.296	10.944	14.592	18.240	21.888
51 00	69.117	3.635	7.270	10.905	14.540	18.176	21.811
10	11.521	3.622	7.244	10.866	14.488	18.110	21.732
20	23.043	3.609	7.218	10.827	14.436	18.045	21.653
30	34.564	3.596	7.191	10.787	14.383	17.979	21.574
40	46.086	3.583	7.165	10.748	14.330	17.913	21.496
50	57.607	3.570	7.139	10.709	14.278	17.848	21.417
52 00	69.128	3.556	7.113	10.669	14.226	17.782	21.338
10	11.523	3.543	7.086	10 629	14.172	17.716	21.259
20	23.047	3.530	7.060	10.589	14.119	17.649	21.179
30	34.570	3.516	7.033	10.550	14.066	17.583	21.099
40	46.094	3.503	7.006	10.510	14.013	17.516	21.019
50	57.617	3.490	6.980	10.470	13.960	17.450	20.939
53 00	69.140	3.477	6.953	10.430	13.906	17.383	20.860
10	11.525	3.463	6.926	10.389	13.852	17.316	20.779
20	23.051	3.450	6.899	10.349	13.798	17.248	20.698
30	34.576	3.436	6.872	10.309	13.745	17.181	20.617
40	46.102	3.423	6.845	10.268	13.691	17.114	20.536
50	57.627	3.409	6.818	10.228	13.637	17.046	20.455
54 00	69.152	3.396	6.791	10.187	13.583	16.979	20.374
10	11.527	3.382	6.764	10.146	13.528	16.910	20.292
20	23.055	3.368	6.737	10.105	13.474	16.842	20.210
30	34.582	3.355	6.709	10.064	13.419	16.774	20.128
40	46.109	3.341	6.682	10.023	13.364	16.706	20.047
50	57.636	3.327	6.655	9.982	13.310	16.637	19.964
55 00	69.164	3.314	6.628	9.941	13.255	16.569	19.883
10	11.529	3.300	6.600	9.900	13.200	16.500	19.800
20	23.059	3.286	6.572	9.859	13.145	16.431	19.717
30	34.588	3.272	6.545	9.817	13.089	16.362	19.634
40	46.117	3.258	6.517	9.776	13.034	16.293	19.551
50	57.646	3.245	6.489	9.734	12.979	16.224	19.468
56 00	69.176	3.231	6.462	9.693	12.924	16.155	19.385

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	49°	50°
	Inches.	*Inches.*
5′	0.002	0.002
10	.008	.008
15	.019	.019
20	.033	.033
25	.052	.052
30	.075	.075

Longitude interval.	51°	52°
5	0.002	0.002
10	.008	.008
15	.019	.018
20	.033	.033
25	.051	.051
30	.074	.073

Longitude interval.	53°	54°
5	0.002	0.002
10	.008	.008
15	.018	.018
20	.032	.032
25	.050	.050
30	.073	.072

Longitude interval.	55°	56°
5	0.002	0.002
10	.008	.008
15	.018	.018
20	.032	.031
25	.049	.049
30	.071	.070

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
56°00′	69.176	3.231	6.462	9.693	12.924	16.155	19.385
10	11.531	3.217	6.434	9.651	12.868	16.085	19.301
20	23.063	3.203	6.406	9.609	12.812	16.015	19.217
30	34.594	3.189	6.378	9.567	12.756	15.945	19.134
40	46.125	3.175	6.350	9.525	12.700	15.875	19.050
50	57.656	3.161	6.322	9.483	12.644	15.805	18.966
57 00	69.188	3.147	6.294	9.441	12.588	15.735	18.882
10	11.533	3.133	6.266	9.398	12.531	15.664	18.797
20	23.066	3.119	6.237	9.356	12.475	15.594	18.712
30	34.599	3.104	6.209	9.314	12.418	15.523	18.627
40	46.132	3.090	6.181	9.271	12.362	15.452	18.542
50	57.666	3.076	6.152	9.229	12.305	15.381	18.457
58 00	69.199	3.062	6.124	9.186	12.248	15.311	18.373
10	11.535	3.048	6.096	9.143	12.191	15.239	18.287
20	23.070	3.034	6.067	9.101	12.134	15.168	18.201
30	34.605	3.019	6.038	9.058	12.077	15.096	18.115
40	46.140	3.005	6.010	9.015	12.020	15.025	18.029
50	57.675	2.991	5.981	8.972	11.962	14.953	17.944
59 00	69.210	2.976	5.953	8.929	11.905	14.882	17.858
10	11.537	2.962	5.924	8.885	11.847	14.809	17.771
20	23.074	2.947	5.895	8.842	11.790	14.737	17.684
30	34.610	2.933	5.866	8.799	11.732	14.665	17.597
40	46.147	2.918	5.837	8.755	11.674	14.592	17.510
50	57.684	2.904	5.808	8.712	11.616	14.520	17.424
60 00	69.221	2.890	5.779	8.669	11.558	14.448	17.337
10	11.539	2.875	5.750	8.625	11.500	14.375	17.249
20	23.077	2.860	5.721	8.581	11.441	14.302	17.162
30	34.616	2.846	5.691	8.537	11.383	14.229	17.074
40	46.154	2.831	5.662	8.493	11.324	14.156	16.987
50	57.693	2.816	5.633	8.450	11.266	14.083	16.899
61 00	69.232	2.802	5.604	8.406	11.208	14.010	16.811
10	11.540	2.787	5.574	8.361	11.148	13.936	16.723
20	23.081	2.772	5.545	8.317	11.090	13.862	16.634
30	34.621	2.758	5.115	8.273	11.030	13.788	16.546
40	46.162	2.743	5.486	8.229	10.972	13.715	16.457
50	57.702	2.728	5.456	8.184	10.912	13.641	16.369
62 00	69.242	2.713	5.427	8.140	10.854	13.567	16.280
10	11.542	2.699	5.397	8.096	10.794	13.493	16.191
20	23.084	2.684	5.367	8.051	10.734	13.418	16.102
30	34.626	2.669	5.337	8.006	10.675	13.344	16.012
40	46.168	2.654	5.308	7.961	10.615	13.269	15.923
50	57.710	2.639	5.278	7.917	10.556	13.195	15.833
63 00	69.253	2.624	5.248	7.872	10.496	13.120	15.744

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	56°	57°
	Inches.	*Inches.*
5′	0.002	0.002
10	.008	.008
15	.018	.017
20	.031	.031
25	.049	.048
30	.070	.069

Longitude interval.	58°	59°
5	0.002	0.002
10	.008	.007
15	.017	.017
20	.030	.030
25	.047	.046
30	.068	.067

Longitude interval.	60°	61°
5	0.002	0.002
10	.007	.007
15	.016	.016
20	.029	.029
25	.045	.045
30	.065	.064

Longitude interval.	62°	63°
5	0.002	0.002
10	.007	.007
15	.016	.015
20	.028	.027
25	.044	.043
30	.063	.061

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
63°00′	69.253	2.624	5.248	7.872	10.496	13.120	15.744
10	11.544	2.609	5.218	7.827	10.436	13.045	15.654
20	23.087	2.594	5.188	7.782	10.376	12.970	15.564
30	34.631	2.579	5.158	7.737	10.316	12.895	15.473
40	46.175	2.564	5.128	7.692	10.256	12.820	15.383
50	57.718	2.549	5.098	7.647	10.196	12.745	15.293
64 00	69.262	2.534	5.068	7.602	10.136	12.670	15.203
10	11.545	2.519	5.037	7.556	10.075	12.594	15.112
20	23.091	2.504	5.007	7.511	10.014	12.518	15.022
30	34.636	2.488	4.977	7.465	9.954	12.442	14.930
40	46.182	2.473	4.947	7.420	9.893	12.367	14.840
50	57.727	2.458	4.916	7.374	9.832	12.291	14.749
65 00	69.272	2.443	4.886	7.329	9.772	12.215	14.658
10	11.547	2.428	4.855	7.283	9.711	12.139	14.566
20	23.094	2.412	4.825	7.237	9.650	12.062	14.474
30	34.641	2.397	4.794	7.191	9.588	11.986	14.383
40	46.188	2.382	4.764	7.145	9.527	11.909	14.291
50	57.735	2.366	4.733	7.100	9.466	11.833	14.199
66 00	69.282	2.351	4.702	7.054	9.405	11.756	14.107
10	11.548	2.336	4.672	7.007	9.343	11.679	14.015
20	23.097	2.320	4.641	6.961	9.282	11.602	13.922
30	34.646	2.305	4.610	6.915	9.220	11.525	13.830
40	46.194	2.290	4.579	6.869	9.158	11.448	13.738
50	57.742	2.274	4.548	6.823	9.097	11.371	13.645
67 00	69.291	2.259	4.518	6.776	9.035	11.294	13.553
10	11.550	2.243	4.487	6.730	8.973	11.217	13.460
20	23.100	2.228	4.455	6.683	8.911	11.139	13.366
30	34.650	2.212	4.424	6.637	8.849	11.061	13.273
40	46.200	2.197	4.393	6.590	8.787	10.984	13.180
50	57.750	2.181	4.362	6.543	8.724	10.906	13.087
68 00	69.300	2.166	4.331	6.497	8.662	10.828	12.994
10	11.552	2.150	4.300	6.450	8.600	10.750	12.900
20	23.103	2.134	4.269	6.403	8.538	10.672	12.806
30	34.654	2.119	4.237	6.356	8.475	10.594	12.712
40	46.206	2.103	4.206	6.309	8.412	10.516	12.619
50	57.758	2.088	4.175	6.263	8.350	10.438	12.525
69 00	69.309	2.072	4.144	6.216	8.288	10.360	12.431
10	11.553	2.056	4.112	6.169	8.225	10.281	12.337
20	23.106	2.040	4.081	6.121	8.162	10.202	12.242
30	34.659	2.025	4.049	6.074	8.099	10.124	12.148
40	46.212	2.009	4.018	6.027	8.036	10.045	12.054
50	57.764	1.993	3.986	5.980	7.973	9.966	11.959
70 00	69.317	1.977	3.955	5.932	7.910	9.888	11.865

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	63°	64°
	Inches.	*Inches.*
5′	0.002	0.002
10	.007	.007
15	.015	.015
20	.027	.026
25	.043	.041
30	.061	.060
	65°	**66°**
5	0.002	0.002
10	.006	.006
15	.014	.014
20	.026	.025
25	.040	.039
30	.058	.056
	67°	**68°**
5	0.001	0.001
10	.006	.006
15	.014	.013
20	.024	.023
25	.038	.036
30	.054	.053
	69°	**70°**
5	0.001	0.001
10	.006	.005
15	.013	.012
20	.022	.022
25	.035	.034
30	.051	.049

TABLE 22.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on p. liii–lvi.]

Latitude of parallel.	Meridionel distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
70°00′	69.317	1.977	3.955	5.932	7.910	9.888	11.865
10	11.554	1.962	3.923	5.885	7.846	9.808	11.770
20	23.109	1.946	3.892	5.837	7.783	9.729	11.675
30	34.663	1.930	3.860	5.790	7.720	9.650	11.579
40	46.217	1.914	3.828	5.742	7.656	9.571	11.485
50	57.772	1.898	3.796	5.695	7.593	9.491	11.389
71 00	69.326	1.882	3.765	5.647	7.530	9.412	11.294
10	11.556	1.866	3.733	5.600	7.466	9.333	11.199
20	23.111	1.850	3.701	5.552	7.402	9.253	11.103
30	34.667	1.835	3.669	5.504	7.338	9.173	11.008
40	46.222	1.819	3.637	5.456	7.275	9.094	10.912
50	57.778	1.803	3.605	5.408	7.211	9.014	10.816
72 00	69.334	1.787	3.574	5.360	7.147	8.934	10.721
10	11.557	1.771	3.542	5.312	7.083	8.854	10.625
20	23.114	1.755	3.509	5.264	7.019	8.774	10.528
30	34.670	1.739	3.477	5.216	6.955	8.694	10.432
40	46.227	1.723	3.445	5.168	6.891	8.614	10.336
50	57.784	1.707	3.413	5.120	6.826	8.533	10.240
73 00	69.341	1.691	3.381	5.072	6.762	8.453	10.144
10	11.558	1.674	3.349	5.024	6.698	8.373	10.047
20	23.116	1.658	3.317	4.975	6.634	8.292	9.950
30	34.674	1.642	3.284	4.927	6.569	8.211	9.853
40	46.232	1.626	3.252	4.878	6.504	8.131	9.757
50	57.790	1.610	3.220	4.830	6.440	8.050	9.660
74 00	69.348	1.594	3.188	4.782	6.376	7.970	9.563
10	11.559	1.578	3.155	4.733	6.311	7.889	9.466
20	23.118	1.562	3.123	4.685	6.246	7.808	9.369
30	34.677	1.545	3.091	4.636	6.181	7.727	9.272
40	46.236	1.529	3.058	4.587	6.116	7.645	9.175
50	57.796	1.513	3.026	4.539	6.052	7.565	9.077
75 00	69.355	1.497	2.993	4.490	5.987	7.484	8.980
10	11.560	1.480	2.961	4.441	5.922	7.402	8.882
20	23.120	1.464	2.928	4.392	5.856	7.321	8.785
30	34.681	1.448	2.896	4.344	5.792	7.240	8.687
40	46.241	1.432	2.863	4.295	5.726	7.158	8.590
50	57.801	1.415	2.831	4.246	5.661	7.077	8.492
76 00	69.361	1.399	2.798	4.197	5.596	6.995	8.394
10	11.561	1.383	2.765	4.148	5.530	6.913	8.296
20	23.122	1.366	2.733	4.099	5.465	6.832	8.198
30	34.683	1.350	2.700	4.050	5.400	6.750	8.099
40	46.244	1.334	2.667	4.001	5.334	6.668	8.002
50	57.806	1.317	2.634	3.952	5.269	6.586	7.903
77 00	69.367	1.301	2.602	3.903	5.204	6.505	7.805

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	70°	71°	72°	73°	74°	75°	76°	77°
	Inches.	*Inches.*						
5′	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
10	.005	.005	.005	.005	.004	.004	.004	.004
15	.012	.012	.011	.011	.010	.009	.009	.008
20	.022	.021	.020	.019	.018	.017	.016	.015
25	.034	.032	.031	.029	.028	.026	.025	.023
30	.049	.047	.044	.042	.040	.038	.036	.033

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{63360}$.

[Derivation of table explained on p. liii-lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
77°00′	69.367	1.301	2.602	3.903	5.204	6.505	7.805
10	11.562	1.284	2.569	3.854	5.138	6.423	7.707
20	23.124	1.268	2.536	3.804	5.072	6.341	7.609
30	34.686	1.252	2.503	3.755	5.006	6.258	7.510
40	46.248	1.235	2.470	3.706	4.941	6.176	7.411
50	57.810	1.219	2.438	3.656	4.875	6.094	7.313
78 00	69.373	1.202	2.405	3.607	4.810	6.012	7.214
10	11.563	1.186	2.372	3.558	4.744	5.930	7.115
20	23.126	1.169	2.339	3.508	4.678	5.847	7.016
30	34.689	1.153	2.306	3.459	4.612	5.765	6.918
40	46.252	1.136	2.273	3.410	4.546	5.683	6.819
50	57.814	1.120	2.240	3.360	4.480	5.600	6.720
79 00	69.377	1.104	2.207	3.311	4.414	5.518	6.621
10	11.564	1.087	2.174	3.261	4.348	5.435	6.522
20	23.127	1.070	2.141	3.211	4.282	5.352	6.422
30	34.691	1.054	2.108	3.162	4.216	5.270	6.323
40	46.255	1.037	2.075	3.112	4.150	5.187	6.224
50	57.818	1.021	2.042	3.062	4.083	5.104	6.125
80 00	69.382	1.004	2.009	3.013	4.017	5.022	6.026

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	77°	78°
	Inches.	*Inches.*
5′	0.001	0.001
10	.004	.003
15	.008	.008
20	.015	.014
25	.023	.021
30	.033	.031

Longitude interval.	79°	80°
5	0.001	0.001
10	.003	.003
15	.007	.006
20	.013	.011
25	.020	.018
30	.028	.026

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{200000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	Co-ordinates of developed parallel for— 10′ longitude. x	10′ longitude. y	20′ longitude. x	20′ longitude. y	30′ longitude. x	30′ longitude. y	40′ longitude. x	40′ longitude. y	50′ longitude. x	50′ longitude. y	1° longitude. x	1° longitude. y
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
0°00′	....	92.8	.0	185.5	.0	278.3	.0	371.1	.0	463.8	.0	556.6	.0
10	92.1	92.8	.0	185.5	.0	278.3	.0	371.1	.0	463.8	.0	556.6	.0
20	184.3	92.8	.0	185.5	.0	278.3	.0	371.1	.0	463.8	.0	556.6	.0
30	276.4	92.8	.0	185.5	.0	278.3	.0	371.0	.0	463.8	.0	556.6	.0
40	368.6	92.8	.0	185.5	.0	278.3	.0	371.0	.0	463.8	.0	556.6	.0
50	460.7	92.8	.0	185.5	.0	278.3	.0	371.0	.0	463.7	.0	556.5	.1
1 00	....	92.8	.0	185.5	.0	278.3	.0	371.0	.0	463.7	.1	556.5	.1
10	92.1	92.7	.0	185.5	.0	278.2	.0	371.0	.0	463.7	.1	556.4	.1
20	184.3	92.7	.0	185.5	.0	278.2	.0	371.0	.0	463.7	.1	556.4	.1
30	276.4	92.7	.0	185.5	.0	278.2	.0	370.9	.0	463.7	.1	556.4	.1
40	368.6	92.7	.0	185.4	.0	278.2	.0	370.9	.0	463.6	.1	556.3	.1
50	460.7	92.7	.0	185.4	.0	278.2	.0	370.9	.1	463.6	.1	556.3	.2
2 00	....	92.7	.0	185.4	.0	278.1	.0	370.8	.1	463.6	.1	556.3	.2
10	92.1	92.7	.0	185.4	.0	278.1	.0	370.8	.1	463.5	.1	556.2	.2
20	184.3	92.7	.0	185.4	.0	278.1	.0	370.8	.1	463.4	.1	556.1	.2
30	276.4	92.7	.0	185.3	.0	278.0	.0	370.7	.1	463.4	.1	556.0	.2
40	368.6	92.7	.0	185.3	.0	278.0	.0	370.6	.1	463.3	.2	556.0	.2
50	460.7	92.7	.0	185.3	.0	278.0	.1	370.6	.1	463.2	.2	555.9	.2
3 00	....	92.6	.0	185.3	.0	277.9	.1	370.6	.1	463.2	.2	555.8	.2
10	92.1	92.6	.0	185.2	.0	277.9	.1	370.5	.1	463.1	.2	555.7	.3
20	184.3	92.6	.0	185.2	.0	277.8	.1	370.4	.1	463.0	.2	555.7	.3
30	276.4	92.6	.0	185.2	.0	277.8	.1	370.4	.1	463.0	.2	555.5	.3
40	368.6	92.6	.0	185.1	.0	277.7	.1	370.3	.1	462.8	.2	555.4	.3
50	460.7	92.6	.0	185.1	.0	277.7	.1	370.2	.1	462.8	.2	555.4	.3
4 00	....	92.5	.0	185.1	.0	277.6	.1	370.2	.2	462.7	.2	555.2	.3
10	92.1	92.5	.0	185.0	.0	277.6	.1	370.1	.2	462.6	.2	555.1	.3
20	184.3	92.5	.0	185.0	.0	277.5	.1	370.0	.2	462.5	.2	555.0	.3
30	276.4	92.5	.0	185.0	.0	277.4	.1	369.9	.2	462.4	.2	554.9	.3
40	368.6	92.5	.0	184.9	.0	277.4	.1	369.8	.2	462.3	.3	554.8	.4
50	460.7	92.4	.0	184.9	.0	277.3	.1	369.8	.2	462.2	.3	554.6	.4
5 00	....	92.4	.0	184.8	.0	277.3	.1	369.7	.2	462.1	.3	554.5	.4
10	92.2	92.4	.0	184.8	.1	277.2	.1	369.6	.2	462.0	.3	554.3	.4
20	184.3	92.4	.0	184.7	.1	277.1	.1	369.5	.2	461.8	.3	554.2	.4
30	276.4	92.3	.0	184.7	.1	277.0	.1	369.4	.2	461.7	.3	554.0	.4
40	368.6	92.3	.0	184.6	.1	276.9	.1	369.2	.2	461.6	.3	553.9	.5
50	460.7	92.3	.0	184.6	.1	276.9	.1	369.2	.2	461.4	.3	553.7	.5
6 00	....	92.3	.0	184.5	.1	276.8	.1	369.0	.2	461.3	.4	553.6	.5
10	92.2	92.2	.0	184.5	.1	276.7	.1	368.9	.2	461.2	.4	553.4	.5
20	184.3	92.2	.0	184.4	.1	276.6	.1	368.8	.2	461.0	.4	553.2	.5
30	276.4	92.2	.0	184.3	.1	276.5	.1	368.7	.2	460.8	.4	553.0	.5
40	368.6	92.1	.0	184.3	.1	276.4	.1	368.6	.2	460.7	.4	552.8	.6
50	460.7	92.1	.0	184.2	.1	276.3	.1	368.4	.2	460.6	.4	552.7	.6
7 00	....	92.1	.0	184.2	.1	276.2	.1	368.3	.3	460.4	.4	552.5	.6
10	92.2	92.0	.0	184.1	.1	276.1	.1	368.2	.3	460.2	.4	552.2	.6
20	184.3	92.0	.0	184.0	.1	276.0	.1	368.0	.3	460.0	.4	552.1	.6
30	276.4	92.0	.0	184.0	.1	275.9	.1	367.9	.3	459.9	.4	551.9	.6
40	368.6	91.9	.0	183.9	.1	275.8	.1	367.8	.3	459.7	.4	551.6	.6
50	460.7	91.9	.0	183.8	.1	275.7	.1	367.6	.3	459.5	.5	551.4	.7
8 00	....	91.9	.0	183.7	.1	275.6	.2	367.5	.3	459.4	.5	551.2	.7

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{200000}$.

[Derivation of table explained on pp. liii-lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—											
		10′ longitude.		20′ longitude.		30′ longitude.		40′ longitude.		50′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y	x	y	x	y
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
8°00′	....	91.9	.0	183.7	.1	275.6	.2	367.5	.3	459.4	.5	551.2	.7
10	92.2	91.8	.0	183.7	.1	275.5	.2	367.3	.3	459.2	.5	551.0	.7
20	184.3	91.8	.0	183.6	.1	275.4	.2	367.2	.3	459.0	.5	550.7	.7
30	276.5	91.8	.0	183.5	.1	275.2	.2	367.0	.3	458.8	.5	550.5	.7
40	368.6	91.7	.0	183.4	.1	275.1	.2	366.8	.3	458.6	.5	550.3	.7
50	460.8	91.7	.0	183.3	.1	275.0	.2	366.7	.3	458.4	.5	550.0	.7
9 00	....	91.6	.0	183.3	.1	274.9	.2	366.5	.3	458.2	.5	549.8	.8
10	92.2	91.6	.0	183.2	.1	274.8	.2	366.4	.3	458.0	.5	549.5	.8
20	184.3	91.5	.0	183.1	.1	274.6	.2	366.2	.3	457.7	.5	549.2	.8
30	276.5	91.5	.0	183.0	.1	274.5	.2	366.0	.3	457.5	.5	549.0	.8
40	368.6	91.5	.0	182.9	.1	274.4	.2	365.8	.4	457.3	.6	548.8	.8
50	460.8	91.4	.0	182.8	.1	274.2	.2	365.6	.4	457.0	.6	548.5	.8
10 00	....	91.4	.0	182.7	.1	274.1	.2	365.5	.4	456.8	.6	548.2	.8
10	92.2	91.3	.0	182.6	.1	274.0	.2	365.3	.4	456.6	.6	547.9	.8
20	184.3	91.3	.0	182.5	.1	273.8	.2	365.1	.4	456.4	.6	547.6	.9
30	276.5	91.2	.0	182.4	.1	273.7	.2	364.9	.4	456.1	.6	547.3	.9
40	368.7	91.2	.0	182.3	.1	273.5	.2	364.7	.4	455.9	.6	547.0	.9
50	460.8	91.1	.0	182.2	.1	273.4	.2	364.5	.4	455.6	.6	546.7	.9
11 00	....	91.1	.0	182.1	.1	273.2	.2	364.3	.4	455.4	.6	546.4	.9
10	92.2	91.0	.0	182.0	.1	273.1	.2	364.1	.4	455.1	.6	546.1	.9
20	184.3	91.0	.0	181.9	.1	272.9	.2	363.8	.4	454.8	.6	545.8	.9
30	276.5	90.9	.0	181.8	.1	272.7	.2	363.6	.4	454.6	.7	545.5	.9
40	368.7	90.9	.0	181.7	.1	272.6	.2	363.4	.4	454.3	.7	545.2	1.0
50	460.8	90.8	.0	181.6	.1	272.4	.2	363.2	.4	454.0	.7	544.8	1.0
12 00	....	90.8	.0	181.5	.1	272.2	.2	363.0	.4	453.8	.7	544.5	1.0
10	92.2	90.7	.0	181.4	.1	272.1	.2	362.8	.4	453.4	.7	544.1	1.0
20	184.4	90.6	.0	181.3	.1	271.9	.2	362.5	.4	453.2	.7	543.8	1.0
30	276.5	90.6	.0	181.1	.1	271.7	.3	362.3	.4	452.8	.7	543.4	1.0
40	368.7	90.5	.0	181.0	.1	271.6	.3	362.1	.4	452.6	.7	543.1	1.0
50	460.9	90.5	.0	180.9	.1	271.4	.3	361.8	.5	452.3	.7	542.8	1.1
13 00	....	90.4	.0	180.8	.1	271.2	.3	361.6	.5	452.0	.7	542.4	1.1
10	92.2	90.3	.0	180.7	.1	271.0	.3	361.4	.5	451.7	.7	542.0	1.1
20	184.4	90.3	.0	180.6	.1	270.8	.3	361.1	.5	451.4	.8	541.7	1.1
30	276.6	90.2	.0	180.4	.1	270.6	.3	360.8	.5	451.0	.8	541.3	1.1
40	368.8	90.2	.0	180.3	.1	270.4	.3	360.6	.5	450.8	.8	540.9	1.1
50	461.0	90.1	.0	180.2	.1	270.3	.3	360.4	.5	450.4	.8	540.5	1.1
14 00	....	90.0	.0	180.1	.1	270.1	.3	360.1	.5	450.2	.8	540.2	1.1
10	92.2	90.0	.0	179.9	.1	269.9	.3	359.8	.5	449.8	.8	539.8	1.2
20	184.4	89.9	.0	179.8	.1	269.7	.3	359.6	.5	449.5	.8	539.4	1.2
30	276.6	89.8	.0	179.7	.1	269.5	.3	359.3	.5	449.2	.8	539.0	1.2
40	368.8	89.8	.0	179.5	.1	269.3	.3	359.0	.5	448.8	.8	538.6	1.2
50	461.0	89.7	.0	179.4	.1	269.1	.3	358.8	.5	448.5	.8	538.2	1.2
15 00	....	89.6	.0	179.3	.1	268.9	.3	358.5	.5	448.2	.8	537.8	1.2
10	92.2	89.6	.0	179.1	.1	268.7	.3	358.2	.5	447.8	.8	537.4	1.2
20	184.4	89.5	.0	179.0	.1	268.5	.3	358.0	.6	447.4	.8	536.9	1.2
30	276.6	89.4	.0	178.8	.1	268.3	.3	357.7	.6	447.1	.9	536.5	1.2
40	368.8	89.3	.0	178.7	.1	268.0	.3	357.4	.6	446.7	.9	536.0	1.3
50	461.0	89.3	.0	178.5	.1	267.8	.3	357.1	.6	446.4	.9	535.6	1.3
16 00	....	89.2	.0	178.4	.1	267.6	.3	356.8	.6	446.0	.9	535.2	1.3

