DEPARTMENT OF THE INTERIOR
CANADA

HON. W. J. ROCHE, *Minister*. W. W. CORY, C.M.G., *Deputy Minister*.

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

W. F. KING, C.M.G., LL.D., *Director*.

Vol. III, No. 2

Seismological Tables

BY

OTTO KLOTZ, D.Sc., F.R.A.S.

OTTAWA
GOVERNMENT PRINTING BUREAU
1916

90434—1

CONTENTS.

SEISMOLOGICAL TABLES.

BY OTTO KLOTZ, D.Sc., F.R.A.S.

FOREWORD.

There has been a general desire for a compilation or collection of seismological tables useful to the working seismologist. To meet such want the following symbols, tables and data are issued.

SYMBOLS.

The symbols are those of Göttingen, adopted by the International Seismological Association with the addition of O, suggested by Professor J. B. Woodworth, as indicating the time of the earthquake at the epicentre; and of γ and γ_μ suggested by the writer for gal, unit acceleration of one centimetre per second per second, and for milligal the one thousandth of a gal, or ten microns per second per second.

P = Longitudinal waves, and time of arrival.
PR_1 = " " once reflected, and time of arrival.
PR_2 = " " twice reflected, " "
etc.
S = Transverse waves, and time of arrival.
SR_1 = " " once reflected, and time of arrival.
SR_2 = " " twice reflected " "
etc.
PS = Alternating waves (Wechselwellen), and time of arrival, $= PR_1S = SR_1P$.
L = Long or surface waves, and time of arrival.
M = Maximum of long waves, and time of arrival.
$M_1\ M_2\ M_3 \ldots$ = When more than one maximum of long waves.
L_{rep_1} = Long waves reaching the station from the anti-epicentre; path $40000 - \Delta$.

L_{rep_2} = Long waves again reaching the station from the anti-epicentre; path 40000 + Δ.

F = End of record on seismogram.

e = emersio,—emergence of phase not sharply defined.

i = impetus,—a sharply defined impulse, especially used with P and S.

A_N = Amplitude or half range of movement of earth particle—not of the instrument, or measurement from the zero line for the $N-S$ component, expressed in microns.

A_E = Amplitude similarly for the $E-W$ component.

A_Z = " " vertical "

μ = Microns or 1/1000 of a millimetre.

γ = Gal, or unit acceleration, one centimetre per second per second.

γ_μ = Milligal, or 1/1000 of a gal, or acceleration of 10 microns per second per second.

O = Time of earthquake at epicentre.

φ = Latitude.

λ = Longitude from Greenwich.

Δ = Distance, epicentre to station.

ca. = Approximately.

T = Period, complete time of oscillation; for simple pendulum = $2\pi\sqrt{\frac{l}{g}}$

T_o = Period of undamped pendulum (seismograph).

T_e = Period of earth particle.

h, m, s = Time, Greenwich Mean Time, midnight to midnight.

$\mathcal{M}$ = Theoretical magnification of seismograph.

$\mathcal{M}_a$ = Actual magnification, for damping ratio and periods of earth particle and undamped pendulum.

V_P, V_S, V_L = Velocity of P, S and L waves respectively.

* = Epicentre.

EXPLANATION OF TABLES, THEIR SOURCE AND USE.

Table 1. This table gives the time interval $P-O$ or I_P between the arrival of the P, longitudinal waves, and the time O, of the earthquake at the epicentre. The symbol O, suggested by

Professor J. B. Woodworth, is a very useful one, for O, deduced from various stations should be the same for any particular earthquake. This table is due to Dr. Mohorovičić of Agram.

Table 2. This table gives the time interval between the arrival of the P waves and of the PR_1 waves, the latter having been once reflected, hence the time of arrival of the latter will be twice the time a P wave requires to travel the half distance or $\frac{\Delta}{2}$. This table, as well as the next one, table 3, has been directly computed from the preceding one.

Table 3. This table gives the time interval between the arrival of the P waves and of the PR_2 waves, the latter having been twice reflected.

Table 4. This table gives the time interval between the arrival of the P waves and of the PS waves, the path of the latter being one part P waves, the other part S waves, and which may be written too as PR_1S or SR_1P waves.

Table 5. This is the well-known table of Zeissig, based on Wiechert and Zöppritz's values, so useful in determining the distance, Δ, of an earthquake, its epicentre, from the seismological station. It expresses the time-interval between the arrival of the P and S or transverse waves.

Table 6. This table has been compiled from tables 1 and 5, being the sum of the two, but expressed in a smoothed series of whole seconds. For distant earthquakes the horizontal component is weak, often wanting; hence O may be obtained from $S-O$, written too I_S, provided we obtain the distance, Δ, from $L-S$. Knowing O, even approximately, we can now look for P, and frequently identify it then. Applying now $P-O=I_P$, the value of O can be corrected.

Table 7. This table gives the time interval between the arrival of the S waves and of the SR_1 waves, the latter having been once reflected. The derivation is from table 6, and computed similarly to table 2.

Table 8. This table corresponds to table 3, and is for transverse waves.

Table 9. This table gives the time interval between the arrival of the P waves and of the L or surface waves. It is less accurate than any of the preceding, due to the uncertainty of the velocity of propagation of the L waves. This uncertainty is partly due to the difficulty of reading the appearance of the L waves on the seismogram, necessary for deducing the rate of propagation. In an isotropic medium the velocity is constant, but not in the medium of the crust of the earth. From an examination here of 234 earthquake records of