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{200000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—											
		10′ longitude.		20′ longitude.		30′ longitude.		40′ longitude.		50′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y	x	y	x	y
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
16°00′	....	89.2	.0	178.4	.1	267.6	.3	356.8	.6	446.0	.9	535.2	1.3
10	92.2	89.1	.0	178.2	.1	267.4	.3	356.5	.6	445.6	.9	534.7	1.3
20	184.4	89.0	.0	178.1	.1	267.2	.3	356.2	.6	445.2	.9	534.3	1.3
30	276.6	89.0	.0	177.9	.1	266.9	.3	355.9	.6	444.8	.9	533.8	1.3
40	368.8	88.9	.0	177.8	.1	266.7	.3	355.6	.6	444.4	.9	533.3	1.3
50	461.0	88.8	.0	177.6	.1	266.5	.3	355.3	.6	444.1	.9	532.9	1.4
17 00	....	88.7	.0	177.5	.2	266.2	.3	355.0	.6	443.7	.9	532.4	1.4
10	92.2	88.7	.0	177.3	.2	266.0	.3	354.6	.6	443.3	.9	532.0	1.4
20	184.4	88.6	.0	177.2	.2	265.7	.3	354.3	.6	442.9	1.0	531.5	1.4
30	276.7	88.5	.0	177.0	.2	265.5	.3	354.0	.6	442.5	1.0	531.0	1.4
40	368.9	88.4	.0	176.8	.2	265.2	.4	353.6	.6	442.0	1.0	530.5	1.4
50	461.1	88.3	.0	176.7	.2	265.0	.4	353.3	.6	441.6	1.0	530.0	1.4
18 00	....	88.3	.0	176.5	.2	264.8	.4	353.0	.6	441.2	1.0	529.5	1.4
10	92.2	88.2	.0	176.3	.2	264.5	.4	352.6	.6	440.8	1.0	529.0	1.4
20	184.5	88.1	.0	176.2	.2	264.2	.4	352.3	.6	440.4	1.0	528.5	1.5
30	276.7	88.0	.0	176.0	.2	264.0	.4	352.0	.6	440.0	1.0	528.0	1.5
40	368.9	87.9	.0	175.8	.2	263.7	.4	351.6	.6	439.6	1.0	527.5	1.5
50	461.2	87.8	.0	175.6	.2	263.5	.4	351.3	.7	439.1	1.0	526.9	1.5
19 00	....	87.7	.0	175.5	.2	263.2	.4	351.0	.7	438.7	1.0	526.4	1.5
10	92.2	87.6	.0	175.3	.2	263.0	.4	350.6	.7	438.2	1.0	525.9	1.5
20	184.5	87.6	.0	175.1	.2	262.7	.4	350.2	.7	437.8	1.0	525.4	1.5
30	276.7	87.5	.0	174.9	.2	262.4	.4	349.9	.7	437.4	1.1	524.8	1.5
40	369.0	87.4	.0	174.8	.2	262.1	.4	349.5	.7	436.9	1.1	524.3	1.5
50	461.2	87.3	.0	174.6	.2	261.9	.4	349.2	.7	436.4	1.1	523.7	1.6
20 00	....	87.2	.0	174.4	.2	261.6	.4	348.8	.7	436.0	1.1	523.2	1.6
10	92.2	87.1	.0	174.2	.2	261.3	.4	348.4	.7	435.6	1.1	522.7	1.6
20	184.5	87.0	.0	174.0	.2	261.0	.4	348.0	.7	435.0	1.1	522.1	1.6
30	276.8	86.9	.0	173.8	.2	260.8	.4	347.7	.7	434.6	1.1	521.5	1.6
40	369.0	86.8	.0	173.7	.2	260.5	.4	347.3	.7	434.2	1.1	521.0	1.6
50	461.2	86.7	.0	173.5	.2	260.2	.4	346.9	.7	433.6	1.1	520.4	1.6
21 00	....	86.6	.0	173.3	.2	259.9	.4	346.6	.7	433.2	1.1	519.8	1.6
10	92.3	86.5	.0	173.1	.2	259.6	.4	346.2	.7	432.7	1.1	519.2	1.6
20	184.5	86.4	.0	172.9	.2	259.3	.4	345.8	.7	432.2	1.1	518.6	1.6
30	276.8	86.3	.0	172.7	.2	259.0	.4	345.4	.7	431.7	1.2	518.0	1.7
40	369.0	86.2	.0	172.5	.2	258.8	.4	345.0	.7	431.2	1.2	517.5	1.7
50	461.3	86.1	.0	172.3	.2	258.4	.4	344.6	.7	430.8	1.2	516.9	1.7
22 00	....	86.0	.0	172.1	.2	258.2	.4	344.2	.7	430.2	1.2	516.3	1.7
10	92.3	85.9	.0	171.9	.2	257.8	.4	343.8	.8	429.8	1.2	515.7	1.7
20	184.5	85.8	.0	171.7	.2	257.6	.4	343.4	.8	429.2	1.2	515.1	1.7
30	276.8	85.7	.0	171.5	.2	257.2	.4	343.0	.8	428.8	1.2	514.5	1.7
40	369.1	85.6	.0	171.3	.2	256.9	.4	342.6	.8	428.2	1.2	513.8	1.7
50	461.4	85.5	.0	171.1	.2	256.6	.4	342.2	.8	427.7	1.2	513.2	1.7
23 00	....	85.4	.0	170.9	.2	256.3	.4	341.8	.8	427.2	1.2	512.6	1.7
10	92.3	85.3	.0	170.7	.2	256.0	.4	341.3	.8	426.6	1.2	512.0	1.8
20	184.6	85.2	.0	170.4	.2	255.7	.4	340.9	.8	426.1	1.2	511.3	1.8
30	276.8	85.1	.0	170.2	.2	255.3	.4	340.4	.8	425.6	1.2	510.7	1.8
40	369.1	85.0	.0	170.0	.2	255.0	.4	340.0	.8	425.0	1.2	510 1	1.8
50	461.4	84.9	.0	169.8	.2	254.7	.4	339.6	.8	424.5	1.2	509.4	1.8
24 00	....	84.8	.0	169.6	.2	254.4	.4	339.2	.8	424.0	1.3	508.7	1.8

TABLE 23.

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{200000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	Co-ordinates of developed parallel for— 10′ longitude. x	10′ longitude. y	20′ longitude. x	20′ longitude. y	30′ longitude. x	30′ longitude. y	40′ longitude. x	40′ longitude. y	50′ longitude. x	50′ longitude. y	1° longitude. x	1° longitude. y
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
24°00′	....	84.8	.0	169.6	.2	254.4	.4	339.2	.8	424.0	1.3	508.7	1.8
10	92.3	84.7	.0	169.4	.2	254.0	.5	338.7	.8	423.4	1.3	508.1	1.8
20	184.6	84.6	.0	169.1	.2	253.7	.5	338.3	.8	422.8	1.3	507.4	1.8
30	276.9	84.5	.0	168.9	.2	253.4	.5	337.8	.8	422.3	1.3	506.8	1.8
40	369.2	84.4	.0	168.7	.2	253.0	.5	337.4	.8	421.8	1.3	506.1	1.8
50	461.5	84.2	.0	168.5	.2	252.7	.5	337.0	.8	421.2	1.3	505.4	1.9
25 00	....	84.1	.1	168.3	.2	252.4	.5	336.5	.8	420.6	1.3	504.8	1.9
10	92.3	84.0	.1	168.0	.2	252.0	.5	336.0	.8	420.0	1.3	504.1	1.9
20	184.6	83.9	.1	167.8	.2	251.7	.5	335.6	.8	419.5	1.3	503.4	1.9
30	276.9	83.8	.1	167.6	.2	251.3	.5	335.1	.8	418.9	1.3	502.7	1.9
40	369.2	83.7	.1	167.3	.2	251.0	.5	334.6	.8	418.3	1.3	502.0	1.9
50	461.6	83.6	.1	167.1	.2	250.6	.5	334.2	.8	417.8	1.3	501.3	1.9
26 00	....	83.4	.1	166.9	.2	250.3	.5	333.7	.9	417.2	1.3	500.6	1.9
10	92.3	83.3	.1	166.6	.2	249.9	.5	333.2	.9	416.6	1.3	499.9	1.9
20	184.6	83.2	.1	166.4	.2	249.6	.5	332.8	.9	416.0	1.3	499.1	1.9
30	277.0	83.1	.1	166.1	.2	249.2	.5	332.3	.9	415.4	1.3	498.4	1.9
40	369.3	82.9	.1	165.9	.2	248.8	.5	331.8	.9	414.8	1.4	497.7	2.0
50	461.6	82.8	.1	165.7	.2	248.5	.5	331.3	.9	414.2	1.4	497.0	2.0
27 00	....	82.7	.1	165.4	.2	248.1	.5	330.8	.9	413.6	1.4	496.3	2.0
10	92.3	82.6	.1	165.2	.2	247.8	.5	330.4	.9	413.0	1.4	495.5	2.0
20	184.7	82.5	.1	164.9	.2	247.4	.5	329.8	.9	412.3	1.4	494.8	2.0
30	277.0	82.3	.1	164.7	.2	247.0	.5	329.4	.9	411.7	1.4	494.0	2.0
40	369.3	82.2	.1	164.4	.2	246.7	.5	328.9	.9	411.1	1.4	493.3	2.0
50	461.6	82.1	.1	164.2	.2	246.3	.5	328.4	.9	410.4	1.4	492.5	2.0
28 00	....	82.0	.1	163.9	.2	245.9	.5	327.9	.9	409.8	1.4	491.8	2.0
10	92.4	81.8	.1	163.7	.2	245.5	.5	327.4	.9	409.2	1.4	491.0	2.0
20	184.7	81.7	.1	163.4	.2	245.1	.5	326.8	.9	408.6	1.4	490.3	2.0
30	277.0	81.6	.1	163.2	.2	244.7	.5	326.3	.9	407.9	1.4	489.5	2.0
40	369.4	81.5	.1	162.9	.2	244.4	.5	325.8	.9	407.3	1.4	488.8	2.0
50	461.8	81.3	.1	162.7	.2	244.0	.5	325.3	.9	406.6	1.4	488.0	2.1
29 00	....	81.2	.1	162.4	.2	243.6	.5	324.8	.9	406.0	1.4	487.2	2.1
10	92.4	81.1	.1	162.1	.2	243.2	.5	324.3	.9	405.4	1.4	486.4	2.1
20	184.7	80.9	.1	161.9	.2	242.8	.5	323.8	.9	404.7	1.4	485.6	2.1
30	277.1	80.8	.1	161.6	.2	242.4	.5	323.2	.9	404.0	1.4	484.8	2.1
40	369.4	80.7	.1	161.3	.2	242.0	.5	322.7	.9	403.4	1.4	484.0	2.1
50	461.8	80.5	.1	161.1	.2	241.6	.5	322.2	.9	402.7	1.5	483.2	2.1
30 00	....	80.4	.1	160.8	.2	241.2	.5	321.6	.9	402.0	1.5	482.5	2.1
10	92.4	80.3	.1	160.5	.2	240.8	.5	321.1	.9	401.4	1.5	481.6	2.1
20	184.8	80.1	.1	160.3	.2	240.4	.5	320.6	.9	400.7	1.5	480.8	2.1
30	277.1	80.0	.1	160.0	.2	240.0	.5	320.0	.9	400.0	1.5	480.0	2.1
40	369.5	79.9	.1	159.7	.2	239.6	.5	319.4	.9	399.3	1.5	479.2	2.1
50	461.9	79.7	.1	159.5	.2	239.2	.5	318.9	.9	398.6	1.5	478.4	2.1
31 00	....	79.6	.1	159.2	.2	238.8	.5	318.4	1.0	398.0	1.5	477.5	2.1
10	92.4	79.4	.1	158.9	.2	238.4	.5	317.8	1.0	397.2	1.5	476.7	2.1
20	184.8	79.3	.1	158.6	.2	237.9	.5	317.2	1.0	396.6	1.5	475.9	2.2
30	277.2	79.2	.1	158.3	.2	237.5	.5	316.7	1.0	395.8	1.5	475.0	2.2
40	369.6	79.0	.1	158.1	.2	237.1	.5	316.1	1.0	395.2	1.5	474.2	2.2
50	462.0	78.9	.1	157.8	.2	236.7	.5	315.6	1.0	394.4	1.5	473.3	2.2
32 00	....	78.8	.1	157.5	.2	236.2	.5	315.0	1.0	393.8	1.5	472.5	2.2

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{2000000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—											
		10′ longitude.		20′ longitude.		30′ longitude.		40′ longitude.		50′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y	x	y	x	y
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
32°00′	....	78.8	.1	157.5	.2	236.2	.5	315.0	1.0	393.8	1.5	472.5	2.2
10	92.4	78.6	.1	157.2	.2	235.8	.5	314.4	1.0	393.0	1.5	471.6	2.2
20	184.8	78.5	.1	156.9	.2	235.4	.5	313.8	1.0	392.3	1.5	470.8	2.2
30	277.2	78.3	.1	156.6	.2	235.0	.5	313.3	1.0	391.6	1.5	469.9	2.2
40	369.6	78.2	.1	156.3	.2	234.5	.5	312.7	1.0	390.8	1.5	469.0	2.2
50	462.0	78.0	.1	156.0	.2	234.1	.5	312.1	1.0	390.1	1.5	468.1	2.2
33 00	....	77.9	.1	155.8	.2	233.6	.6	311.5	1.0	389.4	1.5	467.3	2.2
10	92.4	77.7	.1	155.5	.2	233.2	.6	310.9	1.0	388.6	1.5	466.4	2.2
20	184.8	77.6	.1	155.2	.2	232.7	.6	310.3	1.0	387.9	1.5	465.5	2.2
30	277.3	77.4	.1	154.9	.2	232.3	.6	309.7	1.0	387.2	1.6	464.6	2.2
40	369.7	77.3	.1	154.6	.2	231.9	.6	309.2	1.0	386.4	1.6	463.7	2.2
50	462.1	77.1	.1	154.3	.2	231.4	.6	308.6	1.0	385.7	1.6	462.8	2.2
34 00	....	77.0	.1	154.0	.3	231.0	.6	308.0	1.0	384.9	1.6	461.9	2.3
10	92.4	76.8	.1	153.7	.3	230.5	.6	307.4	1.0	384.2	1.6	461.0	2.3
20	184.9	76.7	.1	153.4	.3	230.0	.6	306.7	1.0	383.4	1.6	460.1	2.3
30	277.3	76.5	.1	153.1	.3	229.6	.6	306.1	1.0	382.6	1.6	459.2	2.3
40	369.7	76.4	.1	152.8	.3	229.1	.6	305.5	1.0	381.9	1.6	458.3	2.3
50	462.1	76.2	.1	152.4	.3	228.7	.6	304.9	1.0	381.1	1.6	457.3	2.3
35 00	....	76.1	.1	152.1	.3	228.2	.6	304.3	1.0	380.4	1.6	456.4	2.3
10	92.4	75.9	.1	151.8	.3	227.8	.6	303.7	1.0	379.6	1.6	455.5	2.3
20	184.9	75.8	.1	151.5	.3	227.3	.6	303.0	1.0	378.8	1.6	454.6	2.3
30	277.4	75.6	.1	151.2	.3	226.8	.6	302.4	1.0	378.0	1.6	453.6	2.3
40	369.8	75.4	.1	150.9	.3	226.4	.6	301.8	1.0	377.2	1.6	452.7	2.3
50	462.2	75.3	.1	150.6	.3	225.9	.6	301.2	1.0	376.5	1.6	451.8	2.3
36 00	....	75.1	.1	150.3	.3	225.4	.6	300.6	1.0	375.7	1.6	450.8	2.3
10	92.5	75.0	.1	150.0	.3	224.9	.6	299.9	1.0	374.9	1.6	449.9	2.3
20	184.9	74.8	.1	149.6	.3	224.5	.6	299.3	1.0	374.1	1.6	448.9	2.3
30	277.4	74.7	.1	149.3	.3	224.0	.6	298.6	1.0	373.3	1.6	448.0	2.3
40	369.8	74.5	.1	149.0	.3	223.5	.6	298.0	1.0	372.5	1.6	447.0	2.3
50	462.3	74.3	.1	148.7	.3	223.0	.6	297.4	1.0	371.7	1.6	446.0	2.3
37 00	....	74.2	.1	148.4	.3	222.5	.6	296.7	1.0	370.9	1.6	445.1	2.3
10	92.5	74.0	.1	148.0	.3	222.1	.6	296.1	1.0	370.1	1.6	444.1	2.3
20	185.0	73.8	.1	147.7	.3	221.6	.6	295.4	1.0	369.2	1.6	443.1	2.3
30	277.4	73.7	.1	147.4	.3	221.1	.6	294.8	1.0	368.4	1.6	442.1	2.3
40	369.9	73.5	.1	147.1	.3	220.6	.6	294.1	1.0	367.6	1.6	441.2	2.4
50	462.4	73.4	.1	146.7	.3	220.1	.6	293.4	1.0	366.8	1.6	440.2	2.4
38 00	....	73.2	.1	146.4	.3	219.6	.6	292.8	1.0	366.0	1.6	439.2	2.4
10	92.5	73.0	.1	146.1	.3	219.1	.6	292.1	1.0	365.1	1.6	438.2	2.4
20	185.0	72.9	.1	145.7	.3	218.6	.6	291.4	1.1	364.3	1.6	437.2	2.4
30	277.5	72.7	.1	145.4	.3	218.1	.6	290.8	1.1	363.5	1.6	436.2	2.4
40	370.0	72.5	.1	145.1	.3	217.6	.6	290.1	1.1	362.6	1.6	435.2	2.4
50	462.5	72.4	.1	144.7	.3	217.1	.6	289.4	1.1	361.8	1.6	434.2	2.4
39 00	....	72.2	.1	144.4	.3	216.6	.6	288.8	1.1	361.0	1.7	433.1	2.4
10	92.5	72.0	.1	144.0	.3	216.1	.6	288.1	1.1	360.1	1.7	432.1	2.4
20	185.0	71.8	.1	143.7	.3	215.6	.6	287.4	1.1	359.2	1.7	431.1	2.4
30	277.5	71.7	.1	143.4	.3	215.0	.6	286.7	1.1	358.4	1.7	430.1	2.4
40	370.0	71.5	.1	143.0	.3	214.5	.6	286.0	1.1	357.5	1.7	429.0	2.4
50	462.6	71.3	.1	142.7	.3	214.0	.6	285.3	1.1	356.6	1.7	428.0	2.4
40 00	....	71.2	.1	142.3	.3	213.5	.6	284.6	1.1	355.8	1.7	427.0	2.4

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{200000}$.

[Derivation of table explained on pp. liii-lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—											
		10′ longitude.		20′ longitude.		30′ longitude.		40′ longitude.		50′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y	x	y	x	y
	mm.	*mm*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
40°00′	....	71.2	.1	142.3	.3	213.5	.6	284.6	1.1	355.8	1.7	427.0	2.4
10	92.5	71.0	.1	142.0	.3	212.9	.6	283.9	1.1	354.9	1.7	425.9	2.4
20	185.1	70.8	.1	141.6	.3	212.4	.6	283.2	1.1	354.0	1.7	424.9	2.4
30	277.6	70.6	.1	141.3	.3	211.9	.6	282.6	1.1	353.2	1.7	423.8	2.4
40	370.1	70.5	.1	140.9	.3	211.4	.6	281.8	1.1	352.3	1.7	422.8	2.4
50	462.6	70.3	.1	140.6	.3	210.8	.6	281.1	1.1	351.4	1.7	421.7	2.4
41 00	....	70.1	.1	140.2	.3	210.3	.6	280.4	1.1	350.6	1.7	420.7	2.4
10	92.5	69.9	.1	139.9	.3	209.8	.6	279.7	1.1	349.6	1.7	419.6	2.4
20	185.1	69.8	.1	139.5	.3	209.2	.6	279.0	1.1	348.8	1.7	418.5	2.4
30	277.6	69.6	.1	139.2	.3	208.7	.6	278.3	1.1	347.9	1.7	417.5	2.4
40	370.2	69.4	.1	138.8	.3	208.2	.6	277.6	1.1	347.0	1.7	416.4	2.4
50	462.7	69.2	.1	138.4	.3	207.7	.6	276.9	1.1	346.1	1.7	415.3	2.4
42 00	....	69.0	.1	138.1	.3	207.1	.6	276.2	1.1	345.2	1.7	414.2	2.4
10	92.6	68.9	.1	137.7	.3	206.6	.6	275.4	1.1	344.3	1.7	413.2	2.4
20	185.1	68.7	.1	137.4	.3	206.0	.6	274.7	1.1	343.4	1.7	412.1	2.4
30	277.7	68.5	.1	137.0	.3	205.5	.6	274.0	1.1	342.4	1.7	410.9	2.4
40	370.2	68.3	.1	136.6	.3	204.9	.6	273.2	1.1	341.5	1.7	409.9	2.4
50	462.8	68.1	.1	136.3	.3	204.4	.6	272.5	1.1	340.6	1.7	408.8	2.4
43 00	....	68.0	.1	135.9	.3	203.8	.6	271.8	1.1	339.8	1.7	407.7	2.4
10	92.6	67.8	.1	135.5	.3	203.3	.6	271.0	1.1	338.8	1.7	406.6	2.4
20	185.2	67.6	.1	135.2	.3	202.7	.6	270.3	1.1	337.9	1.7	405.5	2.4
30	277.7	67.4	.1	134.8	.3	202.2	.6	269.6	1.1	337.0	1.7	404.4	2.4
40	370.3	67.2	.1	134.4	.3	201.6	.6	268.8	1.1	336.0	1.7	403.3	2.4
50	462.9	67.0	.1	134.0	.3	201.1	.6	268.1	1.1	335.1	1.7	402.1	2.4
44 00	....	66.8	.1	133.7	.3	200.5	.6	267.4	1.1	334.2	1.7	401.0	2.4
10	92.6	66.6	.1	133.3	.3	200.0	.6	266.6	1.1	333.2	1.7	399.9	2.4
20	185.2	66.5	.1	132.9	.3	199.4	.6	265.8	1.1	332.3	1.7	398.8	2.4
30	277.8	66.3	.1	132.6	.3	198.8	.6	265.1	1.1	331.4	1.7	397.7	2.4
40	370.4	66.1	.1	132.2	.3	198.3	.6	264.4	1.1	330.4	1.7	396.5	2.4
50	463.0	65.9	.1	131.8	.3	197.7	.6	263.6	1.1	329.5	1.7	395.4	2.4
45 00	....	65.7	.1	131.4	.3	197.1	.6	262.8	1.1	328.6	1.7	394.3	2.4
10	92.6	65.5	.1	131.0	.3	196.6	.6	262.1	1.1	327.6	1.7	393.1	2.4
20	185.2	65.3	.1	130.6	.3	196.0	.6	261.3	1.1	326.6	1.7	391.9	2.4
30	277.8	65.1	.1	130.3	.3	195.4	.6	260.5	1.1	325.6	1.7	390.8	2.4
40	370.4	64.9	.1	129.9	.3	194.8	.6	259.8	1.1	324.7	1.7	389.6	2.4
50	463.0	64.7	.1	129.5	.3	194.2	.6	259.0	1.1	323.7	1.7	388.4	2.4
46 00	....	64.6	.1	129.1	.3	193.6	.6	258.2	1.1	322.8	1.7	387.3	2.4
10	92.6	64.4	.1	128.7	.3	193.1	.6	257.4	1.1	321.8	1.7	386.2	2.4
20	185.3	64.2	.1	128.3	.3	192.5	.6	256.6	1.1	320.8	1.7	385.0	2.4
30	277.9	64.0	.1	127.9	.3	191.9	.6	255.9	1.1	319.8	1.7	383.8	2.4
40	370.5	63.8	.1	127.6	.3	191.3	.6	255.1	1.1	318.9	1.7	382.7	2.4
50	463.1	63.6	.1	127.2	.3	190.7	.6	254.3	1.1	317.9	1.7	381.5	2.4
47 00	....	63.4	.1	126.8	.3	190.1	.6	253.5	1.1	316.9	1.7	380.3	2.4
10	92.6	63.2	.1	126.4	.3	189.5	.6	252.7	1.1	315.9	1.7	379.1	2.4
20	185.3	63.0	.1	126.0	.3	188.9	.6	251.9	1.1	314.9	1.7	377.9	2.4
30	277.9	62.8	.1	125.6	.3	188.3	.6	251.1	1.1	313.9	1.7	376.7	2.4
40	370.6	62.6	.1	125.2	.3	187.8	.6	250.4	1.1	313.0	1.7	375.5	2.4
50	463.2	62.4	.1	124.8	.3	187.2	.6	249.6	1.1	312.0	1.7	374.3	2.4
48 00	....	62.2	.1	124.4	.3	186.6	.6	248.8	1.1	311.0	1.7	373.1	2.4

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{200000}$.

[Derivation of table explaiued on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—											
		10′ longitude.		20′ longitude.		30′ longitude.		40′ longitude.		50′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y	x	y	x	y
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
48°00′	....	62.2	.1	124.4	.3	186.6	.6	248.8	1.1	311.0	1.7	373.1	2.4
10	92.7	62.0	.1	124.0	.3	186.0	.6	248.0	1.1	310.0	1.7	371.9	2.4
20	185.3	61.8	.1	123.6	.3	185.4	.6	247.2	1.1	309.0	1.7	370.7	2.4
30	278.0	61.6	.1	123.2	.3	184.7	.6	246.3	1.1	307.9	1.7	369.5	2.4
40	370.6	61.4	.1	122.8	.3	184.1	.6	245.5	1.1	306.9	1.7	368.3	2.4
50	463.3	61.2	.1	122.4	.3	183.5	.6	244.7	1.1	305.9	1.7	367.1	2.4
49 00	....	61.0	.1	122.0	.3	182.9	.6	243.9	1.1	304.9	1.7	365.9	2.4
10	92.7	60.8	.1	121.6	.3	182.3	.6	243.1	1.1	303.9	1.7	364.7	2.4
20	185.4	60.6	.1	121.1	.3	181.7	.6	242.3	1.1	302.8	1.7	363.4	2.4
30	278.0	60.4	.1	120.7	.3	181.1	.6	241.4	1.1	301.8	1.7	362.2	2.4
40	370.7	60.2	.1	120.3	.3	180.5	.6	240.6	1.1	300.8	1.7	361.0	2.4
50	463.4	60.0	.1	119.9	.3	179.9	.6	239.8	1.1	299.8	1.7	359.8	2.4
50 00	....	59.8	.1	119.5	.3	179.2	.6	239.0	1.1	298.8	1.7	358.5	2.4
10	92.7	59.5	.1	119.1	.3	178.6	.6	238.2	1.1	297.7	1.7	357.2	2.4
20	185.4	59.3	.1	118.7	.3	178.0	.6	237.3	1.1	296 6	1.7	356.0	2.4
30	278.1	59.1	.1	118.2	.3	177.4	.6	236.5	1.1	295.6	1.7	354.7	2.4
40	370.8	58.9	.1	117.8	.3	176.8	.6	235.7	1.1	294.6	1.7	353.5	2.4
50	463.4	58.7	.1	117.4	.3	176.1	.6	234.8	1.1	293.6	1.7	352.3	2.4
51 00	....	58.5	.1	117.0	.3	175.5	.6	234.0	1.1	292.5	1.7	351.0	2.4
10	92.7	58.3	.1	116.6	.3	174.9	.6	233.2	1.1	291.4	1.6	349.7	2.4
20	185.4	58.1	.1	116.2	.3	174.2	.6	232.3	1.1	290.4	1.6	348.5	2.4
30	278.1	57.9	.1	115.7	.3	173.6	.6	231.5	1.1	289.4	1.6	347.2	2.4
40	370.8	57.6	.1	115.3	.3	173.0	.6	230.6	1.1	288.2	1.6	345.9	2.4
50	463.6	57.4	.1	114.9	.3	172.3	.6	229.8	1.1	287.2	1.6	344.6	2.4
52 00	....	57.2	.1	114.5	.3	171.7	.6	228.9	1.0	286.2	1.6	343.4	2.4
10	92.7	57.0	.1	114.0	.3	171.1	.6	228.1	1.0	285.1	1.6	342.1	2.4
20	185.4	56.8	.1	113.6	.3	170.4	.6	227.2	1.0	284.0	1.6	340.8	2.4
30	278.2	56.6	.1	113.2	.3	169.8	.6	226.4	1.0	283.0	1.6	339.5	2.3
40	370.9	56.4	.1	112.8	.3	169.1	.6	225.5	1.0	281.9	1.6	338.3	2.3
50	463.6	56.2	.1	112.3	.3	168.5	.6	224.6	1.0	280.8	1.6	337.0	2.3
53 00	....	56.0	.1	111.9	.3	167.9	.6	223.8	1.0	279.8	1.6	335.7	2.3
10	92.7	55.7	.1	111.5	.3	167.2	.6	222.9	1.0	278.6	1.6	334.4	2.3
20	185.5	55.5	.1	111.0	.3	166.6	.6	222.1	1.0	277.6	1.6	333.1	2.3
30	278.2	55.3	.1	110.6	.3	165.9	.6	221.2	1.0	276.5	1.6	331.8	2.3
40	371.0	55.1	.1	110.2	.3	165.2	.6	220.3	1.0	275.4	1.6	330.5	2.3
50	463.7	54.9	.1	109.7	.3	164.6	.6	219.5	1.0	274.4	1.6	329.2	2.3
54 00	....	54.6	.1	109.3	.3	164.0	.6	218.6	1.0	273.2	1.6	327.9	2.3
10	92.8	54.4	.1	108.9	.3	163.3	.6	217.7	1.0	272.1	1.6	326.6	2.3
20	185.5	54.2	.1	108.4	.3	162.6	.6	216.8	1.0	271.0	1.6	325.3	2.3
30	278.3	54.0	.1	108.0	.3	162.0	.6	216.0	1.0	269.9	1.6	323.9	2.3
40	371.0	53.8	.1	107.5	.3	161.3	.6	215.1	1.0	268.8	1.6	322.6	2.3
50	463.8	53.6	.1	107.1	.3	160.6	.6	214.2	1.0	267.7	1.6	321.3	2.3
55 00	....	53.3	.1	106.7	.3	160.0	.6	213.3	1.0	266.6	1.6	320.0	2.3
10	92.8	53.1	.1	106.2	.3	159.3	.6	212.4	1.0	265.6	1.6	318.7	2.3
20	185.5	52.9	.1	105.8	.3	158.7	.6	211.6	1.0	264.4	1.6	317.3	2.3
30	278 3	52.7	.1	105.3	.3	158.0	.6	210.7	1.0	263.4	1.6	316.0	2.3
40	371.1	52.4	.1	104.9	.3	157.3	.6	209.8	1.0	262.2	1.6	314.6	2.3
50	463.8	52.2	.1	104.4	.3	156.7	.6	208.9	1.0	261.1	1.6	313.3	2.3
56 00	....	52.0	.1	104.0	.2	156.0	.6	208.0	1.0	260.0	1.6	312.0	2.3

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{200000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—											
		10′ longitude.		20′ longitude.		30′ longitude.		40′ longitude.		50′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y	x	y	x	y
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
56°00′	....	52.0	.1	104.0	.2	156.0	.6	208.0	1.0	260.0	1.6	312.0	2.3
10	92.8	51.8	.1	103.6	.2	155.3	.6	207.1	1.0	258.9	1.6	310.7	2.3
20	185.6	51.6	.1	103.1	.2	154.6	.6	206.2	1.0	257.8	1.6	309.3	2.2
30	278.4	51.3	.1	102.6	.2	154.0	.6	205.3	1.0	256.6	1.6	307.9	2.2
40	371.2	51.1	.1	102.2	.2	153.3	.6	204.4	1.0	255.5	1.5	306.6	2.2
50	464.0	50.9	.1	101.8	.2	152.6	.6	203.5	1.0	254.4	1.5	305.3	2.2
57 00	....	50.6	.1	101.3	.2	152.0	.6	202.6	1.0	253.2	1.5	303.9	2.2
10	92.8	50.4	.1	100.8	.2	151.3	.6	201.7	1.0	252.1	1.5	302.5	2.2
20	185.6	50.2	.1	100.4	.2	150.6	.6	200.8	1.0	251.0	1.5	301.1	2.2
30	278.4	50.0	.1	99.9	.2	149.9	.6	199.8	1.0	249.8	1.5	299.8	2.2
40	371.2	49.7	.1	99.5	.2	149.2	.6	199.0	1.0	248.7	1.5	298.4	2.2
50	464.0	49.5	.1	99.0	.2	148.5	.5	198.0	1.0	247.6	1.5	297.1	2.2
58 00	....	49.3	.1	98.6	.2	147.8	.5	197.1	1.0	246.4	1.5	295.7	2.2
10	92.8	49.0	.1	98.1	.2	147.2	.5	196.2	1.0	245.2	1.5	294.3	2.2
20	185.6	48.8	.1	97.6	.2	146.5	.5	195.3	1.0	244.1	1.5	292.9	2.2
30	278.5	48 6	.1	97.2	.2	145.8	.5	194.4	1.0	243.0	1.5	291.5	2.2
40	371.3	48.4	.1	96.7	.2	145.1	.5	193.4	1.0	241.8	1.5	290.2	2.2
50	464.1	48.1	.1	96.3	.2	144.4	.5	192.5	1.0	240.6	1.5	288.8	2.1
59 00	....	47.9	.1	95.8	.2	143.7	.5	191.6	1.0	239.5	1.5	287.4	2.1
10	92.8	47.7	.1	95.3	.2	143.0	.5	190.7	1.0	238.4	1.5	286.0	2.1
20	185.7	47.4	.1	94.9	.2	142.3	.5	189.7	1.0	237.2	1.5	284.6	2.1
30	278.5	47.2	.1	94.4	.2	141.6	.5	188.8	1.0	236.0	1.5	283.2	2.1
40	371.3	47.0	.1	93.9	.2	140.9	.5	187.9	.9	234.8	1.5	281.8	2.1
50	464.2	46.7	.1	93.5	.2	140.2	.5	186.9	.9	233.6	1.5	280.4	2.1
60 00	....	46.5	.1	93.0	.2	139.5	.5	186.0	.9	232.5	1.5	279.0	2.1
10	92.8	46.3	.1	92.5	.2	138.8	.5	185.0	.9	231.3	1.5	277.6	2.1
20	185.7	46.0	.1	92.1	.2	138.1	.5	184.1	9	230.2	1.4	276.2	2.1
30	278.6	45.8	.1	91.6	.2	137.4	.5	183.2	.9	229.0	1.4	274.8	2.1
40	371.4	45.6	.1	91.1	.2	136.7	.5	182.2	.9	227.8	1.4	273.4	2.1
50	464.2	45.3	.1	90.6	.2	136.0	.5	181.3	.9	226.6	1.4	271.9	2.1
61 00	....	45.1	.1	90.2	.2	135.3	.5	180.4	.9	225.4	1.4	270.5	2.1
10	92.9	44.8	.1	89.7	.2	134.6	.5	179.4	.9	224.2	1.4	269.1	2.1
20	185.7	44.6	.1	89.2	.2	133.9	.5	178.5	.9	223.1	1.4	267.7	2.1
30	278.6	44.4	.1	88.8	.2	133.1	.5	177.5	.9	221.9	1.4	266.3	2.0
40	371.4	44.1	.1	88.3	.2	132.4	.5	176.6	.9	220.7	1.4	264.8	2.0
50	464.3	43.9	.1	87.8	.2	131.7	.5	175.6	.9	219.6	1.4	263.5	2.0
62 00	....	43.7	.1	87.3	.2	131.0	.5	174.7	.9	218.4	1.4	262.0	2.0
10	92.9	43.4	.1	86.9	.2	130.3	.5	173.7	.9	217.2	1.4	260.6	2.0
20	185.7	43.2	.1	86.4	.2	129.6	.5	172.8	.9	216.0	1.4	259.1	2.0
30	278.6	43.0	.1	85.9	.2	128.8	.5	171.8	.9	214.8	1.4	257.7	2.0
40	371.5	42.7	.1	85.4	.2	128.1	.5	170.8	.9	213.6	1.4	256.3	2.0
50	464.4	42.5	.1	84.9	.2	127.4	.5	169.9	.9	212.4	1.4	254.8	2.0
63 00	....	42.2	.1	84.5	.2	126.7	.5	168.9	.9	211.2	1.4	253.4	2.0
10	92.9	42.0	.1	84.0	.2	126.0	.5	168.0	.9	210.0	1.4	251.9	2.0
20	185.8	41.7	.1	83.5	.2	125.2	.5	167.0	.9	208.8	1.4	250.5	2.0
30	278.7	41.5	.1	83.0	.2	124.5	.5	166.0	.9	207.5	1.3	249.0	1.9
40	371.6	41.3	.1	82.5	.2	123.8	.5	165.0	.9	206.3	1.3	247.6	1.9
50	464.4	41.0	.1	82.0	.2	123.1	.5	164.1	.9	205.1	1.3	246.1	1.9
64 00	....	40.8	.1	81.6	.2	122.3	.5	163.1	.9	203.9	1.3	244.7	1.9

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{200000}$.

[Derivation of table explained on pp. liii.-lviii.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR— 10′ longitude. x	10′ longitude. y	20′ longitude. x	20′ longitude. y	30′ longitude. x	30′ longitude. y	40′ longitude. x	40′ longitude. y	50′ longitude. x	50′ longitude. y	1° longitude. x	1° longitude. y
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
64°00′	....	40.8	.1	81.6	.2	122.3	.5	163.1	.9	203.9	1.3	244.7	1.9
10	92.9	40.5	.1	81.1	.2	121.6	.5	162.2	.8	202.7	1.3	243.2	1.9
20	185.8	40.3	.1	80.6	.2	120.9	.5	161.2	.8	201.4	1.3	241.7	1.9
30	278.7	40.0	.1	80.1	.2	120.1	.5	160.2	.8	200.2	1.3	240.2	1.9
40	371.6	39.8	.1	79.6	.2	119.4	.5	159.2	.8	199.0	1.3	238.8	1.9
50	464.5	39.6	.1	79.1	.2	118.7	.5	158.2	.8	197.8	1.3	237.4	1.9
65 00	....	39.3	.1	78.6	.2	117.9	.5	157.2	.8	196.6	1.3	235.9	1.9
10	92.9	39.1	.1	78.1	.2	117.2	.5	156.2	.8	195.3	1.3	234.4	1.9
20	185.8	38.8	.1	77.6	.2	116.5	.5	155.3	.8	194.1	1.3	232.9	1.8
30	278.7	38.6	.1	77.2	.2	115.7	.5	154.3	.8	192.9	1.3	231.5	1.8
40	371.6	38.3	.1	76.7	.2	115.0	.5	153.3	.8	191.6	1.3	230.0	1.8
50	464.6	38.1	.1	76.2	.2	114.2	.5	152.3	.8	190.4	1.3	228.5	1.8
66 00	....	37.8	.1	75.7	.2	113.5	.5	151.4	.8	189.2	1.3	227.0	1.8
10	92.9	37.6	.0	75.2	.2	112.8	.4	150.4	.8	188.0	1.3	225.5	1.8
20	185.9	37.3	.0	74.7	.2	112.0	.4	149.4	.8	186.7	1.2	224.0	1.8
30	278.8	37.1	.0	74.2	.2	111.3	.4	148.4	.8	185.4	1.2	222.5	1.8
40	371.7	36.8	.0	73.7	.2	110.6	.4	147.4	.8	184.2	1.2	221.1	1.8
50	464.6	36.6	.0	73.2	.2	109.8	.4	146.4	.8	183.0	1.2	219.6	1.8
67 00	....	36.4	.0	72.7	.2	109.0	.4	145.4	.8	181.8	1.2	218.1	1.8
10	92.9	36.1	.0	72.2	.2	108.3	.4	144.4	.8	180.5	1.2	216.6	1.7
20	185.9	35.8	.0	71.7	.2	107.6	.4	143.4	.8	179.2	1.2	215.1	1.7
30	278.8	35.6	.0	71.2	.2	106.8	.4	142.4	.8	178.0	1.2	213.6	1.7
40	371.8	35.4	.0	70.7	.2	106.0	.4	141.4	.8	176.8	1.2	212.1	1.7
50	464.7	35.1	.0	70.2	.2	105.3	.4	140.4	.8	175.5	1.2	210.6	1.7
68 00	....	34.8	.0	69.7	.2	104.6	.4	139.4	.8	174.2	1.2	209.1	1.7
10	93.0	34.6	.0	69.2	.2	103.8	.4	138.4	.7	173.0	1.2	207.6	1.7
20	185.9	34.4	.0	68.7	.2	103.0	.4	137.4	.7	171.8	1.2	206.1	1.7
30	278.8	34.1	.0	68.2	.2	102.3	.4	136.4	.7	170.4	1.1	204.5	1.7
40	371.8	33.8	.0	67.7	.2	101.5	.4	135.4	.7	169.2	1.1	203.0	1.7
50	464.8	33.6	.0	67.2	.2	100.8	.4	134.4	.7	168.0	1.1	201.5	1.6
69 00	....	33.3	.0	66.7	.2	100.0	.4	133.4	.7	166.7	1.1	200.0	1.6
10	93.0	33.1	.0	66.2	.2	99.3	.4	132.4	.7	165.4	1.1	198.5	1.6
20	185.9	32.8	.0	65.7	.2	98.5	.4	131.3	.7	164.2	1.1	197.0	1.6
30	278.9	32.6	.0	65.2	.2	97.7	.4	130.3	.7	162.9	1.1	195.5	1.6
40	371.8	32.3	.0	64.7	.2	97.0	.4	129.3	.7	161.6	1.1	194.0	1.6
50	464.8	32.1	.0	64.1	.2	96.2	.4	128.3	.7	160.4	1.1	192.4	1.6
70 00	....	31.8	.0	63.6	.2	95.5	.4	127.3	.7	159.1	1.1	190.9	1.6
10	93.0	31.6	.0	63.1	.2	94.7	.4	126.2	.7	157.8	1.1	189.4	1.6
20	185.9	31.3	.0	62.6	.2	93.9	.4	125.2	.7	156.6	1.1	187.9	1.6
30	278.9	31.1	.0	62.1	.2	93.2	.4	124.2	.7	155.3	1.1	186.4	1.5
40	371.9	30.8	.0	61.6	.2	92.4	.4	123.2	.7	154.0	1.1	184.8	1.5
50	464.9	30.5	.0	61.1	.2	91.6	.4	122.2	.7	152.7	1.0	183.2	1.5
71 00	....	30.3	.0	60.6	.2	90.9	.4	121.2	.7	151.4	1.0	181.7	1.5
10	93.0	30.0	.0	60.1	.2	90.1	.4	120.2	.7	150.2	1.0	180.2	1.5
20	186.0	29.8	.0	59.6	.2	89.3	.4	119.1	.7	148.9	1.0	178.7	1.5
30	278.9	29.5	.0	59.0	.2	88.6	.4	118.1	.7	147.6	1.0	177.1	1.5
40	371.9	29.3	.0	58.5	.2	87.8	.4	117.1	.6	146.4	1.0	175.6	1.5
50	464.9	29.0	.0	58.0	.2	87.1	.4	116.1	.6	145.1	1.0	174.1	1.4
72 00	....	28.8	.0	57.5	.2	86.3	.4	115.0	.6	143.8	1.0	172.6	1.4

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{200000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	CO-ORDINATES OF DEVELOPED PARALLEL FOR—											
		10′ longitude.		20′ longitude.		30′ longitude.		40′ longitude.		50′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y	x	y	x	y
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
72°00′	....	28.8	.0	57.5	.2	86.3	.4	115.0	.6	143.8	1.0	172.6	1.4
10	93.0	28.5	.0	57.0	.2	85.5	.4	114.0	.6	142.5	1.0	171.0	1.4
20	186.0	28.2	.0	56.5	.2	84.7	.3	113.0	.6	141.2	1.0	169.4	1.4
30	279.0	28.0	.0	56.0	.2	83.9	.3	111.9	.6	139.9	1.0	167.9	1.4
40	372.0	27.7	.0	55.5	.2	83.2	.3	110.9	.6	138.6	1.0	166.4	1.4
50	465.0	27.5	.0	54.9	.2	82.4	.3	109.9	.6	137.4	1.0	164.8	1.4
73 00	....	27.2	.0	54.4	.2	81.6	.3	108.8	.6	136.0	.9	163.3	1.4
10	93.0	27.0	.0	53.9	.1	80.8	.3	107.8	.6	134.8	.9	161.7	1.4
20	186.0	26.7	.0	53.4	.1	80.1	.3	106.8	.6	133.4	.9	160.1	1.3
30	279.0	26.4	.0	52.9	.1	79.3	.3	105.7	.6	132.2	.9	158.6	1.3
40	372.0	26.2	.0	52.3	.1	78.5	.3	104.7	.6	130.8	.9	157.0	1.3
50	465.0	25.9	.0	51.8	.1	77.7	.3	103.6	.6	129.6	.9	155.5	1.3
74 00	....	25.6	.0	51.3	.1	77.0	.3	102.6	.6	128.2	.9	153.9	1.3
10	93.0	25.4	.0	50.8	.1	76.2	.3	101.6	.6	127.0	.9	152.3	1.3
20	186.0	25.1	.0	50.3	.1	75.4	.3	100.5	.6	125.6	.9	150.8	1.3
30	279.0	24.9	.0	49.7	.1	74.6	.3	99.5	.6	124.4	.9	149.2	1.3
40	372.0	24.6	.0	49.2	.1	73.8	.3	98.4	.6	123.0	.9	147.7	1.2
50	465.0	24.4	.0	48.7	.1	73.0	.3	97.4	.5	121.8	.9	146.1	1.2
75 00	....	24.1	.0	48.2	.1	72.3	.3	96.4	.5	120.4	.8	144.5	1.2
10	93.0	23.8	.0	47.7	.1	71.5	.3	95.3	.5	119.2	.8	143.0	1.2
20	186.0	23.6	.0	47.1	.1	70.7	.3	94.2	.5	117.8	.8	141.4	1.2
30	279.1	23.3	.0	46.6	.1	69.9	.3	93.2	.5	116.5	.8	139.8	1.2
40	372.1	23.0	.0	46.1	.1	69.1	.3	92.2	.5	115.2	.8	138.2	1.2
50	465.1	22.8	.0	45.5	.1	68.3	.3	91.1	.5	113.8	.8	136.6	1.1
76 00	....	22.5	.0	45.0	.1	67.5	.3	90.0	.5	112.6	.8	135.1	1.1
10	93.0	22.2	.0	44.5	.1	66.8	.3	89.0	.5	111.2	.8	133.5	1.1
20	186.1	22.0	.0	44.0	.1	65.9	.3	87.9	.5	109.9	.8	131.9	1.1
30	279.1	21.7	.0	43.4	.1	65.2	.3	86.9	.5	108.6	.8	130.3	1.1
40	372.1	21.5	.0	42.9	.1	64.4	.3	85.8	.5	107.3	.8	128.8	1.1
50	465.1	21.2	.0	42.4	.1	63.6	.3	84.8	.5	106.0	.7	127.1	1.1
77 00	....	20.9	.0	41.9	.1	62.8	.3	83.7	.5	104.6	.7	125.6	1.1
10	93.0	20.7	.0	41.3	.1	62.0	.3	82.7	.5	103.4	.7	124.0	1.1
20	186.1	20.4	.0	40.8	.1	61.2	.3	81.6	.5	102.0	.7	122.4	1.0
30	279.1	20.1	.0	40.3	.1	60.4	.3	80.6	.5	100.7	.7	120.8	1.0
40	372.2	19.9	.0	39.8	.1	59.6	.3	79.5	.4	99.4	.7	119.3	1.0
50	465.2	19.6	.0	39.2	.1	58.8	.3	78.4	.4	98.0	.7	117.7	1.0
78 00	....	19.4	.0	38.7	.1	58.0	.2	77.4	.4	96.8	.7	116.1	1.0
10	93.0	19.1	.0	38.2	.1	57.2	.2	76.3	.4	95.4	.7	114.5	1.0
20	186.1	18.8	.0	37.6	.1	56.5	.2	75.3	.4	94.1	.7	112.9	1.0
30	279.1	18.6	.0	37.1	.1	55.7	.2	74.2	.4	92.8	.7	111.4	1.0
40	372.2	18.3	.0	36.6	.1	54.9	.2	73.2	.4	91.4	.6	109.7	.9
50	465.2	18.0	.0	36.0	.1	54.1	.2	72.1	.4	90.1	.6	108.1	.9
79 00	....	17.8	.0	35.5	.1	53.3	.2	71.0	.4	88.8	.6	106.6	.9
10	93.0	17.5	.0	35.0	.1	52.5	.2	70.0	.4	87.4	.6	104.9	.9
20	186.1	17.2	.0	34.5	.1	51.7	.2	68.9	.4	86.2	.6	103.4	.9
30	279.2	17.0	.0	33.9	.1	50.9	.2	67.8	.4	84.8	.6	101.8	.9
40	372.2	16.7	.0	33.4	.1	50.1	.2	66.8	.4	83.4	.6	100.1	.8
50	465.2	16.4	.0	32.9	.1	49.3	.2	65.7	.4	82.2	.6	98.6	.8
80 00	....	16.2	.0	32.3	.1	48.5	.2	64.6	.4	80.8	.6	97.0	.8

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{80000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
0°00′	....	116.0	231.9	347.9	463.8	579.8	695.8
10	230.4	116.0	231.9	347.9	463.8	579.8	695.8
20	460.7	116.0	231.9	347.8	463.8	579.8	695.7
30	691.0	116.0	231.9	347.8	463.8	579.8	695.7
40	921.4	116.0	231.9	347.8	463.8	579.8	695.7
50	1151.8	115.9	231.9	347.8	463.8	579.7	695.6
1 00	....	115.9	231.9	347.8	463.8	579.7	695.6
10	230.4	115.9	231.9	347.8	463.7	579.6	695.6
20	460.7	115.9	231.8	347.8	463.7	579.6	695.5
30	691.0	115.9	231.8	347.7	463.6	579.6	695.5
40	921.4	115.9	231.8	347.7	463.6	579.6	695.5
50	1151.8	115.9	231.8	347.7	463.6	579.5	695.4
2 00	....	115.9	231.8	347.7	463.6	579.4	695.3
10	230.4	115.9	231.8	347.6	463.5	579.4	695.3
20	460.7	115.9	231.7	347.6	463.4	579.3	695.2
30	691.0	115.8	231.7	347.5	463.4	579.2	695.0
40	921.4	115.8	231.7	347.5	463.3	579.2	695.0
50	1151.8	115.8	231.6	347.5	463.3	579.1	694.9
3 00	....	115.8	231.6	347.4	463.2	579.0	694.8
10	230.4	115.8	231.6	347.3	463.1	578.9	694.7
20	460.7	115.8	231.5	347.3	463.0	578.8	694.6
30	691.1	115.7	231.5	347.2	463.0	578.7	694.4
40	921.4	115.7	231.4	347.2	462.9	578.6	694.3
50	1151.8	115.7	231.4	347.1	462.8	578.5	694.2
4 00	....	115.7	231.4	347.0	462.7	578.4	694.1
10	230.4	115.7	231.3	347.0	462.6	578.2	693.9
20	460.7	115.6	231.3	346.9	462.5	578.2	693.8
30	691.1	115.6	231.2	346.8	462.4	578.0	693.6
40	921.4	115.6	231.1	346.7	462.3	577.8	693.4
50	1151.8	115.6	231.1	346.6	462.2	577.8	693.3
5 00	....	115.5	231.0	346.6	462.1	577.6	693.1
10	230.4	115.5	231.0	346.5	462.0	577.4	692.9
20	460.7	115.5	230.9	346.4	461.8	577.3	692.8
30	691.1	115.4	230.8	346.3	461.7	577.1	692.5
40	921.5	115.4	230.8	346.2	461.6	577.0	692.3
50	1151.8	115.4	230.7	346.1	461.4	576.8	692.2
6 00	....	115.3	230.7	346.0	461.3	576.6	692.0
10	230.4	115.3	230.6	345.9	461.2	576.4	691.7
20	460.8	115.2	230.5	345.8	461.0	576.2	691.5
30	691.1	115.2	230.4	345.7	460.9	576.1	691.3
40	921.5	115.2	230.4	345.5	460.7	575.9	691.1
50	1151.9	115.1	230.3	345.4	460.6	575.7	690.8
7 00	....	115.1	230.2	345.3	460.4	575.5	690.6
10	230.4	115.1	230.1	345.2	460.2	575.3	690.4
20	460.8	115.0	230.0	345.0	460.0	575.0	690.1
30	691.1	115.0	229.9	344.9	459.9	574.8	689.8
40	921.5	114.9	229.9	344.8	459.7	574.6	689.6
50	1151.9	114.9	229.8	344.6	459.5	574.4	689.3
8 00	....	114.8	229.7	344.5	459.4	574.2	689.0

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	0°	1°	2°	3°	4°	5°	6°	7°	8°
	mm.	*mm.*							
5′	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
20	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
25	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3
30	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{800000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
8°00′	....	114.8	229.7	344.5	459.4	574.2	689.0
10	230.4	114.8	229.6	344.4	459.2	574.0	688.7
20	460.8	114.7	229.5	344.2	459.0	573.7	688.4
30	691.2	114.7	229.4	344.1	458.8	573.4	688.1
40	921.6	114.6	229.3	343.9	458.6	573.2	687.8
50	1152.0	114.6	229.2	343.8	458.4	573.0	687.5
9 00	....	114.5	229.1	343.6	458.2	572.7	687.2
10	230.4	114.5	229.0	343.4	457.9	572.4	686.9
20	460.8	114.4	228.9	343.3	457.7	572.2	686.6
30	691.2	114.4	228.7	343.1	457.5	571.8	686.2
40	921.6	114.3	228.6	343.0	457.3	571.6	685.9
50	1152.0	114.3	228.5	342.8	457.0	571.3	685.6
10 00	....	114.2	228.4	342.6	456.8	571.0	685.3
10	230.4	114.2	228.3	342.4	456.6	570.8	684.9
20	460.8	114.1	228.2	342.3	456.4	570.4	684.5
30	691.3	114.0	228.0	342.1	456.1	570.1	684.1
40	921.7	114.0	227.9	341.9	455.8	569.8	683.8
50	1152.1	113.9	227.8	341.7	455.6	569.5	683.4
11 00	....	113.8	227.7	341.5	455.4	569.2	683.0
10	230.4	113.8	227.5	341.3	455.1	568.8	682.6
20	460.9	113.7	227.4	341.1	454.8	568.6	682.3
30	691.3	113.6	227.3	340.9	454.6	568.2	681.8
40	921.8	113.6	227.1	340.7	454.3	567.8	681.4
50	1152.2	113.5	227.0	340.5	454.0	567.6	681.1
12 00	....	113.4	226.9	340.3	453.8	567.2	680.6
10	230.4	113.4	226.7	340.1	453.5	566.8	680.2
20	460.9	113.3	226.6	339.9	453.2	566.5	679.8
30	691.2	113.2	226.4	339.7	452.9	566.1	679.3
40	921.8	113.2	226.3	339.4	452.6	565.8	678.9
50	1152.2	113.1	226.2	339.2	452.3	565.4	678.5
13 00	....	113.0	226.0	339.0	452.0	565.0	678.1
10	230.5	112.9	225.9	338.8	451.7	564.6	677.6
20	460.9	112.8	225.7	338.6	451.4	564.2	677.1
30	691.4	112.8	225.6	338.3	451.1	563.9	676.7
40	921.9	112.7	225.4	338.1	450.8	563.5	676.2
50	1152.4	112.6	225.2	337.9	450.5	563.1	675.7
14 00	....	112.5	225.1	337.6	450.2	562.7	675.2
10	230.5	112.5	224.9	337.4	449.8	562.3	674.8
20	461.0	112.4	224.7	337.1	449.5	561.8	674.2
30	691.5	112.3	224.6	336.8	449.1	561.4	673.7
40	922.0	112.2	224.4	336.6	448.8	561.0	673.2
50	1152.4	112.1	224.2	336.4	448.5	560.6	672.7
15 00	....	112.0	224.1	336.1	448.1	560.2	672.2
10	230.5	111.9	223.9	335.8	447.8	559.7	671.6
20	461.0	111.8	223.7	335.6	447.4	559.2	671.1
30	691.5	111.8	223.5	335.3	447.0	558.8	670.6
40	922.0	111.7	223.3	335.0	446.7	558.4	670.0
50	1152.6	111.6	223.2	334.7	446.3	557.9	669.5
16 00	....	111.5	223.0	334.5	446.0	557.4	668.9

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	8°	9°
	mm.	*mm.*
5′	0.0	0.0
10	0.0	0.1
15	0.1	0.1
20	0.2	0.2
25	0 3	0.3
30	0.4	0.5

Longitude interval.	10°	11°
5	0.0	0.0
10	0.1	0.1
15	0.1	0.1
20	0.2	0.2
25	0.4	0.4
30	0.5	0.6

Longitude interval.	12°	13°
5	0.0	0.0
10	0.1	0.1
15	0.2	0.2
20	0.3	0.3
25	0.4	0.5
30	0.6	0.7

Longitude interval.	14°	15°
5	0.0	0.0
10	0.1	0.1
15	0.2	0.2
20	0.3	0.3
25	0.5	0.5
30	0.7	0.8

Longitude interval.	16°
5	0.0
10	0.1
15	0.2
20	0.4
25	0.6
30	0.8

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{80000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
16°00′	....	111.5	223.0	334.5	446.0	557.4	668.9
10	230.5	111.4	222.8	334.2	445.6	557.0	668.3
20	461.1	111.3	222.6	333.9	445.2	556.5	667.8
30	691.6	111.2	222.4	333.6	444.8	556.0	667.2
40	922.1	111.1	222.2	333.3	444.4	555.6	666.7
50	1152.6	111.0	222.0	333.1	444.1	555.1	666.1
17 00	....	110.9	221.8	332.8	443.7	554.6	665.5
10	230.6	110.8	221.6	332.5	443.3	554.1	664.9
20	461.1	110.7	221.4	332.2	442.9	553.6	664.3
30	691.6	110.6	221.2	331.9	442.5	553.1	663.7
40	922.2	110.5	221.0	331.6	442.1	552.6	663.1
50	1152.8	110.4	220.8	331.3	441.7	552.1	662.5
18 00	....	110.3	220.6	331.0	441.3	551.6	661.9
10	230.6	110.2	220.4	330.6	440.8	551.0	661.3
20	461.1	110.1	220.2	330.3	440.4	550.6	660.7
30	691.7	110.0	220.0	330.0	440.0	550.0	660.0
40	922.3	109.9	219.8	329.7	439.6	549.4	659.3
50	1152.8	109.8	219.6	329.4	439.2	549.0	658.7
19 00	....	109.7	219.4	329.0	438.7	548.4	658.1
10	230.6	109.6	219.1	328.7	438.3	547.8	657.4
20	461.2	109.5	218.9	328.4	437.8	547.3	656.8
30	691.8	109.4	218.7	328.0	437.4	546.8	656.1
40	922.4	109.2	218.5	327.7	436.9	546.1	655.4
50	1153.0	109.1	218.2	327.4	436.5	545.6	654.7
20 00	....	109.0	218.0	327.0	436.0	545.0	654.1
10	230.6	108.9	217.8	326.7	435.6	544.4	653.3
20	461.2	108.8	217.5	326.3	435.1	543.8	652.6
30	691.9	108.7	217.3	326.0	434.6	543.3	652.0
40	922.5	108.5	217.1	325.6	434.2	542.7	651.2
50	1153.1	108.4	216.8	325.3	433.7	542.1	650.5
21 00	....	108.3	216.6	324.9	433.2	541.5	649.8
10	230.6	108.2	216.4	324.5	432.7	540.9	649.1
20	461.3	108.1	216.1	324.2	432.2	540.3	648.4
30	692.0	107.9	215.9	323.8	431.7	539.6	647.6
40	922.6	107.8	215.6	323.4	431.2	539.0	646.9
50	1153.2	107.7	215.4	323.1	430.8	538.4	646.1
22 00	....	107.6	215.1	322.7	430.3	537.8	645.4
10	230.7	107.4	214.9	322.3	429.8	537.2	644.6
20	461.4	107.3	214.6	321.9	429.2	536.6	643.9
30	692.0	107.2	214.4	321.6	428.8	536.0	643.1
40	922.7	107.1	214.1	321.2	428.2	535.3	642.4
50	1153.4	106.9	213.9	320.8	427.7	534.6	641.6
23 00	....	106.8	213.6	320.4	427.2	534.0	640.8
10	230.7	106.7	213.3	320.0	426.6	533.3	640.0
20	461.4	106.5	213.1	319.6	426.1	532.6	639.2
30	692.1	106.4	212.8	319.2	425.6	532.0	638.4
40	922.8	106.3	212.5	318.8	425.0	531.3	637.6
50	1153.6	106.1	212.3	318.4	424.5	530.6	636.8
24 00	....	106.0	212.0	318.0	424.0	530.0	636.0

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	16°	17°
	mm.	*mm.*
5′	0.0	0.0
10	0.1	0.1
15	0.2	0.2
20	0.4	0.4
25	0.6	0.6
30	0.8	0.8
	18°	**19°**
5	0.0	0.0
10	0.1	0.1
15	0.2	0.2
20	0.4	0.4
25	0.6	0.6
30	0.9	0.9
	20°	**21°**
5	0.0	0.0
10	0.1	0.1
15	0.2	0.3
20	0.4	0.5
25	0.7	0.7
30	1.0	1.0
	22°	**23°**
5	0.0	0.0
10	0.1	0.1
15	0.3	0.3
20	0.5	0.5
25	0.7	0.8
30	1.1	1.1
	24°	
5	0.0	
10	0.1	
15	0.3	
20	0.5	
25	0.8	
30	1.1	

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{80000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
24°00′	....	106.0	212.0	318.0	424.0	530.0	636.0
10	230.7	105.9	211.7	317.6	423.4	529.3	635.2
20	461.5	105.7	211.4	317.2	422.9	528.6	634.3
30	692.2	105.6	211.2	316.7	422.3	527.9	633.5
40	923.0	105.4	210.9	316.3	421.8	527.2	632.6
50	1153.7	105.3	210.6	315.9	421.2	526.5	631.8
25 00	....	105.2	210.3	315.5	420.6	525.8	631.0
10	230.8	105.0	210.0	315.0	420.0	525.0	630.1
20	461.5	104.9	209.7	314.6	419.5	524.4	629.2
30	692.3	104.7	209.4	314.2	418.9	523.6	628.3
40	923.1	104.6	209.2	313.7	418.3	522.9	627.5
50	1153.8	104.4	208.9	313.3	417.7	522.2	626.6
26 00	....	104.3	208.6	312.9	417.2	521.4	625.7
10	230.8	104.1	208.3	312.4	416.6	520.7	624.8
20	461.6	104.0	208.0	312.0	416.0	520.0	623.9
30	692.4	103.8	207.7	311.5	415.4	519.2	623.0
40	923.2	103.7	207.4	311.1	414.8	518.4	622.1
50	1154.0	103.5	207.1	310.6	414.2	517.7	621.2
27 00	....	103.4	206.8	310.2	413.6	517.0	620.3
10	230.8	103.2	206.5	309.7	413.0	516.2	619.4
20	461.7	103.1	206.2	309.2	412.3	515.4	618.5
30	692.5	102.9	205.8	308.8	411.7	514.6	617.5
40	923.3	102.8	205.5	308.3	411.1	513.8	616.6
50	1154.2	102.6	205.2	307.9	410.5	513.1	615.7
28 00	....	102.5	204.9	307.4	409.8	512.3	614.8
10	230.9	102.3	204.6	306.9	409.2	511.5	613.8
20	461.7	102.1	204.3	306.4	408.6	510.7	612.8
30	692.6	102.0	204.0	305.9	407.9	509.9	611.9
40	923.5	101.8	203.6	305.5	407.3	509.1	610.9
50	1154.4	101.7	203.3	305.0	406.6	508.3	610.0
29 00	....	101.5	203.0	304.5	406.0	507.5	609.0
10	230.9	101.3	202.7	304.0	405.4	506.7	608.0
20	461.8	101.2	202.3	303.5	404.7	505.8	607.0
30	692.7	101.0	202.0	303.0	404.0	505.0	606.0
40	923.6	100.8	201.7	302.5	403.4	504.2	605.0
50	1154.5	100.7	201.4	302.0	402.7	503.4	604.1
30 00	....	100.5	201.0	301.5	402.0	502.6	603.1
10	230.9	100.3	200.7	301.0	401.4	501.7	602.0
20	461.9	100.2	200.3	300.5	400.7	500.8	601.0
30	692.8	100.0	200.0	300.0	400.0	500.0	599.9
40	923.8	99.8	199.6	299.5	399.3	499.1	598.9
50	1154.7	99.6	199.3	299.0	398.6	498.2	597.9
31 00	....	99.5	199.0	298.4	397.9	497.4	596.9
10	231.0	99.3	198.6	297.9	397.2	496.5	595.8
20	461.9	99.1	198.3	297.4	396.5	495.6	594.8
30	692.9	99.0	197.9	296.9	395.8	494.8	593.8
40	923.9	98.8	197.6	296.3	395.1	493.9	592.7
50	1154.8	98.6	197.2	295.8	394.4	493.0	591.6
32 00	....	98.4	196.9	295.3	393.7	492.2	590.6

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	24°	25°
	mm.	*mm.*
5′	0.0	0.0
10	0.1	0.1
15	0.3	0.3
20	0.5	0.5
25	0.8	0.8
30	1.1	1.2
	26°	**27°**
5	0.0	0.0
10	0.1	0.1
15	0.3	0.3
20	0.5	0.5
25	0.8	0.8
30	1.2	1.2
	28°	**29°**
5	0.0	0.0
10	0.1	0.1
15	0.3	0.3
20	0.6	0.6
25	0.9	0.9
30	1.3	1.3
	30°	**31°**
5	0.0	0.0
10	0.1	0.1
15	0.3	0.3
20	0.6	0.6
25	0.9	0.9
30	1.3	1.3
	32°	
5	0.0	
10	0.2	
15	0.3	
20	0.6	
25	0.9	
30	1.4	

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{80000}$.

[Derivation of table explained on pp. liii-lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
32°00′	....	98.4	196.9	295.3	393.7	492.2	590.6
10	231.0	98.2	196.5	294.8	393.0	491.2	589.5
20	462.0	98.1	196.1	294.2	392.3	490.4	588.4
30	693.0	97.9	195.8	293.7	391.6	489.4	587.3
40	924.0	97.7	195.4	293.1	390.8	488.6	586.3
50	1155.0	97.5	195.1	292.6	390.1	487.6	585.2
33 00	....	97.4	194.7	292.1	389.4	486.8	584.1
10	231.0	97.2	194.3	291.5	388.6	485.8	583.0
20	462.1	97.0	194.0	290.9	387.9	484.9	581.9
30	693.2	96.8	193.6	290.4	387.2	484.0	580.8
40	924.2	96.6	193.2	289.8	386.4	483.0	579.7
50	1155.2	96.4	192.8	289.3	385.7	482.1	578.5
34 00	....	96.2	192.5	288.7	385.0	481.2	577.4
10	231.1	96.0	192.1	288.2	384.2	480.2	576.3
20	462.2	95.9	191.7	287.6	383.4	479.3	575.2
30	693.2	95.7	191.3	287.0	382.6	478.3	574.0
40	924.3	95.5	190.9	286.4	381.9	477.4	572.8
50	1155.4	95.3	190.6	285.8	381.1	476.4	571.7
35 00	....	95.1	190.2	285.3	380.4	475.4	570.5
10	231.1	94.9	189.8	284.7	379.6	474.5	569.4
20	462.2	94.7	189.4	284.1	378.8	473.5	568.2
30	693.4	94.5	189.0	283.5	378.0	472.5	567.0
40	924.5	94.3	188.6	282.9	377.2	471.6	565.9
50	1155.6	94.1	188.2	282.4	376.5	470.6	564.7
36 00	....	93.9	187.8	281.8	375.7	469.6	563.5
10	231.2	93.7	187.4	281.2	374.9	468.6	562.3
20	462.3	93.5	187.0	280.6	374.1	467.6	561.1
30	693.5	93.3	186.6	280.0	373.3	466.6	559.9
40	924.6	93.1	186.2	279.4	372.5	465.6	558.7
50	1155.8	92.9	185.8	278.8	371.7	464.6	557.5
37 00	....	92.7	185.4	278.2	370.9	463.6	556.3
10	231.2	92.5	185.0	277.6	370.1	462.6	555.1
20	462.4	92.3	184.6	276.9	369.2	461.6	553.9
30	693.6	92.1	184.2	276.3	368.4	460.5	552.6
40	924.8	91.9	183.8	275.7	367.6	459.5	551.4
50	1156.0	91.7	183.4	275.1	366.8	458.5	550.2
38 00	....	91.5	183.0	274.5	366.0	457.4	548.9
10	231.2	91.3	182.6	273.8	365.1	456.4	547.7
20	462.5	91.1	182.1	273.2	364.3	455.4	546.4
30	693.7	90.9	181.7	272.6	363.5	454.4	545.2
40	925.0	90.7	181.3	272.0	362.6	453.3	544.0
50	1156.2	90.4	180.9	271.4	361.8	452.2	542.7
39 00	....	90.2	180.5	270.7	361.0	451.2	541.4
10	231.3	90.0	180.1	270.1	360.1	450.2	540.2
20	462.6	89.8	179.6	269.4	359.2	449.0	538.9
30	693.8	89.6	179.2	268.8	358.4	448.0	537.6
40	925.1	89.4	178.8	268.2	357.6	447.0	536.3
50	1156.4	89.2	178.3	267.5	356.7	445.8	535.0
40 00	....	89.0	177.9	266.9	355.8	444.8	533.8

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	32°	33°	34°	35°	36°	37°	38°	39°	40°
	mm.	*mm.*							
5′	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
20	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7
25	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
30	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{80000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
40°00′	....	89.0	177.9	266.9	355.8	444.8	533.8
10	231.3	88.7	177.5	266.2	355.0	443.7	532.4
20	462.6	88.5	177.0	265.6	354.1	442.6	531.1
30	694.0	88.3	176.6	264.9	353.2	441.5	529.8
40	925.3	88.1	176.2	264.2	352.3	440.4	528.5
50	1156.6	87.9	175.7	263.6	351.4	439.3	527.2
41 00	....	87.6	175.3	262.9	350.6	438.2	525.8
10	231.4	87.4	174.8	262.3	349.7	437.1	524.5
20	462.7	87.2	174.4	261.6	348.8	436.0	523.1
30	694.1	87.0	173.9	260.9	347.9	434.8	521.8
40	925.4	86.8	173.5	260.2	347.0	433.8	520.5
50	1156.8	86.5	173.0	259.6	346.1	432.6	519.1
42 00	....	86.3	172.6	258.9	345.2	431.5	517.8
10	231.4	86.1	172.1	258.2	344.3	430.4	516.4
20	462.8	85.8	171.7	257.6	343.4	429.2	515.1
30	694.2	85.6	171.2	256.9	342.5	428.1	513.7
40	925.6	85.4	170.8	256.2	341.6	427.0	512.3
50	1157.0	85.2	170.3	255.5	340.7	425.8	511.0
43 00	....	84.9	169.9	254.8	339.8	424.7	509.6
10	231.4	84.7	169.4	254.1	338.8	423.6	508.3
20	462.9	84.5	169.0	253.4	337.9	422.4	506.9
30	694.3	84.2	168.5	252.8	337.0	421.2	505.5
40	925.8	84.0	168.0	252.0	336.0	420.0	504.1
50	1157.2	83.8	167.6	251.3	335.1	418.9	502.7
44 00	....	83.6	167.1	250.6	334.2	417.8	501.3
10	231.5	83.3	166.6	249.9	333.2	416.6	499.9
20	463.0	83.1	166.2	249.2	332.3	415.4	498.5
30	694.4	82.8	165.7	248.5	331.4	414.2	497.0
40	925.9	82.6	165.2	247.8	330.4	413.0	495.6
50	1157.4	82.4	164.7	247.1	329.5	411.8	494.2
45 00	....	82.1	164.3	246.4	328.5	410.6	492.8
10	231.5	81.9	163.8	245.7	327.6	409.4	491.3
20	463.1	81.6	163.3	245.0	326.6	408.2	489.9
30	694.6	81.4	162.8	244.2	325.6	407.0	488.5
40	926.1	81.2	162.3	243.5	324.7	405.8	487.0
50	1157.6	80.9	161.9	242.8	323.7	404.6	485.6
46 00	....	80.7	161.4	242.1	322.8	403.4	484.1
10	231.6	80.4	160.9	241.4	321.8	402.2	482.7
20	463.1	80.2	160.4	240.6	320.8	401.0	481.2
30	694.7	80.0	159.9	239.9	319.8	399.8	479.8
40	926.3	79.7	159.4	239.2	318.9	398.6	478.3
50	1157.8	79.5	158.9	238.4	317.9	397.4	476.8
47 00	....	79.2	158.5	237.7	316.9	396.2	475.4
10	231.6	79.0	158.0	236.9	315.9	394.9	473.9
20	463.2	78.7	157.5	236.2	314.9	393.6	472.4
30	694.8	78.5	157.0	235.5	314.0	392.4	470.9
40	926.4	78.2	156.5	234.7	313.0	391.2	469.4
50	1158.0	78.0	156.0	234.0	312.0	390.0	467.9
48 00	....	77.7	155.5	233.2	311.0	388.7	466.4

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	40°	41°
	mm.	*mm.*
5′	0.0	0.0
10	0.2	0.2
15	0.4	0.4
20	0.7	0.7
25	1.0	1.0
30	1.5	1.5
	42°	43°
5	0.0	0.0
10	0.2	0.2
15	0.4	0.4
20	0.7	0.7
25	1.0	1.1
30	1.5	1.5
	44°	45°
5	0.0	0.0
10	0.2	0.2
15	0.4	0.4
20	0.7	0.7
25	1.1	1.1
30	1.5	1.5
	46°	47°
5	0.0	0.0
10	0.2	0.2
15	0.4	0.4
20	0.7	0.7
25	1.1	1.1
30	1.5	1.5
	48°	
5	0.0	
10	0.2	
15	0.4	
20	0.7	
25	1.0	
30	1.5	

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{80000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
48°00′	....	77.7	155.5	233.2	311.0	388.7	466.4
10	231.6	77.5	155.0	232.5	310.0	387.4	464.9
20	463.3	77.2	154.5	231.7	308.9	386.2	463.4
30	695.0	77.0	154.0	230.9	307.9	384.9	461.9
40	926.6	76.7	153.5	230.2	306.9	383.6	460.4
50	1158.2	76.5	152.9	229.4	305.9	382.4	458.8
49 00	....	76.2	152.4	228.7	304.9	381.1	457.3
10	231.7	76.0	151.9	227.9	303.8	379.8	455.8
20	463.4	75.7	151.4	227.1	302.8	378.6	454.3
30	695.1	75.4	150.9	226.4	301.8	377.2	452.7
40	926.8	75.2	150.4	225.6	300.8	376.0	451.1
50	1158.4	74.9	149.9	224.8	299.8	374.7	449.6
50 00	....	74.7	149.4	224.0	298.7	373.4	448.1
10	231.7	74.4	148.8	223.3	297.7	372.1	446.5
20	463.5	74.2	148.3	222.5	296.6	370.8	445.0
30	695.2	73.9	147.8	221.7	295.6	369.5	443.4
40	926.9	73.6	147.3	220.9	294.6	368.2	441.8
50	1158.6	73.4	146.8	220.1	293.5	366.9	440.3
51 00	....	73.1	146.2	219.4	292.5	365.6	438.7
10	231.8	72.9	145.7	218.6	291.4	364.3	437.2
20	463.5	72.6	145.2	217.8	290.4	363.0	435.5
30	695.3	72.3	144.7	217.0	289.3	361.6	434.0
40	927.1	72.1	144.1	216.2	288.3	360.4	432.4
50	1158.8	71.8	143.6	215.4	287.2	359.0	430.8
52 00	....	71.5	143.1	214.6	286.2	357.7	429.2
10	231.8	71.3	142.5	213.8	285.1	356.4	427.6
20	463.6	71.0	142.0	213.0	284.0	355.0	426.1
30	695.4	70.7	141.5	212.2	283.0	353.7	424.4
40	927.2	70.5	140.9	211.4	281.9	352.4	422.8
50	1159.0	70.2	140.4	210.6	280.8	351.0	421.3
53 00	....	69.9	139.9	209.8	279.8	349.7	419.6
10	231.8	69.7	139.3	209.0	278.7	348.4	418.0
20	463.7	69.4	138.8	208.2	277.6	347.0	416.4
30	695.6	69.1	138.3	207.4	276.5	345.6	414.8
40	927.4	68.8	137.7	206.6	275.4	344.2	413.1
50	1159.2	68.6	137.2	205.7	274.3	342.9	411.5
54 00	....	68.3	136.6	204.9	273.2	341.6	409.9
10	231.9	68.0	136.1	204.1	272.2	340.2	408.2
20	463.8	67.8	135.5	203.3	271.0	338.8	406.6
30	695.7	67.5	135.0	202.4	269.9	337 4	404.9
40	927.6	67.2	134.4	201.6	268.8	336.0	403.3
50	1159.4	66.9	133.9	200.8	267.8	334.7	401.6
55 00	....	66.7	133.3	200.0	266.6	333.3	400.0
10	231.9	66.4	132.8	199.1	265.5	331.9	398.3
20	463.9	66.1	132.2	198.3	264.4	330.5	396.6
30	695.8	65.8	131.7	197.5	263.3	329.2	395.0
40	927.7	65.6	131.1	196.6	262.2	327.8	393.3
50	1159.6	65.3	130.5	195.8	261.1	326.4	391.6
56 00	....	65.0	130.0	195.0	260.0	325.0	389.9

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	48°	49°
	mm	*mm.*
5′	0.0	0.0
10	0.2	0.2
15	0.4	0.4
20	0.7	0.7
25	1.0	1.0
30	1.5	1.5
	50°	**51°**
5	0.0	0.0
10	0.2	0.2
15	0.4	0.4
20	0.7	0.7
25	1.0	1.0
30	1.5	1.5
	52°	**53°**
5	0.0	0.0
10	0.2	0.2
15	0.4	0.4
20	0.7	0.6
25	1.0	1.0
30	1.5	1.5
	54°	**55°**
5	0.0	0.0
10	0.2	0.2
15	0.4	0.4
20	0.6	0.6
25	1.0	1.0
30	1.4	1.4
	56°	
5	0.0	
10	0.2	
15	0.4	
20	0.6	
25	1.0	
30	1.4	

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{250000}$.

[Derivation of table explained on pp. liii-lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
56°00′	....	65.0	130.0	195.0	260.0	325.0	389.9
10	232.0	64.7	129.4	194.1	258.8	323.6	388.3
20	463.9	64.4	128.9	193.3	257.7	322.2	386.6
30	695.9	64.2	128.3	192.4	256.6	320.8	384.9
40	927.9	63.9	127.7	191.6	255.5	319.4	383.2
50	1159.8	63.6	127.2	190.8	254.4	318.0	381.5
57 00	....	63.3	126.6	189.9	253.2	316.6	379.9
10	232.0	63.0	126.0	189.1	252.1	315.1	378.1
20	464.0	62.7	125.5	188.2	251.0	313.7	376.4
30	696.0	62.5	124.9	187.4	249.8	312.3	374.8
40	928.0	62.2	124.3	186.5	248.7	310.8	373.0
50	1160.0	61.9	123.8	185.6	247.5	309.4	371.3
58 00	....	61.6	123.2	184.8	246.4	308.0	369.6
10	232.0	61.3	122.6	183.9	245.2	306.6	367.9
20	464.1	61.0	122.0	183.1	244.1	305.1	365.1
30	696.1	60.7	121.5	182.2	242.9	303.6	364.4
40	928.2	60.4	120.9	181.4	241.8	302.2	362.7
50	1160.2	60.2	120.3	180.5	240.6	300.8	361.0
59 00	....	59.9	119.7	179.6	239.5	299.4	359.2
10	232.1	59.6	119.2	178.7	238.3	297.9	357.5
20	464.2	59.3	118.6	177.9	237.2	296.4	355.7
30	696.2	59.0	118.0	177.0	236.0	295.0	354.0
40	928.3	58.7	117.4	176.1	234.8	293.6	352.3
50	1160.4	58.4	116.8	175.3	233.7	292.1	350.5
60 00	....	58.1	116.3	174.4	232.5	290.6	348.8
10	232.1	57.8	115.7	173.5	231.4	289.2	347.0
20	464.2	57.5	115.1	172.6	230.2	287.7	345.2
30	696.4	57.2	114.5	171.7	229.0	286.2	343.4
40	928.5	57.0	113.9	170.8	227.8	284.8	341.7
50	1160.6	56.7	113.3	170.0	226.6	283.3	340.0
61 00	....	56.4	112.7	169.1	225.4	281.8	338.2
10	232.2	56.1	112.1	168.2	224.2	280.3	336.4
20	464.3	55.8	111.5	167.3	223.1	278.8	334.6
30	696.4	55.5	110.9	166.4	221.9	277.4	332.8
40	928.6	55.2	110.3	165.5	220.7	275.8	331.0
50	1160.8	54.9	109.8	164.6	219.5	274.4	329.3
62 00	....	54.6	109.2	163.7	218.3	272.9	327.5
10	232.2	54.3	108.6	162.8	217.1	271.4	325.7
20	464.4	54.0	108.0	161.9	215.9	269.9	323.9
30	696.6	53.7	107.4	161.0	214.7	268.4	322.1
40	928.8	53.4	106.8	160.1	213.5	266.9	320.3
50	1161.0	53.1	106.2	159.2	212.3	265.4	318.5
63 00	....	52.8	105.6	158.3	211.1	263.9	316.7
10	232.2	52.5	105.0	157.4	209.9	262.4	314.9
20	464.4	52.2	104.4	156.5	208.7	260.9	313.1
30	696.7	51.9	103.8	155.6	207.5	259.4	311.3
40	928.9	51.6	103.1	154.7	206.3	257.8	309.4
50	1161.1	51.3	102.5	153.8	205.1	256.4	307.6
64 00	....	51.0	101.9	152.9	203.9	254.8	305.8

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	56°	57°	58°	59°	60°	61°	62°	63°	64°
	mm.	*mm.*							
5′	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
15	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
20	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5
25	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.8
30	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.2

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{80000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
64°00′	....	51.0	101.9	152.9	203.9	254.8	305.8
10	232.2	50.7	101.3	152.0	202.6	253.3	304.0
20	464.5	50.4	100.7	151.1	201.4	251.8	302.2
30	696.8	50.1	100.1	150.2	200.2	250.3	300.4
40	929.0	49.8	99.5	149.2	199.0	248.8	298.5
50	1161.2	49.4	98.9	148.3	197.8	247.2	296.6
65 00	....	49.1	98.3	147.4	196.6	245.7	294.8
10	232.3	48.8	97.7	146.5	195.3	244.2	293.0
20	464.6	48.5	97.1	145.6	194.1	242.6	291.2
30	696.9	48.2	96.4	144.7	192.9	241.1	289.3
40	929.1	47.9	95.8	143.7	191.6	239.6	287.5
50	1161.4	47.6	95.2	142.8	190.4	238.0	285.7
66 00	....	47.3	94.6	141.9	189.2	236.5	283.8
10	232.3	47.0	94.0	141.0	188.0	235.0	281.9
20	464.6	46.7	93.4	140.0	186.7	233.4	280.1
30	697.0	46.4	92.7	139.1	185.5	231.8	278.2
40	929.3	46.1	92.1	138.2	184.2	230.3	276.4
50	1161.6	45.8	91.5	137.2	183.0	228.8	274.5
67 00	....	45.4	90.9	136.3	181.8	227.2	272.6
10	232.4	45.1	90.3	135.4	180.5	225.6	270.8
20	464.7	44.8	89.6	134.4	179.2	224.0	268.9
30	697.0	44.5	89.0	133.5	178.0	222.5	267.0
40	929.4	44.2	88.4	132.6	176.8	221.0	265.1
50	1161.8	43.9	87.7	131.6	175.5	219.4	263.2
68 00	....	43.6	87.1	130.7	174.2	217.8	261.4
10	232.4	43.2	86.5	129.8	173.0	216.2	259.5
20	464.8	42.9	85.9	128.8	171.7	214.6	257.6
30	697.1	42.6	85.2	127.9	170.5	213.1	255.7
40	929.5	42.3	84.6	126.9	169.2	211.6	253.9
50	1161.9	42.0	84.0	126.0	168.0	210.0	251.9
69 00	....	41.7	83.4	125.0	166.7	208.4	250.1
10	232.4	41.4	82.7	124.1	165.4	206.8	248.2
20	464.8	41.0	82.1	123.2	164.2	205.2	246.3
30	697.2	40.7	81.5	122.2	162.9	203.6	244.4
40	929.6	40.4	80.8	121.2	161.6	202.0	242.5
50	1162.0	40.1	80.2	120.3	160.4	200.5	240.6
70 00	....	39.8	79.6	119.3	159.1	198.9	238.7
10	232.4	39.5	78.9	118.4	157.8	197.3	236.8
20	464.9	39.1	78.3	117.4	156.6	195.7	234.8
30	697.3	38.8	77.6	116.5	155.3	194.1	232.9
40	929.7	38.5	77.0	115.5	154.0	192.6	231.1
50	1162.2	38.2	76.4	114.6	152.8	191.0	229.1
71 00	....	37.9	75.7	113.6	151.5	189.4	227.2
10	232.5	37.6	75.1	112.6	150.2	187.8	225.3
20	464.9	37.2	74.5	111.7	148.9	186.2	223.4
30	697.4	36.9	73.8	110.7	147.6	184.5	221.4
40	929.8	36.6	73.2	109.7	146.3	182.9	219.5
50	1162.3	36.3	72.5	108.8	145.0	181.3	217.6
72 00	....	35.9	71.9	107.8	143.8	179.7	215.6

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	64°	65°
	mm.	*mm.*
5′	0.0	0.0
10	0.1	0.1
15	0.3	0.3
20	0.5	0.5
25	0.8	0.8
30	1.2	1.2
	66°	**67°**
5	0.0	0.0
10	0.1	0.1
15	0.3	0.3
20	0.5	0.5
25	0.8	0.8
30	1.1	1.1
	68°	**69°**
5	0.0	0.0
10	0.1	0.1
15	0.3	0.3
20	0.5	0.5
25	0.7	0.7
30	1.1	1.0
	70°	**71°**
5	0.0	0.0
10	0.1	0.1
15	0.2	0.2
20	0.4	0.4
25	0.7	0.7
30	1.0	0.9
	72°	
5	0.0	
10	0.1	
15	0.2	
20	0.4	
25	0.6	
30	0.9	

CO-ORDINATES FOR PROJECTION OF MAPS. SCALE $\frac{1}{80000}$.

[Derivation of table explained on pp. liii–lvi.]

Latitude of parallel.	Meridional distances from even degree parallels.	ABSCISSAS OF DEVELOPED PARALLEL. 5′ longitude.	10′ longitude.	15′ longitude.	20′ longitude.	25′ longitude.	30′ longitude.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
72°00′	....	35.9	71.9	107.8	143.8	179.7	215.6
10	232.5	35.6	71.2	106.9	142.5	178.1	213.7
20	465.0	35.3	70.6	105.9	141.2	176.5	211.8
30	697.4	35.0	70.0	104.9	139.9	174.9	209.9
40	929.9	34.6	69.3	104.0	138.6	173.2	207.9
50	1162.4	34.3	68.7	103.0	137.3	171.6	206.0
73 00	....	34.0	68.0	102.0	136.0	170.0	204.1
10	232.5	33.7	67.4	101.0	134.7	168.4	202.1
20	465.0	33.4	66.7	100.1	133.4	166.8	200.2
30	697.5	33.0	66.1	99.1	132.2	165.2	198.2
40	930.0	32.7	65.4	98.1	130.8	163.6	196.3
50	1162.6	32.4	64.8	97.1	129.5	161.9	194.3
74 00	....	32.1	64.1	96.2	128.2	160.3	192.4
10	232.5	31.7	63.5	95.2	127.0	158.7	190.4
20	465.1	31.4	62.8	94.2	125.6	157.0	188.5
30	697.6	31.1	62.2	93.2	124.3	155.4	186.5
40	930.1	30.8	61.5	92.3	123.0	153.8	184.6
50	1162.6	30.4	60.9	91.3	121.8	152.2	182.6
75 00	....	30.1	60.2	90.3	120.4	150.6	180.7
10	232.6	29.8	59.6	89.3	119.1	148.9	178.7
20	465.1	29.4	58.9	88.4	117.8	147.2	176.7
30	697.6	29.1	58.3	87.4	116.5	145.6	174.8
40	930.2	28.8	57.6	86.4	115.2	144.0	172.8
50	1162.8	28.5	56.9	85.4	113.9	142.4	170.8
76 00	....	28.1	56.3	84.4	112.6	140.7	168.8
10	232.6	27.8	55.6	83.4	111.2	139.0	166.9
20	465.1	27.5	55.0	82.4	109.9	137.4	164.9
30	697.7	27.2	54.3	81.4	108.6	135.8	162.9
40	930.3	26.8	53.7	80.5	107.3	134.2	161.0
50	1162.8	26.5	53.0	79.5	106.0	132.5	159.0
77 00	....	26.2	52.3	78.5	104.7	130.8	157.0
10	232.6	25.8	51.7	77.5	103.4	129.2	155.0
20	465.2	25.5	51.0	76.5	102.0	127.6	153.1
30	697.8	25.2	50.4	75.5	100.7	125.9	151.1
40	930.4	24.8	49.7	74.6	99.4	124.2	149.1
50	1163.0	24.5	49.0	73.6	98.1	122.6	147.1
78 00	....	24.2	48.4	72.6	96.8	121.0	145.1
10	232.6	23.9	47.7	71.6	95.4	119.3	143.2
20	465.2	23.5	47.1	70.6	94.1	117.6	141.2
30	697.8	23.2	46.4	69.6	92.8	116.0	139.2
40	930.4	22.9	45.7	68.6	91.4	114.3	137.2
50	1163.0	22.5	45.1	67.6	90.1	112.6	135.2
79 00	....	22.2	44.4	66.6	88.8	111.0	133.2
10	232.6	21.9	43.7	65.6	87.5	109.4	131.2
20	465.2	21.5	43.1	64.6	86.1	107.6	129.2
30	697.9	21.2	42.4	63.6	84.8	106.0	127.2
40	930.5	20.9	41.7	62.6	83.5	104.4	125.2
50	1163.1	20.5	41.1	61.6	82.1	102.6	123.2
80 00	....	20.2	40.4	60.6	80.8	101.0	121.2

ORDINATES OF DEVELOPED PARALLEL.

Longitude interval.	72°	73°	74°	75°	76°	77°	78°	79°	80°
	mm.	*mm.*							
5′	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
15	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
20	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2
25	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4
30	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 10° EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l-lii.]

Middle Latitude of Quadrilateral.	Area in Square Miles.
0°	474653
5	472895
10	467631
15	458891
20	446728
25	431213
30	412442
35	390533
40	365627
45	337890
50	307514
55	274714
60	239730
65	202823
70	164279
75	124400
80	83504
85	41924

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 1° EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l-lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
0° 00′	4752.33	26° 00′	4282.50	52° 00′	2950.58
0 30	4752.16	26 30	4264.51	52 30	2917.85
1 00	4751.63	27 00	4246.20	53 00	2884.88
1 30	4750.75	27 30	4227.56	53 30	2851.68
2 00	4749.52	28 00	4208.61	54 00	2818.27
2 30	4747.93	28 30	4189.33	54 30	2784.62
3 00	4746.00	29 00	4169.74	55 00	2750.76
3 30	4743.71	29 30	4149.83	55 30	2716.67
4 00	4741.07	30 00	4129.60	56 00	2682.37
4 30	4738.08	30 30	4109.06	56 30	2647.85
5 00	4734.74	31 00	4088.21	57 00	2613.13
5 30	4731.04	31 30	4067.05	57 30	2578.19
6 00	4727.00	32 00	4045.57	58 00	2543.05
6 30	4722.61	32 30	4023.79	58 30	2507.70
7 00	4717.86	33 00	4001.69	59 00	2472.16
7 30	4712.76	33 30	3979.30	59 30	2436.42
8 00	4707.32	34 00	3956.59	60 00	2400.48
8 30	4701.52	34 30	3933.59	60 30	2364.34
9 00	4695.38	35 00	3910.28	61 00	2338.02
9 30	4688.89	35 30	3886.67	61 30	2291.51
10 00	4682.05	36 00	3862.76	62 00	2254.82
10 30	4674.86	36 30	3838.56	62 30	2217.94
11 00	4667.32	37 00	3814.06	63 00	2180.89
11 30	4659.43	37 30	3789.26	63 30	2143.66
12 00	4651.20	38 00	3764.18	64 00	2106.26
12 30	4642.63	38 30	3738.80	64 30	2068.68
13 00	4633.71	39 00	3713.14	65 00	2030.94
13 30	4624.44	39 30	3687.18	65 30	1993.04
14 00	4614.82	40 00	3660.95	66 00	1954.97
14 30	4604.87	40 30	3634.42	66 30	1916.75
15 00	4594.57	41 00	3607.62	67 00	1878.37
15 30	4583.92	41 30	3580.54	67 30	1839.84
16 00	4572.94	42 00	3553.17	68 00	1801.16
16 30	4561.61	42 30	3525.54	68 30	1762.33
17 00	4549.94	43 00	3497.62	69 00	1723.36
17 30	4537.93	43 30	3469.44	69 30	1684.24
18 00	4525.59	44 00	3440.98	70 00	1645.00
18 30	4512.90	44 30	3412.26	70 30	1605.62
19 00	4499.87	45 00	3383.27	71 00	1566.10
19 30	4486.51	45 30	3354.01	71 30	1526.46
20 00	4472.81	46 00	3324.49	72 00	1486.70
20 30	4458.78	46 30	3294.71	72 30	1446.81
21 00	4444.41	47 00	3264.68	73 00	1406.81
21 30	4429.71	47 30	3234.39	73 30	1366.69
22 00	4414.67	48 00	3203.84	74 00	1326.46
22 30	4399.30	48 30	3173.04	74 30	1286.12
23 00	4383.60	49 00	3141.99	75 00	1245.68
23 30	4367.57	49 30	3110.69	75 30	1205.13
24 00	4351.21	50 00	3079.15	76 00	1164.49
24 30	4334.52	50 30	3047.37	76 30	1123.75
25 00	4317.51	51 00	3015.34	77 00	1082.91
25 30	4300.17	51 30	2983.08	77 30	1041.99

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 1° EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l–lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
78° 00′	1000.99	82° 00′	670.27	86° 00′	336.02
78 30	959.90	82 30	628.64	86 30	294.08
79 00	918.73	83 00	586.97	87 00	252.11
79 30	877.49	83 30	545.24	87 30	210.12
80 00	836.18	84 00	503.47	88 00	168.12
80 30	794.79	84 30	461.66	88 30	126.10
81 00	753.34	85 00	419.81	89 00	84.07
81 30	711.83	85 30	377.93	89 30	42.04

Table 27.

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 30′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l–lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
0° 00′	1188.10	13° 00′	1158.44	26° 00′	1070.64
0 15	1188.08	13 15	1157.29	26 15	1068.40
0 30	1188.05	13 30	1156.12	26 30	1066.14
0 45	1188.00	13 45	1154.93	26 45	1063.86
1 00	1187.92	14 00	1153.72	27 00	1061.56
1 15	1187.82	14 15	1152.48	27 15	1059.24
1 30	1187.70	14 30	1151.23	27 30	1056.90
1 45	1187.56	14 45	1149.95	27 45	1054.54
2 00	1187.39	15 00	1148.65	28 00	1052.16
2 15	1187.20	15 15	1147.33	28 15	1049.76
2 30	1186.99	15 30	1145.99	28 30	1047.34
2 45	1186.76	15 45	1144.63	28 45	1044.90
3 00	1186.51	16 00	1143.25	29 00	1042.44
3 15	1186.24	16 15	1141.84	29 15	1039.97
3 30	1185.95	16 30	1140.41	29 30	1037.47
3 45	1185.62	16 45	1138.96	29 45	1034.95
4 00	1185.28	17 00	1137.50	30 00	1032.41
4 15	1184.92	17 15	1136.00	30 15	1029.85
4 30	1184.53	17 30	1134.49	30 30	1027.27
4 45	1184.13	17 45	1132.96	30 45	1024.68
5 00	1183.70	18 00	1131.41	31 00	1022.06
5 15	1183.24	18 15	1129.83	31 15	1019.43
5 30	1182.77	18 30	1128.24	31 30	1016.77
5 45	1182.28	18 45	1126.62	31 45	1014.10
6 00	1181.76	19 00	1124.98	32 00	1011.40
6 15	1181.22	19 15	1123.32	32 15	1008.69
6 30	1180.66	19 30	1121.64	32 30	1005.96
6 45	1180.08	19 45	1119.93	32 45	1003.20
7 00	1179.48	20 00	1118.21	33 00	1000.43
7 15	1178.85	20 15	1116.47	33 15	997.64
7 30	1178.20	20 30	1114.71	33 30	994.83
7 45	1177.53	20 45	1112.92	33 45	992.00
8 00	1176.84	21 00	1111.11	34 00	989.16
8 15	1176.13	21 15	1109.28	34 15	986.29
8 30	1175.39	21 30	1107.44	34 30	983.41
8 45	1174.63	21 45	1105.57	34 45	980.50
9 00	1173.86	22 00	1103.68	35 00	977.58
9 15	1173.06	22 15	1101.77	35 15	974.64
9 30	1172.23	22 30	1099.84	35 30	971.68
9 45	1171.39	22 45	1097.88	35 45	968.70
10 00	1170.52	23 00	1095.91	36 00	965.70
10 15	1169.63	23 15	1093.92	36 15	962.68
10 30	1168.73	23 30	1091.90	36 30	959.65
10 45	1167.80	23 45	1089.87	36 45	956.60
11 00	1166.84	24 00	1087.81	37 00	953.52
11 15	1165.86	24 15	1085.74	37 15	950.43
11 30	1164.86	24 30	1083.64	37 30	947.32
11 45	1163.85	24 45	1081.52	37 45	944.21
12 00	1162.81	25 00	1079.39	38 00	941.05
12 15	1161.75	25 15	1077.23	38 15	937.88
12 30	1160.67	25 30	1075.05	38 30	934.71
12 45	1159.56	25 45	1072.85	38 45	931.51

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 30′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l-lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
39° 00′	928.29	52° 00′	737.65	65° 00′	507.74
39 15	925.06	52 15	733.57	65 15	503.01
39 30	921.80	52 30	729.47	65 30	498.26
39 45	918.53	52 45	725.36	65 45	493.51
40 00	915.25	53 00	721.23	66 00	488.75
40 15	911.94	53 15	717.08	66 5	483.97
40 30	908.61	53 30	712.93	66 30	479.19
40 45	905.27	53 45	708.76	66 45	474.40
41 00	901.91	54 00	704.57	67 00	469.60
41 15	898.54	54 15	700.38	67 15	464.78
41 30	895.14	54 30	696.16	67 30	459.96
41 45	891.73	54 45	691.94	67 45	455.13
42 00	888.30	55 00	687.70	68 00	450.29
42 15	884.85	55 15	683.44	68 15	445.45
42 30	881.39	55 30	679.17	68 30	440.59
42 45	877.91	55 45	674.89	68 45	435.72
43 00	874.41	56 00	670.60	69 00	430.84
43 15	870.90	56 15	666.29	69 15	425.96
43 30	867.37	56 30	661.97	69 30	421.06
43 45	863.82	56 45	657.64	69 45	416.16
44 00	860.25	57 00	653.29	70 00	411.25
44 15	856.67	57 15	648.93	70 15	406.34
44 30	853.07	57 30	644.55	70 30	401.41
44 45	849.46	57 45	640.17	70 45	396.47
45 00	845.82	58 00	635.77	71 00	391.53
45 15	842.18	58 15	631.36	71 15	386.58
45 30	838.51	58 30	626.93	71 30	381.62
45 45	834.83	58 45	622.49	71 45	376.65
46 00	831.13	59 00	618.05	72 00	371.68
46 15	827.42	59 15	613.59	72 15	366.70
46 30	823.68	59 30	609.11	72 30	361.71
46 45	819.94	59 45	604.62	72 45	356.71
47 00	816.18	60 00	600.13	73 00	351.71
47 15	812.40	60 15	595.62	73 15	346.69
47 30	808.60	60 30	591.09	73 30	341.68
47 45	804.79	60 45	586.56	73 45	336.65
48 00	800.97	61 00	582.01	74 00	331.62
48 15	797.13	61 15	577.45	74 15	326.58
48 30	793.27	61 30	572.88	74 30	321.53
48 45	789.39	61 45	568.30	74 45	316.48
49 00	785.50	62 00	563.71	75 00	311.42
49 15	781.60	62 15	559.11	75 15	306.36
49 30	777.68	62 30	554.49	75 30	301.28
49 45	773.74	62 45	549.86	75 45	296.21
50 00	769.79	63 00	545.23	76 00	291.12
50 15	765.83	63 15	540.58	76 15	286.04
50 30	761.85	63 30	535.92	76 30	280.94
50 45	757.85	63 45	531.25	76 45	275.84
51 00	753.84	64 00	526.57	77 00	270.73
51 15	749.82	64 15	521.88	77 15	265.62
51 30	745.78	64 30	517.17	77 30	260.50
51 45	741.72	64 45	512.46	77 45	255.38

TABLE 27.

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 30′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l–lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
78° 00′	250.25	82° 00′	167.57	86° 00′	84.01
78 15	245.12	82 15	162.37	86 15	78.76
78 30	239.98	82 30	157.16	86 30	73.52
78 45	234.83	82 45	151.95	86 45	68.27
79 00	229.68	83 00	146.74	87 00	63.03
79 15	224.53	83 15	141.53	87 15	57.78
79 30	219.37	83 30	136.31	87 30	52.53
79 45	214.21	83 45	131.09	87 45	47.28
80 00	209.05	84 00	125.87	88 00	42.03
80 15	203.88	84 15	120.64	88 15	36.78
80 30	198.70	84 30	115.42	88 30	31.53
80 45	193.52	84 45	110.18	88 45	26.27
81 00	188.34	85 00	104.95	89 00	21.02
81 15	183.15	85 15	99.72	89 15	15.76
81 30	177.96	85 30	94.48	89 30	10.51
81 45	172.77	85 45	89.25	89 45	5.26

Table 28.

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 15′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l-lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
0° 07′ 30″	297.02	6° 37′ 30″	295.09	13° 07′ 30″	289.47
0 15 00	297.02	6 45 00	295.02	13 15 00	289.33
0 22 30	297.02	6 52 30	294.95	13 22 30	289.18
0 30 00	297.01	7 00 00	294.87	13 30 00	289.03
0 37 30	297.01	7 07 30	294.79	13 37 30	288.88
0 45 00	297.00	7 15 00	294.71	13 45 00	288.73
0 52 30	296.99	7 22 30	294.63	13 52 30	288.58
1 00 00	296.98	7 30 00	294.55	14 00 00	288.43
1 07 30	296.97	7 37 30	294.47	14 07 30	288.28
1 15 00	296.96	7 45 00	294.39	14 15 00	288.12
1 22 30	296.94	7 52 30	294.30	14 22 30	287.96
1 30 00	296.93	8 00 00	294.21	14 30 00	287.81
1 37 30	296.91	8 07 30	294.12	14 37 30	287.65
1 45 00	296.89	8 15 00	294.03	14 45 00	287.49
1 52 30	296.87	8 22 30	293.94	14 52 30	287.33
2 00 00	296.85	8 30 00	293.85	15 00 00	287.17
2 07 30	296.82	8 37 30	293.75	15 07 30	287.00
2 15 00	296.80	8 45 00	293.66	15 15 00	286.83
2 22 30	296.77	8 52 30	293.56	15 22 30	286.67
2 30 00	296.75	9 00 00	293.47	15 30 00	286.50
2 37 30	296.72	9 07 30	293.37	15 37 30	286.33
2 45 00	296.69	9 15 00	293.27	15 45 00	286.16
2 52 30	296.66	9 22 30	293.16	15 52 30	285.99
3 00 00	296.63	9 30 00	293.06	16 00 00	285.82
3 07 30	296.60	9 37 30	292.95	16 07 30	285.64
3 15 00	296.56	9 45 00	292.85	16 15 00	285.46
3 22 30	296.53	9 52 30	292.74	16 22 30	285.28
3 30 00	296.49	10 00 00	292.63	16 30 00	285.10
3 37 30	296.45	10 07 30	292.52	16 37 30	284.92
3 45 00	296.41	10 15 00	292.41	16 45 00	284.74
3 52 30	296.36	10 22 30	292.30	16 52 30	284.56
4 00 00	296.32	10 30 00	292.19	17 00 00	284.38
4 07 30	296.28	10 37 30	292.07	17 07 30	284.19
4 15 00	296.23	10 45 00	291.95	17 15 00	284.00
4 22 30	296.18	10 52 30	291.83	17 22 30	283.81
4 30 00	296.13	11 00 00	291.71	17 30 00	283.62
4 37 30	296.08	11 07 30	291.59	17 37 30	283.43
4 45 00	296.03	11 15 00	291.47	17 45 00	283.24
4 52 30	295.98	11 22 30	291.34	17 52 30	283.05
5 00 00	295.93	11 30 00	291.22	18 00 00	282.86
5 07 30	295.87	11 37 30	291.09	18 07 30	282.66
5 15 00	295.81	11 45 00	290.96	18 15 00	282.46
5 22 30	295.75	11 52 30	290.83	18 22 30	282.26
5 30 00	295.69	12 00 00	290.70	18 30 00	282.06
5 37 30	295.63	12 07 30	290.57	18 37 30	281.86
5 45 00	295.57	12 15 00	290.44	18 45 00	281.66
5 52 30	295.51	12 22 30	290.30	18 52 30	281.45
6 00 00	295.44	12 30 00	290.17	19 00 00	281.25
6 07 30	295.37	12 37 30	290.03	19 07 30	281.04
6 15 00	295.31	12 45 00	289.89	19 15 00	280.83
6 22 30	295.24	12 52 30	289.75	19 22 30	280.62
6 30 00	295.17	13 00 00	289.61	19 30 00	280.41

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 15′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l-lii.]

Middle latitude of quadrilateral.	Area in square miles	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
19° 37′ 30″	280.20	26° 07′ 30″	267.38	32° 37′ 30″	251.15
19 45 00	279.99	26 15 00	267.10	32 45 00	250.80
19 52 30	279.77	26 22 30	266.82	32 52 30	250.45
20 00 00	279.55	26 30 00	266.54	33 00 00	250.11
20 07 30	279.34	26 37 30	266.25	33 07 30	249.76
20 15 00	279.12	26 45 00	265.97	33 15 00	249.41
20 22 30	278.90	26 52 30	265.68	33 22 30	249.06
20 30 00	278.68	27 00 00	265.39	33 30 00	248.71
20 37 30	278.46	27 07 30	265.10	33 37 30	248.36
20 45 00	278.23	27 15 00	264.81	33 45 00	248.00
20 52 30	278.00	27 22 30	264.52	33 52 30	247.65
21 00 00	277.78	27 30 00	264.23	34 00 00	247.29
21 07 30	277.55	27 37 30	263.93	34 07 30	246.93
21 15 00	277.32	27 45 00	263.64	34 15 00	246.57
21 22 30	277.09	27 52 30	263.34	34 22 30	246.21
21 30 00	276.86	28 00 00	263.04	34 30 00	245.85
21 37 30	276.63	28 07 30	262.74	34 37 30	245.49
21 45 00	276.39	28 15 00	262.44	34 45 00	245.13
21 52 30	276.16	28 22 30	262.14	34 52 30	244.76
22 00 00	275.92	28 30 00	261.84	35 00 00	244.40
22 07 30	275.68	28 37 30	261.53	35 07 30	244.03
22 15 00	275.44	28 45 00	261.23	35 15 00	243.66
22 22 30	275.20	28 52 30	260.92	35 22 30	243.29
22 30 00	274.96	29 00 00	260.61	35 30 00	242.92
22 37 30	274.72	29 07 30	260.30	35 37 30	242.55
22 45 00	274.47	29 15 00	259.99	35 45 00	242.18
22 52 30	274.22	29 22 30	259.68	35 52 30	241.80
23 00 00	273.98	29 30 00	259.37	36 00 00	241.43
23 07 30	273.73	29 37 30	259.05	36 07 30	241.05
23 15 00	273.48	29 45 00	258.74	36 15 00	240.67
23 22 30	273.23	29 52 30	258.42	36 22 30	240.29
23 30 00	272.98	30 00 00	258.10	36 30 00	239.91
23 37 30	272.72	30 07 30	257.78	36 37 30	239.53
23 45 00	272.47	30 15 00	257.46	36 45 00	239.15
23 52 30	272.21	30 22 30	257.14	36 52 30	238.77
24 00 00	271.95	30 30 00	256.82	37 00 00	238.38
24 07 30	271.69	30 37 30	256.49	37 07 30	237.99
24 15 00	271.44	30 45 00	256.17	37 15 00	237.61
24 22 30	271.17	30 52 30	255.84	37 22 30	237.22
24 30 00	270.91	31 00 00	255.52	37 30 00	236.83
24 37 30	270.65	31 07 30	255.19	37 37 30	236.44
24 45 00	270.38	31 15 00	254.86	37 45 00	236.05
24 52 30	270.11	31 22 30	254.53	37 52 30	235.66
25 00 00	269.85	31 30 00	254.19	38 00 00	235.26
25 07 30	269.58	31 37 30	253.86	38 07 30	234.87
25 15 00	269.31	31 45 00	253.53	38 15 00	234.47
25 22 30	269.04	31 52 30	253.19	38 22 30	234.07
25 30 00	268.76	32 00 00	252.85	38 30 00	233.68
25 37 30	268.49	32 07 30	252.51	38 37 30	233.28
25 45 00	268.21	32 15 00	252.17	38 45 00	232.88
25 52 30	267.94	32 22 30	251.83	38 52 30	232.48
26 00 00	267.66	32 30 00	251.49	39 00 00	232.07

TABLE 28.

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 15′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l–lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
39° 07′ 30″	231.67	45° 37′ 30″	209.17	52° 07′ 30″	183.90
39 15 00	231.27	45 45 00	208.71	52 15 00	183.39
39 22 30	230.86	45 52 30	208.25	52 22 30	182.88
39 30 00	230.45	46 00 00	207.78	52 30 00	182.37
39 37 30	230.04	46 07 30	207.32	52 37 30	181.85
39 45 00	229.63	46 15 00	206.86	52 45 00	181.34
39 52 30	229.22	46 22 30	206.39	52 52 30	180.82
40 00 00	228.81	46 30 00	205.92	53 00 00	180.31
40 07 30	228.40	46 37 30	205.45	53 07 30	179.79
40 15 00	227.99	46 45 00	204.99	53 15 00	179.27
40 22 30	227.57	46 52 30	204.52	53 22 30	178.75
40 30 00	227.15	47 00 00	204.05	53 30 00	178.23
40 37 30	226.73	47 07 30	203.57	53 37 30	177.71
40 45 00	226.32	47 15 00	203.10	53 45 00	177.19
40 52 30	225.90	47 22 30	202.63	53 52 30	176.67
41 00 00	225.48	47 30 00	202.15	54 00 00	176.14
41 07 30	225.06	47 37 30	201.67	54 07 30	175.62
41 15 00	224.64	47 45 00	201.20	54 15 00	175.10
41 22 30	224.21	47 52 30	200.72	54 22 30	174.57
41 30 00	223.79	48 00 00	200.24	54 30 00	174.04
41 37 30	223.36	48 07 30	199.76	54 37 30	173.51
41 45 00	222.93	48 15 00	199.28	54 45 00	172.99
41 52 30	222.50	48 22 30	198.80	54 52 30	172.46
42 00 00	222.08	48 30 00	198.32	55 00 00	171.93
42 07 30	221.65	48 37 30	197.83	55 07 30	171.39
42 15 00	221.21	48 45 00	197.35	55 15 00	170.86
42 22 30	220.78	48 52 30	196.86	55 22 30	170.33
42 30 00	220.35	49 00 00	196.38	55 30 00	169.79
42 37 30	219.91	49 07 30	195.89	55 37 30	169.26
42 45 00	219.48	49 15 00	195.40	55 45 00	168.72
42 52 30	219.04	49 22 30	194.91	55 52 30	168.19
43 00 00	218.60	49 30 00	194.42	56 00 00	167.65
43 07 30	218.16	49 37 30	193.93	56 07 30	167.11
43 15 00	217.73	49 45 00	193.44	56 15 00	166.57
43 22 30	217.28	49 52 30	192.94	56 22 30	166.03
43 30 00	216.84	50 00 00	192.45	56 30 00	165.49
43 37 30	216.40	50 07 30	191.95	56 37 30	164.95
43 45 00	215.96	50 15 00	191.46	56 45 00	164.41
43 52 30	215.51	50 22 30	190.96	56 52 30	163.87
44 00 00	215.06	50 30 00	190.46	57 00 00	163.32
44 07 30	214.61	50 37 30	189.96	57 07 30	162.78
44 15 00	214.17	50 45 00	189.46	57 15 00	162.23
44 22 30	213.72	50 52 30	188.96	57 22 30	161.68
44 30 00	213.27	51 00 00	188.46	57 30 00	161.14
44 37 30	212.82	51 07 30	187.96	57 37 30	160.59
44 45 00	212.37	51 15 00	187.46	57 45 00	160.04
44 52 30	211.91	51 22 30	186.95	57 52 30	159.49
45 00 00	211.46	51 30 00	186.45	58 00 00	158.94
45 07 30	211.00	51 37 30	185.94	58 07 30	158.39
45 15 00	210.55	51 45 00	185.43	58 15 00	157.84
45 22 30	210.09	51 52 30	184.92	58 22 30	157.29
45 30 00	209.63	52 00 00	184.41	58 30 00	156.73

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 15′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l-lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
58° 37′ 30″	156.18	65° 07′ 30″	126.34	71° 37′ 30″	94.78
58 45 00	155.62	65 15 00	125.75	71 45 00	94.16
58 52 30	155.07	65 22 30	125.16	71 52 30	93.54
59 00 00	154.51	65 30 00	124.57	72 00 00	92.92
59 07 30	153.96	65 37 30	123.97	72 07 30	92.30
59 15 00	153.40	65 45 00	123.38	72 15 00	91.68
59 22 30	152.84	65 52 30	122.78	72 22 30	91.05
59 30 00	152.28	66 00 00	122.19	72 30 00	90.43
59 37 30	151.72	66 07 30	121.59	72 37 30	89.80
59 45 00	151.16	66 15 00	120.99	72 45 00	89.18
59 52 30	150.60	66 22 30	120.40	72 52 30	88.55
60 00 00	150.03	66 30 00	119.80	73 00 00	87.93
60 07 30	149.47	66 37 30	119.20	73 07 30	87.30
60 15 00	148.91	66 45 00	118.60	73 15 00	86.67
60 22 30	148.34	66 52 30	118.00	73 22 30	86.05
60 30 00	147.77	67 00 00	117.40	73 30 00	85.42
60 37 30	147.21	67 07 30	116.80	73 37 30	84.79
60 45 00	146.64	67 15 00	116.20	73 45 00	84.16
60 52 30	146.07	67 22 30	115.59	73 52 30	83.53
61 00 00	145.50	67 30 00	114.99	74 00 00	82.91
61 07 30	144.93	67 37 30	114.39	74 07 30	82.28
61 15 00	144.36	67 45 00	113.78	74 15 00	81.65
61 22 30	143.79	67 52 30	113.18	74 22 30	81.01
61 30 00	143.22	68 00 00	112.57	74 30 00	80.38
61 37 30	142.65	68 07 30	111.97	74 37 30	79.75
61 45 00	142.08	68 15 00	111.36	74 45 00	79.12
61 52 30	141.50	68 22 30	110.76	74 52 30	78.49
62 00 00	140.93	68 30 00	110.15	75 00 00	77.86
62 07 30	140.35	68 37 30	109.54	75 07 30	77.22
62 15 00	139.78	68 45 00	108.93	75 15 00	76.59
62 22 30	139.20	68 52 30	108.32	75 22 30	75.95
62 30 00	138.62	69 00 00	107.71	75 30 00	75.32
62 37 30	138.04	69 07 30	107.10	75 37 30	74.69
62 45 00	137.47	69 15 00	106.49	75 45 00	74.05
62 52 30	136.89	69 22 30	105.88	75 52 30	73.42
63 00 00	136.31	69 30 00	105.27	76 00 00	72.78
63 07 30	135.73	69 37 30	104.65	76 07 30	72.14
63 15 00	135.15	69 45 00	104.04	76 15 00	71.51
63 22 30	134.56	69 52 30	103.43	76 22 30	70.87
63 30 00	133.98	70 00 00	102.81	76 30 00	70.24
63 37 30	133.40	70 07 30	102.20	76 37 30	69.60
63 45 00	132.81	70 15 00	101.59	76 45 00	68.96
63 52 30	132.23	70 22 30	100.97	76 52 30	68.32
64 00 00	131.64	70 30 00	100.35	77 00 00	67.68
64 07 30	131.06	70 37 30	99.74	77 07 30	67.04
64 15 00	130.47	70 45 00	99.12	77 15 00	66.41
64 22 30	129.88	70 52 30	98.50	77 22 30	65.77
64 30 00	129.29	71 00 00	97.88	77 30 00	65.13
64 37 30	128.70	71 07 30	97.26	77 37 30	64.49
64 45 00	128.12	71 15 00	96.65	77 45 00	63.85
64 52 30	127.53	71 22 30	96.03	77 52 30	63.20
65 00 00	126.94	71 30 00	95.41	78 00 00	62.56

Table 28.

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 15′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l–lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
78° 07′ 30″	61.92	82° 07′ 30″	41.24	86° 07′ 30″	20.35
78 15 00	61.28	82 15 00	40.59	86 15 00	19.69
78 22 30	60.64	82 22 30	39.94	86 22 30	19.04
78 30 00	60.00	82 30 00	39.29	86 30 00	18.38
78 37 30	59.35	82 37 30	38.64	86 37 30	17.72
78 45 00	58.71	82 45 00	37.99	86 45 00	17.07
78 52 30	58.06	82 52 30	37.34	86 52 30	16.41
79 00 00	57.42	83 00 00	36.69	87 00 00	15.76
79 07 30	56.78	83 07 30	36.03	87 07 30	15.10
79 15 00	56.13	83 15 00	35.38	87 15 00	14.44
79 22 30	55.49	83 22 30	34.73	87 22 30	13.79
79 30 00	54.84	83 30 00	34.08	87 30 00	13.13
79 37 30	54.20	83 37 30	33.42	87 37 30	12.48
79 45 00	53.55	83 45 00	32.77	87 45 00	11.82
79 52 30	52.91	83 52 30	32.12	87 52 30	11.16
80 00 00	52.26	84 00 00	31.47	88 00 00	10.51
80 07 30	51.62	84 07 30	30.81	88 07 30	9.85
80 15 00	50.97	84 15 00	30.16	88 15 00	9.20
80 22 30	50.32	84 22 30	29.51	88 22 30	8.54
80 30 00	49.68	84 30 00	28.86	88 30 00	7.88
80 37 30	49.03	84 37 30	28.20	88 37 30	7.22
80 45 00	48.38	84 45 00	2.54	88 45 00	6.57
80 52 30	47.73	84 52 30	26.89	88 52 30	5.91
81 00 00	47.08	85 00 00	26.24	89 00 00	5.26
81 07 30	46.44	85 07 30	25.58	89 07 30	4.60
81 15 00	45.79	85 15 00	24.93	89 15 00	3.94
81 22 30	45.14	85 22 30	24.27	89 22 30	3.28
81 30 00	44.49	85 30 00	23.62	89 30 00	2.63
81 37 30	43.84	85 37 30	22.97	89 37 30	1.97
81 45 00	43.19	85 45 00	22.31	89 45 00	1.31
81 52 30	42.54	85 52 30	21.66	89 52 30	0.66
82 00 00	41.89	86 00 00	21.00		

Table 29.

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 10′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l–lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
0° 05′	132.01	8° 45′	130.51	17° 25′	126.11
0 15	132.01	8 55	130.46	17 35	126.00
0 25	132.01	9 05	130.40	17 45	125.88
0 35	132.00	9 15	130.34	17 55	125.77
0 45	132.00	9 25	130.28	18 05	125.65
0 55	131.99	9 35	130.22	18 15	125.54
1 05	131.99	9 45	130.15	18 25	125.42
1 15	131.98	9 55	130.09	18 35	125.30
1 25	131.97	10 05	130.02	18 45	125.18
1 35	131.96	10 15	129.96	18 55	125.06
1 45	131.95	10 25	129.89	19 05	124.94
1 55	131.94	10 35	129.82	19 15	124.81
2 05	131.93	10 45	129.76	19 25	124.69
2 15	131.91	10 55	129.68	19 35	124.56
2 25	131.90	11 05	129.61	19 45	124.44
2 35	131.88	11 15	129.54	19 55	124.31
2 45	131.86	11 25	129.47	20 05	124.18
2 55	131.84	11 35	129.39	20 15	124.05
3 05	131.82	11 45	129.32	20 25	123.92
3 15	131.80	11 55	129.24	20 35	123.79
3 25	131.78	12 05	129.16	20 45	123.66
3 35	131.76	12 15	129.08	20 55	123.52
3 45	131.74	12 25	129.00	21 05	123.39
3 55	131.71	12 35	128.92	21 15	123.25
4 05	131.68	12 45	128.84	21 25	123.12
4 15	131.66	12 55	128.76	21 35	122.98
4 25	131.63	13 05	128.67	21 45	122.84
4 35	131.60	13 15	128.59	21 55	122.70
4 45	131.57	13 25	128.50	22 05	122.56
4 55	131.54	13 35	128.41	22 15	122.42
5 05	131.50	13 45	128.33	22 25	122.28
5 15	131.47	13 55	128.24	22 35	122.13
5 25	131.44	14 05	128.14	22 45	121.99
5 35	131.40	14 15	128.05	22 55	121.84
5 45	131.36	14 25	127.96	23 05	121.69
5 55	131.33	14 35	127.87	23 15	121.55
6 05	131.29	14 45	127.77	23 25	121.40
6 15	131.25	14 55	127.67	23 35	121.25
6 25	131.21	15 05	127.58	23 45	121.10
6 35	131.16	15 15	127.48	23 55	120.94
6 45	131.12	15 25	127.38	24 05	120.79
6 55	131.07	15 35	127.28	24 15	120.64
7 05	131.03	15 45	127.18	24 25	120.48
7 15	130.98	15 55	127.08	24 35	120.33
7 25	130.93	16 05	126.98	24 45	120.17
7 35	130.88	16 15	126.87	24 55	120.01
7 45	130.84	16 25	126.77	25 05	119.85
7 55	130.79	16 35	126.66	25 15	119.69
8 05	130.73	16 45	126.55	25 25	119.53
8 15	130.68	16 55	126.44	25 35	119.37
8 25	130.63	17 05	126.33	25 45	119.21
8 35	130.57	17 15	126.22	25 55	119.04

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 10′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l–lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
26° 05′	118.87	34° 45′	108.94	43° 25′	96.50
26 15	118.71	34 55	108.73	43 35	96.24
26 25	118.54	35 05	108.51	43 45	95.98
26 35	118.37	35 15	108.29	43 55	95.71
26 45	118.21	35 25	108.07	44 05	95.45
26 55	118.04	35 35	107.85	44 15	95.19
27 05	117.87	35 45	107.63	44 25	94.92
27 15	117.69	35 55	107.41	44 35	94.65
27 25	117.52	36 05	107.19	44 45	94.38
27 35	117.35	36 15	106.96	44 55	94.11
27 45	117.17	36 25	106.74	45 05	93.84
27 55	116.99	36 35	106.51	45 15	93.58
28 05	116.82	36 45	106.29	45 25	93.30
28 15	116.64	36 55	106.06	45 35	93.03
28 25	116.46	37 05	105.83	45 45	92.76
28 35	116.28	37 15	105.60	45 55	92.48
28 45	116.10	37 25	105.37	46 05	92.21
28 55	115.92	37 35	105.14	46 15	91.94
29 05	115.73	37 45	104.91	46 25	91.66
29 15	115.55	37 55	104.68	46 35	91.38
29 25	115.37	38 05	104.44	46 45	91.10
29 35	115.18	38 15	104.21	46 55	90.82
29 45	114.99	38 25	103.97	47 05	90.55
29 55	114.81	38 35	103.74	47 15	90.27
30 05	114.62	38 45	103.50	47 25	89.99
30 15	114.43	38 55	103.26	47 35	89.70
30 25	114.24	39 05	103.02	47 45	89.42
30 35	114.04	39 15	102.78	47 55	89.14
30 45	113.85	39 25	102.54	48 05	88.85
30 55	113.66	39 35	102.30	48 15	88.57
31 05	113.47	39 45	102.06	48 25	88.28
31 15	113.27	39 55	101.82	48 35	88.00
31 25	113.07	40 05	101.57	48 45	87.71
31 35	112.88	40 15	101.33	48 55	87.42
31 45	112.68	40 25	101.08	49 05	87.13
31 55	112.48	40 35	100.83	49 15	86.84
32 05	112.28	40 45	100.59	49 25	86.55
32 15	112.08	40 55	100.34	49 35	86.26
32 25	111.87	41 05	100.09	49 45	85.97
32 35	111.67	41 15	99.84	49 55	85.68
32 45	111.47	41 25	99.59	50 05	85.39
32 55	111.26	41 35	99.33	50 15	85.09
33 05	111.06	41 45	99.08	50 25	84.80
33 15	110.85	41 55	98.83	50 35	84.50
33 25	110.64	42 05	98.57	50 45	84.21
33 35	110.43	42 15	98.32	50 55	83.91
33 45	110.22	42 25	98.06	51 05	83.61
33 55	110.01	42 35	97.80	51 15	83.31
34 05	109.80	42 45	97.55	51 25	83.01
34 15	109.59	42 55	97.29	51 35	82.71
34 25	109.37	43 05	97.03	51 45	82.41
34 35	109.16	43 15	96.77	51 55	82.11

TABLE 29.

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 10′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l–lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
52° 05′	81.81	60° 45′	65.17	69° 25′	46.97
52 15	81.51	60 55	64.84	69 35	46.60
52 25	81.20	61 05	64.50	69 45	46.24
52 35	80.90	61 15	64.16	69 55	45.88
52 45	80.60	61 25	63.82	70 05	45.51
52 55	80.29	61 35	63.48	70 15	45.15
53 05	79.98	61 45	63.14	70 25	44.78
53 15	79.68	61 55	62.80	70 35	44.42
53 25	79.37	62 05	62.46	70 45	44.05
53 35	79.06	62 15	62.12	70 55	43.69
53 45	78.75	62 25	61.78	71 05	43.32
53 55	78.44	62 35	61.44	71 15	42.95
54 05	78.13	62 45	61.10	71 25	42.58
54 15	77.82	62 55	60.75	71 35	42.22
54 25	77.51	63 05	60.41	71 45	41.85
54 35	77.19	63 15	60.06	71 55	41.48
54 45	76.88	63 25	59.72	72 05	41.11
54 55	76.57	63 35	59.37	72 15	40.74
55 05	76.25	63 45	59.03	72 25	40.37
55 15	75.94	63 55	58.68	72 35	40.00
55 25	75.62	64 05	58.33	72 45	39.63
55 35	75.30	64 15	57.99	72 55	39.26
55 45	74.99	64 25	57.64	73 05	38.89
55 55	74.67	64 35	57.29	73 15	38.52
56 05	74.35	64 45	56.94	73 25	38.15
56 15	74.03	64 55	56.59	73 35	37.78
56 25	73.71	65 05	56.24	73 45	37.41
56 35	73.39	65 15	55.89	73 55	37.03
56 45	73.07	65 25	55.54	74 05	36.66
56 55	72.75	65 35	55.19	74 15	36.29
57 05	72.43	65 45	54.83	74 25	35.91
57 15	72.10	65 55	54.48	74 35	35.54
57 25	71.78	66 05	54.13	74 45	35.17
57 35	71.46	66 15	53.78	74 55	34.79
57 45	71.13	66 25	53.42	75 05	34.42
57 55	70.80	66 35	53.06	75 15	34.04
58 05	70.48	66 45	52.71	75 25	33.66
58 15	70.15	66 55	52.35	75 35	33.29
58 25	69.82	67 05	52.00	75 45	32.91
58 35	69.49	67 15	51.64	75 55	32.53
58 45	69.17	67 25	51.28	76 05	32.16
58 55	68.84	67 35	50.93	76 15	31.78
59 05	68.51	67 45	50.57	76 25	31.40
59 15	68.18	67 55	50.21	76 35	31.03
59 25	67.84	68 05	49.85	76 45	30.65
59 35	67.51	68 15	49.49	76 55	30.27
59 45	67.18	68 25	49.13	77 05	29.89
59 55	66.85	68 35	48.77	77 15	29.51
60 05	66.51	68 45	48.41	77 25	29.13
60 15	66.18	68 55	48.05	77 35	28.76
60 25	65.84	69 05	47.69	77 45	28.37
60 35	65.51	69 15	47.33	77 55	27.99

AREAS OF QUADRILATERALS OF EARTH'S SURFACE OF 10′ EXTENT IN LATITUDE AND LONGITUDE.

[Derivation of table explained on pp. l-lii.]

Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.	Middle latitude of quadrilateral.	Area in square miles.
78° 05′	27.62	82° 05′	18.43	86° 05′	9.14
78 15	27.24	82 15	18.04	86 15	8.75
78 25	26.85	82 25	17.65	86 25	8.36
78 35	26.47	82 35	17.27	86 35	7.97
78 45	26.09	82 45	16.88	86 45	7.59
78 55	25.71	82 55	16.50	86 55	7.20
79 05	25.33	83 05	16.11	87 05	6.81
79 15	24.95	83 15	15.73	87 15	6.42
79 25	24.57	83 25	15.34	87 25	6.03
79 35	24.18	83 35	14.95	87 35	5.64
79 45	23.80	83 45	14.57	87 45	5.25
79 55	23.42	83 55	14.18	87 55	4.86
80 05	23.04	84 05	13.79	88 05	4.47
80 15	22.65	84 15	13.40	88 15	4.09
80 25	22.27	84 25	13.02	88 25	3.70
80 35	21.89	84 35	12.63	88 35	3.31
80 45	21.50	84 45	12.24	88 45	2.92
80 55	21.12	84 55	11.86	88 55	2.53
81 05	20.73	85 05	11.47	89 05	2.14
81 15	20.35	85 15	11.08	89 15	1.75
81 25	19.97	85 25	10.69	89 25	1.36
81 35	19.58	85 35	10.30	89 35	0.97
81 45	19.20	85 45	9.92	89 45	0.58
81 55	18.81	85 55	9.53	89 55	0.19

DETERMINATION OF HEIGHTS BY THE BAROMETER.

Formula of Babinet.

$$Z = C\frac{B_0 - B}{B_0 + B}$$

$$C \text{ (in feet)} = 52494\left[1 + \frac{t_0 + t - 64}{900}\right] \text{— English Measures.}$$

$$C \text{ (in metres)} = 16000\left[1 + \frac{2(t_0 + t)}{1000}\right] \text{— Metric Measures.}$$

In which Z = Difference of height of two stations in feet or metres.

B_0, B = Barometric readings at the lower and upper stations respectively, corrected for all sources of instrumental error.

t_0, t = Air temperatures at the lower and upper stations respectively.

Values of C.

ENGLISH MEASURES.

$\frac{1}{2}(t_0 + t)$.	log C.	C.
F.		Feet.
10°	4.69834	49928
15	.70339	50511
20	.70837	51094
25	.71330	51677
30	.71818	52261
35	4.72300	52844
40	.72777	53428
45	.73248	54011
50	.73715	54595
55	.74177	55178
60	4.74633	55761
65	.75085	56344
70	.75532	56927
75	.75975	57511
80	.76413	58094
85	4.76847	58677
90	.77276	59260
95	.77702	59844
100	.78123	60427

METRIC MEASURES.

$\frac{1}{2}(t_0 + t)$.	log C.	C.
C.		Metres.
—10°	4.18639	15360
— 8	.19000	15488
— 6	.19357	15616
— 4	.19712	15744
— 2	.20063	15872
0	4.20412	16000
+2	.20758	16128
4	.21101	16256
6	.21442	16384
8	.21780	16512
10	4.22115	16640
12	.22448	16768
14	.22778	16896
16	.23106	17024
18	.23431	17152
20	4.23754	17280
22	.24075	17408
24	.24393	17536
26	.24709	17664
28	.25022	17792
30	4.25334	17920
32	.25643	18048
34	.25950	18176
36	.26255	18304

MEAN REFRACTION.

Apparent altitude.	Refraction.		Apparent altitude.	Refraction.		Apparent altitude.	Refraction.		Apparent altitude.	Refraction.		Apparent altitude.	Refraction.	
° ′	′ ″	″	° ′	° ″	″	° ′	′ ″	″	° ′	′ ″	″	°	″	″
0 0	34 54.1	124.9	7 0	7 19.7	9.2	14 0	3 47.4	5.3	28 0	1 48.2	1.5	42	64.0	2.2
10	32 49.2	116.9	10	7 10.5	8.8	20	3 42.1	5.1	20	1 46.7	1.4	43	61.8	2.1
20	30 52.3	108.8	20	7 1.7	8.4	40	3 37.0	4.9	40	1 45.3	1.5	44	59.7	2.0
30	29 3.5	100.8	30	6 53.3	8.2	15 0	3 32.1	4.7	29 0	1 43.8	1.4	45	57.7	2.0
40	27 22.7	92.9	40	6 45.1	7.9	20	3 27.4	4.5	20	1 42.4	1.4	46	55.7	1.9
50	25 49.8	85.2	50	6 37.2	7.6	40	3 22.9	4.3	40	1 41.0	1.3	47	53.8	1.9
1 0	24 24.6	77.9	8 0	6 29.6	7.3	16 0	3 18.6	4.1	30 0	1 39.7	1.3	48	51.9	1.7
10	23 6.7	71.1	10	6 22.3	7.1	20	3 14.5	4.0	20	1 38.4	1.3	49	50.2	1.8
20	21 55.6	64.7	20	6 15.2	6.8	40	3 10.5	3.9	40	1 37.1	1.3	50	48.4	1.7
30	20 50.9	59.0	30	6 8.4	6.6	17 0	3 6.6	3.7	31 0	1 35.8	1.3	51	46.7	1.6
40	19 51.9	53.9	40	6 1.8	6.4	20	3 2.9	3.6	20	1 34.5	1.2	52	45.1	1.6
50	18 58.0	49.4	50	5 55.4	6.1	40	2 59.3	3.5	40	1 33.3	1.2	53	43.5	1.6
2 0	18 8.6	45.6	9 0	5 49.3	6.0	18 0	2 55.8	3.3	32 0	1 32.1	1.2	54	41.9	1.5
10	17 23.0	42.3	10	5 43.3	5.7	20	2 52.5	3.2	20	1 30.9	1.1	55	40.4	1.5
20	16 40.7	39.8	20	5 37.6	5.6	40	2 49.3	3.2	40	1 29.8	1.1	56	38.9	1.4
30	16 0.9	37.5	30	5 32.0	5.5	19 0	2 46.1	3.0	33 0	1 28.7	1.1	57	37.5	1.4
40	15 23.4	35.6	40	5 26.5	5.2	20	2 43.1	2.9	20	1 27.6	1.1	58	36.1	1.4
50	14 47.8	33.2	50	5 21.3	5.1	40	2 40.2	2.9	40	1 26.5	1.1	59	34.7	1.4
3 0	14 14.6	30.9	10 0	5 16.2	5.0	20 0	2 37.3	2.8	34 0	1 25.4	1.1	60	33.3	1.3
10	13 43.7	28.7	10	5 11.2	4.8	20	2 34.5	2.6	20	1 24.3	1.0	61	32.0	1.3
20	13 15.0	26.7	20	5 6.4	4.7	40	2 31.9	2.6	40	1 23.3	1.0	62	30.7	1.3
30	12 48.3	24.6	30	5 1.7	4.5	21 0	2 29.3	2.5	35 0	1 22.3	1.0	63	29.4	1.2
40	12 23.7	23.0	40	4 57.2	4.4	20	2 26.8	2.5	20	1 21.3	1.0	64	28.2	1.3
50	12 0.7	21.8	50	4 52.8	4.3	40	2 24.3	2.4	40	1 20.3	1.0	65	26.9	1.2
4 0	11 38.9	20.6	11 0	4 48.5	4.2	22 0	2 21.9	2.3	36 0	1 19.3	1.0	66	25.7	1.2
10	11 18.3	19.7	10	4 44.3	4.1	20	2 19.6	2.2	20	1 18.3	0.9	67	24.5	1.2
20	10 58.6	19.0	20	4 40.2	3.9	40	2 17.4	2.2	40	1 17.4	0.9	68	23.3	1.1
30	10 39.6	18.4	30	4 36.3	3.9	23 0	2 15.2	2.2	37 0	1 16.5	0.9	69	22.2	1.2
40	10 21.2	17.9	40	4 32.4	3.7	20	2 13.0	2.1	20	1 15.6	0.9	70	21.0	1.1
50	10 3.3	16.8	50	4 28.7	3.7	40	2 10.9	2.0	40	1 14.7	0.9	71	19.9	1.1
5 0	9 46.5	15.6	12 0	4 25.0	3.6	24 0	2 8.9	1.9	38 0	1 13.8	0.9	72	18.8	1.1
10	9 30.9	14.9	10	4 21.4	3.4	20	2 7.0	1.9	20	1 12.9	0.9	73	17.7	1.1
20	9 16.0	14.1	20	4 18.0	3.4	40	2 5.1	1.9	40	1 12.0	0.8	74	16.6	1.1
30	9 1.9	13.5	30	4 14.6	3.3	25 0	2 3.2	1.8	39 0	1 11.2	0.9	75	15.5	1.0
40	8 48.4	12.8	40	4 11.3	3.2	20	2 1.4	1.8	20	1 10.3	0.8	76	14.5	1.1
50	8 35.6	12.3	50	4 8.1	3.2	40	1 59.6	1.8	40	1 9.5	0.8	77	13.4	1.1
6 0	8 23.3	11.7	13 0	4 4.9	3.1	26 0	1 57.8	1.7	40 0	1 8.7	0.8	78	12.3	1.1
10	8 11.6	11.3	10	4 1.8	3.0	20	1 56.1	1.7	20	1 7.9	0.8	79	11.2	1.0
20	8 0.3	10.8	20	3 58.8	2.9	40	1 54.4	1.6	40	1 7.1	0.8	80	10.2	1.1
30	7 49.5	10.3	30	3 55.9	2.9	27 0	1 52.8	1.6	41 0	1 6.3	0.8	81	9.1	1.0
40	7 39.2	10.0	40	3 53.0	2.8	20	1 51.2	1.5	20	1 5.5	0.8	82	8.1	4.0
50	7 29.2	9.5	50	3 50.2	2.8	40	1 49.7	1.5	40	1 4.7	0.7	86	4.1	4.1
7 0	7 19.7		14 0	3 47.4		28 0	1 48.2		42 0	1 4.0		90	0.0	

FOR CONVERSION OF ARC INTO TIME.

°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	′	m. s.	″	s.
0	0 0	**60**	4 0	**120**	8 0	**180**	12 0	**240**	16 0	**300**	20 0	**0**	0 0	**0**	0.000
1	0 4	61	4 4	121	8 4	181	12 4	241	16 4	301	20 4	1	0 4	1	0.067
2	0 8	62	4 8	122	8 8	182	12 8	242	16 8	302	20 8	2	0 8	2	0.133
3	0 12	63	4 12	123	8 12	183	12 12	243	16 12	303	20 12	3	0 12	3	0.200
4	0 16	64	4 16	124	8 16	184	12 16	244	16 16	304	20 16	4	0 16	4	0.267
5	0 20	**65**	4 20	**125**	8 20	**185**	12 20	**245**	16 20	**305**	20 20	**5**	0 20	**5**	0.333
6	0 24	66	4 24	126	8 24	186	12 24	246	16 24	306	20 24	6	0 24	6	0.400
7	0 28	67	4 28	127	8 28	187	12 28	247	16 28	307	20 28	7	0 28	7	0.467
8	0 32	68	4 32	128	8 32	188	12 32	248	16 32	308	20 3[illegible]	8	0 32	8	0.533
9	0 36	69	4 36	129	8 36	189	12 36	249	16 36	309	20 3[illegible]	9	0 36	9	0.600
10	0 40	**70**	4 40	**130**	8 40	**190**	12 40	**250**	16 40	**310**	20 40	**10**	0 40	**10**	0.667
11	0 44	71	4 44	131	8 44	191	12 44	251	16 44	311	20 44	11	0 44	11	0.733
12	0 48	72	4 48	132	8 48	192	12 48	252	16 48	312	20 48	12	0 48	12	0.800
13	0 52	73	4 52	133	8 52	193	12 52	253	16 52	313	20 52	13	0 52	13	0.867
14	0 56	74	4 56	134	8 56	194	12 56	254	16 56	314	20 56	14	0 56	14	0.933
15	1 0	**75**	5 0	**135**	9 0	**195**	13 0	**255**	17 0	**315**	21 0	**15**	1 0	**15**	1.000
16	1 4	76	5 4	136	9 4	196	13 4	256	17 4	316	21 4	16	1 4	16	1.067
17	1 8	77	5 8	137	9 8	197	13 8	257	17 8	317	21 8	17	1 8	17	1.133
18	1 12	78	5 12	138	9 12	198	13 12	258	17 12	318	21 12	18	1 12	18	1.200
19	1 16	79	5 16	139	9 16	199	13 16	259	17 16	319	21 16	19	1 16	19	1.267
20	1 20	**80**	5 20	**140**	9 20	**200**	13 20	**260**	17 20	**320**	21 20	**20**	1 20	**20**	1.333
21	1 24	81	5 24	141	9 24	201	13 24	261	17 24	321	21 24	21	1 24	21	1.400
22	1 28	82	5 28	142	9 28	202	13 28	262	17 28	322	21 28	22	1 28	22	1.467
23	1 32	83	5 32	143	9 32	203	13 32	263	17 32	323	21 32	23	1 32	23	1.533
24	1 36	84	5 36	144	9 36	204	13 36	264	17 36	324	21 36	24	1 36	24	1.600
25	1 40	**85**	5 40	**145**	9 40	**205**	13 40	**265**	17 40	**325**	21 40	**25**	1 40	**25**	1.667
26	1 44	86	5 44	146	9 44	206	13 44	266	17 44	326	21 44	26	1 44	26	1.733
27	1 48	87	5 48	147	9 48	207	13 48	267	17 48	327	21 48	27	1 48	27	1.800
28	1 52	88	5 52	148	9 52	208	13 52	268	17 52	328	21 52	28	1 52	28	1.867
29	1 56	89	5 56	149	9 56	209	13 56	269	17 56	329	21 56	29	1 56	29	1.933
30	2 0	**90**	6 0	**150**	10 0	**210**	14 0	**270**	18 0	**330**	22 0	**30**	2 0	**30**	2.000
31	2 4	91	6 4	151	10 4	211	14 4	271	18 4	331	22 4	31	2 4	31	2.067
32	2 8	92	6 8	152	10 8	212	14 8	272	18 8	332	22 8	32	2 8	32	2.133
33	2 12	93	6 12	153	10 12	213	14 12	273	18 12	333	22 12	33	2 12	33	2.200
34	2 16	94	6 16	154	10 16	214	14 16	274	18 16	334	22 16	34	2 16	34	2.267
35	2 20	**95**	6 20	**155**	10 20	**215**	14 20	**275**	18 20	**335**	22 20	**35**	2 20	**35**	2.333
36	2 24	96	6 24	156	10 24	216	14 24	276	18 24	336	22 24	36	2 24	36	2.400
37	2 28	97	6 28	157	10 28	217	14 28	277	18 28	337	22 28	37	2 28	37	2.467
38	2 32	98	6 32	158	10 32	218	14 32	278	18 32	338	22 32	38	2 32	38	2.533
39	2 36	99	6 36	159	10 36	219	14 36	279	18 36	339	22 36	39	2 36	39	2.600
40	2 40	**100**	6 40	**160**	10 40	**220**	14 40	**280**	18 40	**340**	22 40	**40**	2 40	**40**	2.667
41	2 44	101	6 44	161	10 44	221	14 44	281	18 44	341	22 44	41	2 44	41	2.733
42	2 48	102	6 48	162	10 48	222	14 48	282	18 48	342	22 48	42	2 48	42	2.800
43	2 52	103	6 52	163	10 52	223	14 52	283	18 52	343	22 52	43	2 52	43	2.867
44	2 56	104	6 56	164	10 56	224	14 56	284	18 56	344	22 56	44	2 56	44	2.933
45	3 0	**105**	7 0	**165**	11 0	**225**	15 0	**285**	19 0	**345**	23 0	**45**	3 0	**45**	3.000
46	3 4	106	7 4	166	11 4	226	15 4	286	19 4	346	23 4	46	3 4	46	3.067
47	3 8	107	7 8	167	11 8	227	15 8	287	19 8	347	23 8	47	3 8	47	3.133
48	3 12	108	7 12	168	11 12	228	15 12	288	19 12	348	23 12	48	3 12	48	3.200
49	3 16	109	7 16	169	11 16	229	15 16	289	19 16	349	23 16	49	3 16	49	3.267
50	3 20	**110**	7 20	**170**	11 20	**230**	15 20	**290**	19 20	**350**	23 20	**50**	3 20	**50**	3.333
51	3 24	111	7 24	171	11 24	231	15 24	291	19 24	351	23 24	51	3 24	51	3.400
52	3 28	112	7 28	172	11 28	232	15 28	292	19 28	352	23 28	52	3 28	52	3.467
53	3 32	113	7 32	173	11 32	233	15 32	293	19 32	353	23 32	53	3 32	53	3.533
54	3 36	114	7 36	174	11 36	234	15 36	294	19 36	354	23 36	54	3 36	54	3.600
55	3 40	**115**	7 40	**175**	11 40	**235**	15 40	**295**	19 40	**355**	23 40	**55**	3 40	**55**	3.667
56	3 44	116	7 44	176	11 44	236	15 44	296	19 44	356	23 44	56	3 44	56	3.733
57	3 48	117	7 48	177	11 48	237	15 48	297	19 48	357	23 48	57	3 48	57	3.800
58	3 52	118	7 52	178	11 52	238	15 52	298	19 52	358	23 52	58	3 52	58	3.867
59	3 56	119	7 56	179	11 56	239	15 56	299	19 56	359	23 56	59	3 56	59	3.933
60	4 0	**120**	8 0	**180**	12 0	**240**	16 0	**300**	20 0	**360**	24 0	**60**	4 0	**60**	4.000

FOR CONVERSION OF TIME INTO ARC.

Hours of Time into Arc.

Time.	Arc.	Time.	Arc.	Time.	Arc.	Time.	Arc.	Time.	Arc.	Time.	Arc.
hrs.	°	*hrs.*	°	*hrs.*	°	*hrs.*	°	*hrs.*	°	*hrs.*	°
1	15	5	75	9	135	13	195	17	255	21	315
2	30	6	90	10	150	14	210	18	270	22	330
3	45	7	105	11	165	15	225	19	285	23	345
4	60	8	120	12	180	16	240	20	300	24	360

Minutes of Time into Arc.

m.	° ′	m.	° ′	m.	° ′
1	0 15	21	5 15	41	10 15
2	0 30	22	5 30	42	10 30
3	0 45	23	5 45	43	10 45
4	1 0	24	6 0	44	11 0
5	1 15	25	6 15	45	11 15
6	1 30	26	6 30	46	11 30
7	1 45	27	6 45	47	11 45
8	2 0	28	7 0	48	12 0
9	2 15	29	7 15	49	12 15
10	2 30	30	7 30	50	12 30
11	2 45	31	7 45	51	12 45
12	3 0	32	8 0	52	13 0
13	3 15	33	8 15	53	13 15
14	3 30	34	8 30	54	13 30
15	3 45	35	8 45	55	13 45
16	4 0	36	9 0	56	14 0
17	4 15	37	9 15	57	14 15
18	4 30	38	9 30	58	14 30
19	4 45	39	9 45	59	14 45
20	5 0	40	10 0	60	15 0

Seconds of Time into Arc.

s.	′ ″	s.	′ ″	s.	′ ″
1	0 15	21	5 15	41	10 15
2	0 30	22	5 30	42	10 30
3	0 45	23	5 45	43	10 45
4	1 0	24	6 0	44	11 0
5	1 15	25	6 15	45	11 15
6	1 30	26	6 30	46	11 30
7	1 45	27	6 45	47	11 45
8	2 0	28	7 0	48	12 0
9	2 15	29	7 15	49	12 15
10	2 30	30	7 30	50	12 30
11	2 45	31	7 45	51	12 45
12	3 0	32	8 0	52	13 0
13	3 15	33	8 15	53	13 15
14	3 30	34	8 30	54	13 30
15	3 45	35	8 45	55	13 45
16	4 0	36	9 0	56	14 0
17	4 15	37	9 15	57	14 15
18	4 30	38	9 30	58	14 30
19	4 45	39	9 45	59	14 45
20	5 0	40	10 0	60	15 0

Hundredths of a Second of Time into Arc.

Hundredths of a Second of Time.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
s.	″	″	″	″	″	″	″	″	″	″
0.00	0.00	0.15	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35
.10	1.50	1.65	1.80	1.95	2.10	2.25	2.40	2.55	2.70	2.85
.20	3.00	3.15	3.30	3.45	3.60	3.75	3.90	4.05	4.20	4.35
.30	4.50	4.65	4.80	4.95	5.10	5.25	5.40	5.55	5.70	5.85
.40	6.00	6.15	6.30	6.45	6.60	6.75	6.90	7.05	7.20	7.35
0.50	7.50	7.65	7.80	7.95	8.10	8.25	8.40	8.55	8.70	8.85
.60	9.00	9.15	9.30	9.45	9.60	9.75	9.90	10.05	10.20	10.35
.70	10.50	10.65	10.80	10.95	11.10	11.25	11.40	11.55	11.70	11.85
.80	12.00	12.15	12.30	12.45	12.60	12.75	12.90	13.05	13.20	13.35
.90	13.50	13.65	13.80	13.95	14.10	14.25	14.40	14.55	14.70	14.85

CONVERSION OF MEAN TIME INTO SIDEREAL TIME.

s	m 0	m 1	m 2	m 3	s	m s	s	m s
	h m s	h m s	h m s	h m s				
0	0 0 0	6 5 15	12 10 29	18 15 44	0.00	0 0	0.50	3 3
1	0 6 5	6 11 20	12 16 34	18 21 49	0.01	0 4	0.51	3 6
2	0 12 10	6 17 25	12 22 40	18 27 54	0.02	0 7	0.52	3 10
3	0 18 16	6 23 30	12 28 45	18 33 59	0.03	0 11	0.53	3 14
4	0 24 21	6 29 36	12 34 50	18 40 5	0.04	0 15	0.54	3 17
5	0 30 26	6 35 41	12 40 55	18 46 10	0.05	0 18	0.55	3 21
6	0 36 31	6 41 46	12 47 1	18 52 15	0.06	0 22	0.56	3 25
7	0 42 37	6 47 51	12 53 6	18 58 20	0.07	0 26	0.57	3 28
8	0 48 42	6 53 56	12 59 11	19 4 26	0.08	0 29	0.58	3 32
9	0 54 47	7 0 2	13 5 16	19 10 31	0.09	0 33	0.59	3 35
10	1 0 52	7 6 7	13 11 21	19 16 36	0.10	0 37	0.60	3 39
11	1 6 58	7 12 12	13 17 27	19 22 41	0.11	0 40	0.61	3 43
12	1 13 3	7 18 17	13 23 32	19 28 47	0.12	0 44	0.62	3 46
13	1 19 8	7 24 23	13 29 37	19 34 52	0.13	0 47	0.63	3 50
14	1 25 13	7 30 28	13 35 42	19 40 57	0.14	0 51	0.64	3 54
15	1 31 19	7 36 33	13 41 48	19 47 2	0.15	0 55	0.65	3 57
16	1 37 24	7 42 38	13 47 53	19 53 7	0.16	0 58	0.66	4 1
17	1 43 29	7 48 44	13 53 58	19 59 13	0.17	1 2	0.67	4 5
18	1 49 34	7 54 49	14 0 3	20 5 18	0.18	1 6	0.68	4 8
19	1 55 40	8 0 54	14 6 9	20 11 23	0.19	1 9	0.69	4 12
20	2 1 45	8 6 59	14 12 14	20 17 28	0.20	1 13	0.70	4 16
21	2 7 50	8 13 5	14 18 19	20 23 34	0.21	1 17	0.71	4 19
22	2 13 55	8 19 10	14 24 24	20 29 39	0.22	1 20	0.72	4 23
23	2 20 1	8 25 15	14 30 30	20 35 44	0.23	1 24	0.73	4 27
24	2 26 6	8 31 20	14 36 35	20 41 49	0.24	1 28	0.74	4 30
25	2 32 11	8 37 26	14 42 40	20 47 55	0.25	1 31	0.75	4 34
26	2 38 16	8 43 31	14 48 45	20 54 0	0.26	1 35	0.76	4 38
27	2 44 22	8 49 36	14 54 51	21 0 5	0.27	1 39	0.77	4 41
28	2 50 27	8 55 41	15 0 56	21 6 10	0.28	1 42	0.78	4 45
29	2 56 32	9 1 47	15 7 1	21 12 16	0.29	1 46	0.79	4 49
30	3 2 37	9 7 52	15 13 6	21 18 21	0.30	1 50	0.80	4 52
31	3 8 43	9 13 57	15 19 12	21 24 26	0.31	1 53	0.81	4 56
32	3 14 48	9 20 2	15 25 17	21 30 31	0.32	1 57	0.82	4 59
33	3 20 53	9 26 8	15 31 22	21 36 37	0.33	2 1	0.83	5 3
34	3 26 58	9 32 13	15 37 27	21 42 42	0.34	2 4	0.84	5 7
35	3 33 3	9 38 18	15 43 33	21 48 47	0.35	2 8	0.85	5 10
36	3 39 9	9 44 23	15 49 38	21 54 52	0.36	2 11	0.86	5 14
37	3 45 14	9 50 28	15 55 43	22 0 58	0.37	2 15	0.87	5 18
38	3 51 19	9 56 34	16 1 48	22 7 3	0.38	2 19	0.88	5 21
39	3 57 24	10 2 39	16 7 54	22 13 8	0.39	2 22	0.89	5 25
40	4 3 30	10 8 44	16 13 59	22 19 13	0.40	2 26	0.90	5 29
41	4 9 35	10 14 49	16 20 4	22 25 19	0.41	2 30	0.91	5 32
42	4 15 40	10 20 55	16 26 9	22 31 24	0.42	2 33	0.92	5 36
43	4 21 45	10 27 0	16 32 14	22 37 29	0.43	2 37	0.93	5 40
44	4 27 51	10 33 5	16 38 20	22 43 34	0.44	2 41	0.94	5 43
45	4 33 56	10 39 10	16 44 25	22 49 39	0.45	2 44	0.95	5 47
46	4 40 1	10 45 16	16 50 30	22 55 45	0.46	2 48	0.96	5 51
47	4 46 6	10 51 21	16 56 35	23 1 50	0.47	2 52	0.97	5 54
48	4 52 12	10 57 26	17 2 41	23 7 55	0.48	2 55	0.98	5 58
49	4 58 17	11 3 31	17 8 46	23 14 0	0.49	2 59	0.99	6 2
50	5 4 22	11 9 37	17 14 51	23 20 6	0.50	3 3	1.00	6 5
51	5 10 27	11 15 42	17 20 56	23 26 11				
52	5 16 33	11 21 47	17 27 2	23 32 16				
53	5 22 38	11 27 52	17 33 7	23 38 21				
54	5 28 43	11 33 58	17 39 12	23 44 27				
55	5 34 48	11 40 3	17 45 17	23 50 32				
56	5 40 54	11 46 8	17 51 23	23 56 37				
57	5 46 59	11 52 13	17 57 28	24 2 42				
58	5 53 4	11 58 19	18 3 33	24 8 48				
59	5 59 9	12 4 24	18 9 38	24 14 53				
60	6 5 15	12 10 29	18 15 44	24 20 58				

Example: Let the given mean time be $14^h\ 57^m\ 32^s.56$.
The table gives
first for $14^h\ 54^m\ 51^s$ $2^m\ 27^s$
then for 2 41 0.44

2 27.44

The sum
$14^h\ 57^m\ 32^s.56 + 2^m\ 27^s.44 = 15^h\ 0^m\ 0^s$
is the required sidereal time.

CONVERSION OF SIDEREAL TIME INTO MEAN TIME.

s	m 0 (h m s)	m 1 (h m s)	m 2 (h m s)	m 3 (h m s)
0	0 0 0	6 6 15	12 12 29	18 18 44
1	0 6 6	6 12 21	12 18 35	18 24 50
2	0 12 12	6 18 27	12 24 42	18 30 56
3	0 18 19	6 24 33	12 30 48	18 37 2
4	0 24 25	6 30 40	12 36 54	18 43 9
5	0 30 31	6 36 46	12 43 0	18 49 15
6	0 36 37	6 42 52	12 49 7	18 55 21
7	0 42 44	6 48 58	12 55 13	19 1 27
8	0 48 50	6 55 4	13 1 19	19 7 34
9	0 54 56	7 1 11	13 7 25	19 13 40
10	1 1 2	7 7 17	13 13 31	19 19 46
11	1 7 9	7 13 23	13 19 38	19 25 52
12	1 13 15	7 19 29	13 25 44	19 31 59
13	1 19 21	7 25 36	13 31 50	19 38 5
14	1 25 27	7 31 42	13 37 56	19 44 11
15	1 31 34	7 37 48	13 44 3	19 50 17
16	1 37 40	7 43 54	13 50 9	19 56 23
17	1 43 46	7 50 1	13 56 15	20 2 30
18	1 49 52	7 56 7	14 2 21	20 8 36
19	1 55 59	8 2 13	14 8 28	20 14 42
20	2 2 5	8 8 19	14 14 34	20 20 48
21	2 8 11	8 14 26	14 20 40	20 26 55
22	2 14 17	8 20 32	14 26 46	20 33 1
23	2 20 24	8 26 38	14 32 53	20 39 7
24	2 26 30	8 32 44	14 38 59	20 45 13
25	2 32 36	8 38 51	14 45 5	20 51 20
26	2 38 42	8 44 57	14 51 11	20 57 26
27	2 44 49	8 51 3	14 57 18	21 3 32
28	2 50 55	8 57 9	15 3 24	21 9 38
29	2 57 1	9 3 16	15 9 30	21 15 45
30	3 3 7	9 9 22	15 15 36	21 21 51
31	3 9 14	9 15 28	15 21 43	21 27 57
32	3 15 20	9 21 34	15 27 49	21 34 3
33	3 21 26	9 27 41	15 33 55	21 40 10
34	3 27 32	9 33 47	15 40 1	21 46 16
35	3 33 38	9 39 53	15 46 8	21 52 22
36	3 39 45	9 45 59	15 52 14	21 58 28
37	3 45 51	9 52 5	15 58 20	22 4 35
38	3 51 57	9 58 12	16 4 26	22 10 41
39	3 58 3	10 4 18	16 10 33	22 16 47
40	4 4 10	10 10 24	16 16 39	22 22 53
41	4 10 16	10 16 30	16 22 45	22 29 0
42	4 16 22	10 22 37	16 28 51	22 35 6
43	4 22 28	10 28 43	16 34 57	22 41 12
44	4 28 35	10 34 49	16 41 4	22 47 18
45	4 34 41	10 40 55	16 47 10	22 53 24
46	4 40 47	10 47 2	16 53 16	22 59 31
47	4 46 53	10 53 8	16 59 22	23 5 37
48	4 53 0	10 59 14	17 5 29	23 11 43
49	4 59 6	11 5 20	17 11 35	23 17 49
50	5 5 12	11 11 27	17 17 41	23 23 56
51	5 11 18	11 17 33	17 23 47	23 30 2
52	5 17 25	11 23 39	17 29 54	23 36 8
53	5 23 31	11 29 45	17 36 0	23 42 14
54	5 29 37	11 35 52	17 42 6	23 48 21
55	5 35 43	11 41 58	17 48 12	23 54 27
56	5 41 50	11 48 4	17 54 19	24 0 33
57	5 47 56	11 54 10	18 0 25	24 6 39
58	5 54 2	12 0 17	18 6 31	24 12 46
59	6 0 8	12 6 23	18 12 37	24 18 52
60	6 6 15	12 12 29	18 18 44	24 24 58

s	m s	s	m s
0.00	0 0	0.50	3 3
0.01	0 4	0.51	3 7
0.02	0 7	0.52	3 10
0.03	0 11	0.53	3 14
0.04	0 15	0.54	3 18
0.05	0 18	0.55	3 21
0.06	0 22	0.56	3 25
0.07	0 26	0.57	3 29
0.08	0 29	0.58	3 32
0.09	0 33	0.59	3 36
0.10	0 37	0.60	3 40
0.11	0 40	0.61	3 43
0.12	0 44	0.62	3 47
0.13	0 48	0.63	3 51
0.14	0 51	0.64	3 54
0.15	0 55	0.65	3 58
0.16	0 59	0.66	4 2
0.17	1 2	0.67	4 5
0.18	1 6	0.68	4 9
0.19	1 10	0.69	4 13
0.20	1 13	0.70	4 16
0.21	1 17	0.71	4 20
0.22	1 21	0.72	4 24
0.23	1 24	0.73	4 27
0.24	1 28	0.74	4 31
0.25	1 32	0.75	4 35
0.26	1 35	0.76	4 38
0.27	1 39	0.77	4 42
0.28	1 43	0.78	4 46
0.29	1 46	0.79	4 49
0.30	1 50	0.80	4 53
0.31	1 54	0.81	4 57
0.32	1 57	0.82	5 0
0.33	2 1	0.83	5 4
0.34	2 5	0.84	5 8
0.35	2 8	0.85	5 11
0.36	2 12	0.86	5 15
0.37	2 16	0.87	5 19
0.38	2 19	0.88	5 22
0.39	2 23	0.89	5 26
0.40	2 26	0.90	5 30
0.41	2 30	0.91	5 33
0.42	2 34	0.92	5 37
0.43	2 37	0.93	5 41
0.44	2 41	0.94	5 44
0.45	2 45	0.95	5 48
0.46	2 48	0.96	5 52
0.47	2 52	0.97	5 55
0.48	2 56	0.98	5 59
0.49	2 59	0.99	6 3
0.50	3 3	1.00	6 6

Example: Given $15^h 0^m 0^s$.
The table gives
first for $14^h 57^m 18^s$ $2^m 27^s$
then for 2 42 0.44
15 0 0 2 27.44
The difference
$15^h 0^m 0^s - 2^m 27^s.44 = 14^h 57^m 32^s.56$
is the required mean time.

LENGTH OF ONE DEGREE OF THE MERIDIAN AT DIFFERENT LATITUDES.

[Derivation of table explained on pp. xlvi-xlviii.]

Latitude.	Metres.	Statute Miles.	Geographic Miles. 1′ of the Eq.	Latitude.	Metres.	Statute Miles.	Geographic Miles. 1′ of the Eq.
0°	110568.5	68.703	59.594	45°	111132.1	69.054	59.898
1	110568.8	68.704	59.594	46	111151.9	69.067	59.908
2	110569.8	68.705	59.595	47	111171.6	69.079	59.919
3	110571.5	68.706	59.596	48	111191.3	69.091	59.929
4	110573.9	68.707	59.597	49	111210.9	69.103	59.940
5	110577.0	68.709	59.598	50	111230.5	69.115	59.951
6	110580.7	68.711	59.600	51	111249.9	69.127	59.961
7	110585.1	68.714	59.603	52	111269.2	69.139	59.972
8	110590.2	68.717	59.606	53	111288.3	69.151	59.982
9	110595.9	68.721	59.609	54	111307.3	69.163	59.992
10	110602.3	68.725	59.612	55	111326.0	69.175	60.002
11	110609.3	68.729	59.616	56	111344.5	69.186	60.012
12	110617.0	68.734	59.620	57	111362.7	69.198	60.022
13	110625.3	68.739	59.625	58	111380.7	69.209	60.032
14	110634.2	68.745	59.629	59	111398.4	69.220	60.041
15	110643.7	68.751	59.634	60	111415.7	69.230	60.051
16	110653.8	68.757	59.640	61	111432.7	69.241	60.060
17	110664.5	68.763	59.646	62	111449.4	69.251	60.069
18	110675.7	68.770	59.652	63	111465.7	69.261	60.077
19	110687.5	68.778	59.658	64	111481.5	69.271	60.086
20	110699.9	68.786	59.665	65	111497.0	69.281	60.094
21	110712.8	68.794	59.672	66	111512.0	69.290	60.102
22	110726.2	68.802	59.679	67	111526.5	69.299	60.110
23	110740.1	68.810	59.686	68	111540.5	69.308	60.118
24	110754.4	68.819	59.694	69	111554.1	69.316	60.125
25	110769.2	68.829	59.702	70	111567.1	69.324	60.132
26	110784.5	68.838	59.710	71	111579.7	69.332	60.139
27	110800.2	68.848	59.719	72	111591.6	69.340	60.145
28	110816.3	68.858	59.727	73	111603.0	69.347	60.151
29	110832.8	68.868	59.736	74	111613.9	69.354	60.157
30	110849.7	68.879	59.745	75	111624.1	69.360	60.163
31	110866.9	68.889	59.755	76	111633.8	69.366	60.168
32	110884.4	68.900	59.764	77	111642.8	69.372	60.173
33	110902.3	68.911	59.774	78	111651.2	69.377	60.177
34	110920.4	68.923	59.784	79	111659.0	69.382	60.182
35	110938.8	68.934	59.794	80	111666.2	69.386	60.186
36	110957.4	68.946	59.804	81	111672.6	69.390	60.189
37	110976.3	68.957	59.814	82	111678.5	69.394	60.192
38	110995.3	68.969	59.824	83	111683.6	69.397	60.195
39	111014.5	68.981	59.834	84	111688.1	69.400	60.197
40	111033.9	68.993	59.845	85	111691.9	69.402	60.199
41	111053.4	69.005	59.855	86	111695.0	69.404	60.201
42	111073.0	69.017	59.866	87	111697.4	69.405	60.202
43	111092.6	69.029	59.876	88	111699.2	69.407	60.203
44	111112.4	69.042	59.887	89	111700.2	69.407	60.204
45	111132.1	69.054	59.898	90	111700.6	69.407	60.204

LENGTH OF ONE DEGREE OF THE PARALLEL AT DIFFERENT LATITUDES.

[Derivation of table explained on p. xlix.]

Latitude.	Metres.	Statute Miles.	Geographic Miles. 1′ of the Eq.	Latitude.	Metres.	Statute Miles.	Geographic Miles. 1′ of the Eq.
0°	111321.9	69.171	60.000	45°	78850.0	48.995	42.498
1	111305.2	69.162	59.991	46	77466.5	48.135	41.753
2	111254.6	69.130	59.964	47	76059.2	47.261	40.994
3	111170.4	69.078	59.918	48	74628.5	46.372	40.223
4	111052.6	69.005	59.855	49	73174.9	45.469	39.440
5	110901.2	68.911	59.773	50	71698.9	44.552	38.644
6	110716.2	68.796	59.673	51	70200.8	43.621	37.837
7	110497.7	68.660	59.556	52	68681.1	42.676	37.018
8	110245.8	68.503	59.420	53	67140.3	41.719	36.187
9	109960.5	68.326	59.266	54	65578.8	40.749	35.346
10	109641.9	68.128	59.095	55	63997.1	39.766	34.493
11	109290.1	67.909	58.905	56	62395.7	38.771	33.630
12	108905.2	67.670	58.697	57	60775.1	37.764	32.757
13	108487.3	67.411	58.472	58	59135.7	36.745	31.873
14	108036.6	67.131	58.229	59	57478.1	35.715	30.979
15	107553.1	66.830	57.969	60	55802.8	34.674	30.076
16	107037.0	66.510	57.690	61	54110.2	33.622	29.164
17	106488.5	66.169	57.395	62	52400.9	32.560	28.243
18	105907.7	65.808	57.082	63	50675.4	31.488	27.313
19	105294.7	65.427	56.751	64	48934.3	30.406	26.374
20	104649.8	65.026	56.404	65	47178.0	29.315	25.428
21	103973.2	64.606	56.039	66	45407.1	28.215	24.473
22	103265.0	64.166	55.657	67	43622.2	27.106	23.511
23	102525.4	63.706	55.259	68	41823.8	25.988	22.542
24	101754.6	63.227	54.843	69	40012.4	24.862	21.566
25	100953.0	62.729	54.411	70	38188.6	23.729	20.583
26	100120.6	62.212	53.963	71	36353.0	22.589	19.593
27	99257.8	61.676	53.498	72	34506.2	21.441	18.598
28	98364.8	61.121	53.016	73	32648.6	20.287	17.597
29	97441.9	60.548	52.519	74	30780.9	19.126	16.590
30	96489.3	59.956	52.006	75	28903.6	17.960	15.578
31	95507.3	59.345	51.476	76	27017.4	16.788	14.562
32	94496.2	58.717	50.931	77	25122.8	15.611	13.541
33	93456.3	58.071	50.371	78	23220.4	14.428	12.515
34	92387.9	57.407	49.795	79	21310.8	13.242	11.486
35	91291.3	56.726	49.204	80	19394.6	12.051	10.453
36	90166.8	56.027	48.598	81	17472.4	10.857	9.417
37	89014.8	55.311	47.977	82	15544.7	9.659	8.378
38	87835.6	54.578	47.341	83	13612.2	8.458	7.337
39	86629.6	53.829	46.691	84	11675.5	7.255	6.293
40	85397.0	53.063	46.027	85	9735.1	6.049	5.247
41	84138.4	52.281	45.349	86	7791.7	4.841	4.200
42	82854.0	51.483	44.656	87	5845.9	3.632	3.151
43	81544.2	50.669	43.950	88	3898.3	2.422	2.101
44	80209.4	49.840	43.231	89	1949.4	1.211	1.051
45	78850.0	48.995	42.498	90	0.0	0.000	0.000

TABLE 38.

INTERCONVERSION OF NAUTICAL AND STATUTE MILES.

1 nautical mile * = 6080.27 feet.

Nautical Miles.	Statute Miles.	Statute Miles.	Nautical Miles.
1	1.1516	1	0.8684
2	2.3031	2	1.7368
3	3.4547	3	2.6052
4	4.6062	4	3.4736
5	5.7578	5	4.3420
6	6.9093	6	5.2104
7	8.0609	7	6.0788
8	9.2124	8	6.9472
9	10.3640	9	7.8155

SMITHSONIAN TABLES.

* As defined by the United States Coast and Geodetic Survey.

TABLE 39.

CONTINENTAL MEASURES OF LENGTH WITH THEIR METRIC AND ENGLISH EQUIVALENTS.

The asterisk (*) indicates that the measure is obsolete or seldom used.

Measure.	Metric Equivalent.	English Equivalent.
El, Netherlands	1 metre.	3.2808 feet.
Fathom, Swedish = 6 feet	1.7814 "	5.8445 "
Foot, Austrian,*	0.31608 "	1.0370 "
old French *	0.32484 "	1.0657 "
Russian	0.30480 "	1 "
Rheinlandisch or Rhenish (Prussia, Denmark, Norway) *	0.31385 "	1.0297 "
Swedish *	0.2969 "	0.9741 "
Spanish * = $\frac{1}{3}$ vara	0.2786 "	0.9140 "
*Klafter, Wiener (Vienna)	1.89648 "	6.2221 "
*Line, old French = $\frac{1}{144}$ foot	0.22558 cm.	0.0888 inch.
Mile, Austrian post * = 24000 feet	7.58594 km.	4.714 statute miles.
German sea	1.852 "	1.1508 " "
Swedish = 36000 feet	10.69 "	6.642 " "
Norwegian = 36000 feet	11.2986 "	7.02 " "
Netherlands (mijl)	1 "	0.6214 " "
Prussian (law of 1868)	7.500 "	4.660 " "
Danish	7.5324 "	4.6804 " "
Palm, Netherlands	0.1 metre.	0.3281 feet.
*Rode, Danish	3.7662 "	12.356 "
*Ruthe, Prussian, Norwegian	3.7662 "	12.356 "
Sagene, Russian	2.1336 "	7 "
*Toise, old French = 6 feet	1.9490 "	6.3943 "
*Vara, Spanish	0.8359 "	2.7424 "
Mexican	0.8380 "	2.7293 "
Werst, or versta, Russian = 500 sagene	1.0668 km.	3500 "

SMITHSONIAN TABLES.

ACCELERATION (g) OF GRAVITY ON SURFACE OF EARTH AND DERIVED FUNCTIONS.

$g = 9.77989 + 0.05221 \sin^2 \phi$
$= 9.80599 - 0.02610 \cos 2\phi$ metres.*
ϕ = geographical latitude.

ϕ	g	$\log g$	$\log \frac{1}{2g}$	$\log \sqrt{2g}$	$\frac{g}{\pi^2}$†
	Metres.				*Metres.*
0°	9.7798	0.99033	8.70864-10	0.64568	0.99090
5	.7803	035	862	569	095
10	.7814	040	857	572	106
15	.7834	049	848	576	127
20	.7859	060	837	582	152
25	.7893	075	822	589	186
30	.7929	091	806	597	222
35	.7969	109	788	606	264
40	.8014	129	768	616	309
45	.8060	149	748	626	355
50	.8105	169	728	636	401
55	.8150	189	708	646	447
60	.8191	207	690	655	488
65	.8227	223	674	663	525
70	.8261	238	659	670	559
75	.8286	249	648	676	584
80	.8306	258	639	680	605
85	.8317	263	634	683	616
90	.8322	265	632	684	621

* From *The Solar Parallax and its Related Constants*, by Wm. Harkness, Professor of Mathematics, U. S. N.; Washington: Government Printing Office, 1891.

† This is length of seconds pendulum.

TABLE 41.

LINEAR EXPANSIONS OF PRINCIPAL METALS, IN MICRONS PER METRE (OR MILLIONTHS PER UNIT LENGTH).

Name of metal.	Expansion per degree C.	Expansion per degree F.
Aluminum	20	11.1
Brass	19	10.5
Copper	17	9.4
Glass	9	5.0
Gold	15	8.3
Iron, cast	11	6.1
Iron, wrought	12	6.7
Lead	28	15.5
Platinum	9	5.0
Platinum-iridium [1]	8.7	4.8
Silver	19	10.5
Steel, hard	12	6.7
Steel, soft	11	6.1
Tin	19	10.5
Zinc	29	16.1

SMITHSONIAN TABLES.

[1] Of International Prototype Metres.

TABLE 42.

FRACTIONAL CHANGE IN A NUMBER CORRESPONDING TO A CHANGE IN ITS LOGARITHM.

Computed from the formula,

$$\frac{\Delta N}{N} = \frac{\Delta \log N}{\mu},$$

μ = modulus of common logarithms = 0.43429448.

For $\Delta \log N$ = 1 unit in	$\frac{\Delta N}{N}$	For $\Delta \log N$ = 4 units in	$\frac{\Delta N}{N}$ (in round numbers)
4th place	$\frac{1}{4343}$	4th place	$\frac{1}{1000}$
5th "	$\frac{1}{43429}$	5th "	$\frac{1}{10000}$
6th "	$\frac{1}{434294}$	6th "	$\frac{1}{100000}$
7th "	$\frac{1}{4342945}$	7th "	$\frac{1}{1000000}$

SMITHSONIAN TABLES.

APPENDIX.

CONSTANTS.

Numerical Constants.

	Number.	Logarithm.
Base of natural (Napierian) logarithms,	$= e = 2.7182818$	0.4342945
Log e, modulus of common logarithms,	$= \mu = 0.4342945$	9.6377843 — 10
Circumference of circle in degrees,	$=$ 360	2.5563025
" " " in minutes,	$=$ 21600	4.3344538
" " " in seconds,	$=$ 1296000	6.1126050
Circumference of circle, diameter unity,	$= \pi = 3.14159265$	0.4971499

Number.	Logarithm.	Number.	Logarithm.
$2\pi = 6.2831853$	0.7981799	$1/\pi^2 = 0.1013212$	9.0057003 — 10
$\frac{\pi}{3} = 1.0471976$	0.0200286	$\sqrt{\pi} = 1.7724539$	0.2485749
$\frac{1}{\pi} = 0.3183099$	9.5028501 — 10	$\frac{1}{\sqrt{\pi}} = 0.5641896$	9.7514251 — 10
$\pi^2 = 9.8696044$	0.9942997	$\sqrt{2} = 1.4142136$	0.1505150
		$\sqrt{3} = 1.7320508$	0.2385607

	Number.	Logarithm.
The arc of a circle equal to its radius is		
in degrees, $\rho^\circ = 180/\pi$	$= 57.29578^\circ$	1.7581226
in minutes, $\rho' = 60\,\rho^\circ$	$= 3437.7468'$	3.5362739
in seconds, $\rho'' = 60\,\rho'$	$= 206264.8''$	5.3144251
For a circle of unit radius, the		
arc of $1^\circ = 1/\rho^\circ$	$= 0.0174533$	8.2418774 — 10
arc of $1' = 1/\rho'$	$= 0.0002909$	6.4637261 — 10
arc (or sine) of $1'' = 1/\rho''$	$= 0.00000485$	4.6855749 — 10

Geodetical Constants.

Dimensions of the earth (Clarke's spheroid, 1866) and derived quantities.

	Number.	Logarithm.
Equatorial semi-axis in feet,	$= a = 20926062.$	7.3206875
in miles,	$= a = 3963.3$	3.5980536
Polar semi-axis in feet,	$= b = 20855121.$	7.3192127
in miles,	$= b = 3949.8$	3.5965788
$(\text{Eccentricity})^2 = \frac{a^2 - b^2}{a^2}$	$e^2 = 0.00676866$	7.8305030 — 10
$\text{Flattening} = \frac{a-b}{a}$	$= f = 1/294.9784$	7.5302098 — 10
Perimeter of meridian ellipse,	$=$ 24859.76 miles.	
Circumference of equator,	$=$ 24901.96 "	
Area of earth's surface,	$=$ 196940400 square miles.	
Mean density of the earth (HARKNESS)	$= 5.576 \pm 0.016.$	
Surface density " "	$= 2.56 \pm 0.16.$	

Acceleration of gravity (HARKNESS):

g (cm. per second) $= 980.60\,(1 - 0.002662 \cos 2\phi)$ for latitude ϕ and sea level.

g, at equator $= 977.99$; g, at Washington $= 980.07$; g, at Paris $= 980.94$;

g, at poles $= 983.21$; g, at Greenwich $= 981.17$.

Length of the seconds pendulum (HARKNESS):

$l = 39.012540 + 0.208268 \sin^2 \phi$ inches $= 0.990910 + 0.005290 \sin^2 \phi$ metres.

CONSTANTS.—Continued.

Astronomical Constants (Harkness).

Sidereal year = 365.256 357 8 mean solar days.

Sidereal day = $23^h\ 56^m\ 4.^s100$ mean solar time.

Mean solar day = $24^h\ 3^m\ 56.^s546$ sidereal time.

Mean distance of the earth from the sun = 92 800 000 miles.

Physical Constants.

Velocity of light (Harkness) = 186 337 miles per second = 299 878 km. per second.

Velocity of sound through dry air = $1090\sqrt{1 + 0.00367\, t^\circ\ C.}$ feet per second.

Weight of distilled water, free from air, barometer 30 inches :

Volume.	Weight in grains. 62° *F.*	Weight in grains. 4° *C.*	Weight in grammes. 62° *F.*	Weight in grammes. 4° *C.*
1 cubic inch (determination of 1890)	252.286	252.568	16.3479	16.3662
1 cubic centimetre (1890)	15.3953	15.4125	0.9976	0.9987
1 cubic foot (1890) at 62° *F.*	62.2786 lbs.			

A standard atmosphere is the pressure of a vertical column of pure mercury whose height is 760 mm. and temperature 0° *C.*, under standard gravity at latitude 45° and at sea level.

1 standard atmosphere = 1033 grammes per sq. cm. = 14.7 pounds per sq. inch.

Pressure of mercurial column 1 inch high = 34.5 grammes per sq. cm. = 0.491 pounds per sq. inch.

Weight of dry air (containing 0.0004 of its weight of carbonic acid) :

1 cubic centimetre at temperature 32° *F.* and pressure 760 mm. and under the standard value of gravity weighs 0.001 293 05 gramme.

Density of mercury at 0° *C.* (compared with water of maximum density under atmospheric pressure) = 13.5956.

Freezing point of mercury = — 38.°5 *C.* (Regnault, 1862.)

Coefficient of expansion of air (at const. pressure of 760^{mm}) for 1° *C.* (do.) : 0.003 670.

Coefficient of expansion of mercury for Centigrade temperatures (Broch) :

$\Delta = \Delta_0\,(1 - 0.000\,181\,792\,t - 0.000\,000\,000\,175\,t^2 - .000\,000\,000\,035\,116\,t^3)$.

Coefficient of linear expansion of brass for 1° *C.*, β = 0.000 0174 to 0.000 0190.

Coefficient of cubical expansion of glass for 1° *C.*, γ = 0.000 021 to 0.000 028.

Ordinary glass (Recknagel) : at 10° *C.*, γ = 0.000 0255 ; at 100°, γ = 0.000 0276.

Specific heat of dry air compared with an equal weight of water :

at constant pressure, K_p = 0.2374 (from 0° to 100° *C.*, Regnault).

at constant volume, K_v = 0.1689.

Ratio of the two specific heats of air (Rontgen) : K_p / K_v = 1.4053.

Thermal conductivity of air (Graetz) : $k = 0.000\,0484\,(1 + 0.001\,85\,t^\circ,\ C.)\ \frac{\text{gramme.}}{\text{cm. sec.}}$

[The quantity of heat that passes in unit time through unit area of a plate of unit thickness, when its opposite faces differ in temperature by one degree.]

Latent heat of liquefaction of ice (Bunsen) = 80.025 mass degrees, *C.*

Latent heat of vaporization of water = 606.5 — 0.695 t° *C.*

Absolute zero of temperature (Thomson, Heat, *Encyc. Brit.*) : — 273.°0 *C.* = — 459.°4 *F.*

Mechanical equivalent of heat : *

1 pound-degree, *F.* (the British thermal unit) = about 778 foot-pounds.

1 pound-degree, *C.* = 1400 foot-pounds.

1 calorie or kilogramme-degree, *C.* = 3087 foot-pounds = 426.8 kilogram-metres = 4187 joules (for g = 981 cm.).

* Based on Prof. Rowland's determinations. (*Proc. Am. Acad. Arts and Sci.*, 1880.)

SYNOPTIC CONVERSION OF ENGLISH AND METRIC UNITS.
English to Metric.

	Metric equivalents.		Logarithms.
Units of length.			
1 inch.	2.54000	centimetres.	0.404 835
1 foot.	0.304801	metre.	9.484 016 — 10
1 yard.	0.914402	"	9.961 137 — 10
1 mile.	1.60935	kilometres.	0.206 650
Units of area.			
1 square inch.	6.45163	square centimetres.	0.809 669
1 square foot.	929.034	" "	2.968 032
1 square yard.	0.836131	square metre.	9.922 274 — 10
1 acre.	0.404687	hectares.	9.607 120 — 10
1 square mile.	2.59000	square kilometres.	0.413 300
" "	259.000	hectares.	2.413 300
Units of volume.			
1 cubic inch.	16.3872	cubic centimetres.	1.214 504
1 cubic foot.	0.028317	cubic metres or steres.	8.452 047 — 10
1 cubic yard.	0.764559	cubic metres or steres.	9.883 411 — 10
Units of capacity.			
1 gallon (U. S.) = 231 cubic inches.	3.78544	litres.	0.578 116
1 quart (U. S.).	0.94636	litres.	9.976 056 — 10
1 Imperial gallon (British). 277.463 cubic inches (1890).	4.54683	litres.	0.657 709
1 bushel (U. S.) = 2150.42 cubic inches.	35.2393	litres.	1.547 027
1 bushel (British).	36.3477	litres.	1.560 477
Units of mass.			
1 grain.	64.7990	milligrammes.	1.811 568
1 pound avoirdupois.	0.453593	kilogrammes.	9.656 666 — 10
1 ounce avoirdupois.	28.3496	grammes.	1.452 546
1 ounce troy.	31.1035	grammes.	1.492 810
1 ton (2240 lbs.).	1.01605	tonnes.	0.006 914
1 ton (2000 lbs.).	0.907186	tonnes.	9.957 696 — 10

Units of velocity.

1 foot per sec. (0.6818 miles per hr.) = 0.30480 metres per sec. = 1.0973 km. per hr.
1 mile per hr. (1.4667 feet per sec.) = 0.44704 metres per sec. = 1.6093 km. per hr.

Units of force.			
1 poundal.	13825.5	dynes.	4.140 682
Weight of 1 grain (for $g = 981$ cm.).	63.57	dynes.	1.803 237
Weight of 1 pound av. (for $g = 981$ cm.).	4.45×10^5	dynes.	5.648 335

Units of stress — in gravitation measure.

1 pound per square inch = 70.307 grammes per sq. centimetre.	1.846 997
1 pound per square foot = 4.8824 kilogrammes per sq. metre.	0.688 634

Units of work — in absolute measure.

1 foot-poundal.	421 403 ergs.	5.624 698

— in gravitation measure.

1 foot-pound (for $g = 981$ cm.) = 1356.3×10^4 ergs = 0.138255 kilogram-metres.

Units of activity (rate of doing work).

1 foot-pound per minute (for $g = 981$ cm.) = 0.022605 watts.
1 horse-power (33 000 foot-pounds per min.) = 746 wa s = 1.01387 force de cheval.

Units of heat.

1 pound-degree, *F.* = 252 small calories or gramme-degrees, *C.*
1 pound-degree, *C.* = 1.8 pound-degrees, *F.*

SYNOPTIC CONVERSION OF ENGLISH AND METRIC UNITS.

Metric to English.

	English equivalents.		Logarithms.
Units of length.			
1 metre (10^6 microns).	39.3700	inches.	1.595 165
"	3.28083	feet.	0.515 984
"	1.09361	yards.	0.038 863
1 kilometre.	0.62137	miles.	9.793 350 — 10
Units of area.			
1 square centimetre.	0.15500	square inches.	9.190 331 — 10
1 square metre.	10.7639	square feet.	1.031 968
" "	1.19599	square yards.	0.077 726
1 hectare.	2.47104	acres.	0.392 880
1 square kilometre.	0.38610	square miles.	9.586 701 — 10
Units of volume.			
1 cubic centimetre.	0.0610234	cubic inches.	8.785 496 — 10
1 cubic metre or stère.	35.3145	cubic feet.	1.547 953
" " "	1.30794	cubic yards.	0.116 589
Units of capacity.			
1 litre (61.023 cubic inches).	0.26417	gallons (U. S.).	9.421 884 — 10
"	1.05668	quarts (U. S.).	0.023 944
"	0.21993	Imp. gallons (British).	9.342 291 — 10
1 hectolitre.	2.83774	bushels (U. S.).	0.452 973
"	2.75121	bushels (British).	0.439 523
Units of mass.			
1 gramme.	15.4324	grains.	1.188 433
1 kilogramme.	2.20462	pounds avoirdupois.	0.343 334
"	35.2739	ounces avoirdupois.	1.547 454
"	32.1507	ounces troy.	1.507 190
1 tonne.	0.98421	tons (2240 lbs.).	9.993 086 — 10
"	1.10231	tons (2000 lbs.).	0.042 304
Units of velocity.			
1 metre per second.	3.2808	feet per second.	0.515 984
" " "	2.2369	miles per hour.	0.349 653
1 km. per hr. (0.2778 m. per sec.).	0.62137	miles per hour.	9.793 350 — 10

Units of force.

1 dyne (weight of $(981)^{-1}$ grammes, for $g = 981$ cm.) $= 7.2330 \times 10^{-5}$ poundals.

Units of stress — in gravitation measure.

1 gramme per square centimetre.	0.014223 pounds per sq. inch.	
1 kilogramme per square metre.	0.204817 pounds per sq. foot.	
1 standard atmosphere.	14.7 pounds per sq. inch.	(*See* def. p. 172.)

Units of work — in absolute measure.

1 erg. 2.3730×10^{-6} foot poundals.

1 megalerg $= 10^6$ ergs; 1 joule $= 10^7$ ergs.

— in gravitation measure.

1 kilogramme-metre (for $g = 981$ cm.) $= 981 \times 10^5$ ergs $= 7.2330$ foot-pounds.

Units of activity (rate of doing work).

1 watt = 1 joule per sec. (= 44.2385 foot-pounds per minute, for $g = 981$ cm.) = 0.10194 kilogramme-metre per sec., for $g = 981$ cm.

1 force de cheval = 75 kilogramme-metres per sec. = $735\frac{3}{4}$ watts = 0.98632 horse-power.

Units of heat.

1 calorie or kilogramme-degree = 3.968 pound-degrees, *F.* = 2.2046 pound-degrees, *C.*

1 small calorie or therm, or gramme-degree = 0.001 calorie or kilogramme-degree.

DIMENSIONS OF PHYSICAL QUANTITIES.

L = length; M = mass; T = time.

Quantity.	Dimensions	Quantity.	Dimensions.
Area.	$[L^2]$	Momentum.	$[L\,M\,T^{-1}]$
Volume.	$[L^3]$	Moment of Inertia.	$[M\,L^2]$
Mass.	$[M]$	Force.	$[L\,M\,T^{-2}]$
Density.	$[M\,L^{-3}]$	Stress (per unit area).	$[L^{-1}\,M\,T^{-2}]$
Velocity.	$[L\,T^{-1}]$	Work or Energy.	$[L^2\,M\,T^{-2}]$
Acceleration.	$[L\,T^{-2}]$	Rate of Working (Power).	$[L^2\,M\,T^{-3}]$
Angle.	$[o]$	Heat.	$[L^2\,M\,T^{-2}]$
Angular Velocity.	$[T^{-1}]$	Thermal Conductivity.	$[L^{-1}\,M\,T^{-1}]$

In Electrostatics.	Symbol.	Dimensions in electrostatic system.
Quantity of Electricity.	e	$[L^{3/2}\,M^{1/2}\,T^{-1}]$
Surface Density: quantity per unit area.	σ	$[L^{-1/2}\,M^{1/2}\,T^{-1}]$
Difference of Potential: quantity of work required to move a quantity of electricity; (work done) ÷ (quantity moved).	E	$[L^{1/2}\,M^{1/2}\,T^{-1}]$
Electric Force, or Electro-motive Intensity: (quantity) ÷ (distance²).	F	$[L^{-1/2}\,M^{1/2}\,T^{-1}]$
Capacity of an accumulator: $e \div E$.	C or q	$[L]$
Specific Inductive Capacity.	k	$[o]$

In Magnetics.		Dimensions in electro-magnetic system.
Quantity of Magnetism, or Strength of Pole.	m	$[L^{3/2}\,M^{1/2}\,T^{-1}]$
Strength or Intensity of Field: (quantity) ÷ (distance²).	S	$[L^{-1/2}\,M^{1/2}\,T^{-1}]$
Magnetic Force.	$\mathfrak{H}$	$[L^{-1/2}\,M^{1/2}\,T^{-1}]$
Magnetic Moment: (quantity) × (length).	$m\,l$	$[L^{5/2}\,M^{1/2}\,T^{-1}]$
Intensity of Magnetization: magnetic moment per unit volume.	I	$[L^{-1/2}\,M^{1/2}\,T^{-1}]$
Magnetic Potential: work done in moving a quantity of magnetism; (work done) ÷ (quantity moved).	V or Ω	$[L^{1/2}\,M^{1/2}\,T^{-1}]$
Magnetic Inductive Capacity.	μ	$[o]$

In Electro-magnetics.	Symbol.	Dimensions in electro-magnetic system.	Name of practical unit.
Intensity of Current.	i	$[L^{1/2}\,M^{1/2}\,T^{-1}]$	Ampère.
Quantity of Electricity conveyed by current: (intensity) × (time).	e	$[L^{1/2}\,M^{1/2}]$	Coulomb.
Potential, or difference of potential: (work done) ÷ (quantity of electricity upon which work is done).	E	$[L^{3/2}\,M^{1/2}\,T^{-2}]$	Volt.
Electric Force: the mechanical force acting on electro-magnetic unit of quantity; (mechanical force) ÷ (quantity).	$\mathfrak{E}$	$[L^{1/2}\,M^{1/2}\,T^{-2}]$	
Resistance of a conductor: $E \div i$.	R	$[L\,T^{-1}]$	Ohm.
Capacity: quantity of electricity stored up per unit potential-difference produced by it.	q	$[L^{-1}\,T^2]$	Farad.
Specific Conductivity: the intensity of current passing across unit area under the action of unit electric force.		$[L^{-2}\,T]$	
Specific Resistance: the reciprocal of specific conductivity.	r	$[L^2\,T^{-1}]$	

INDEX.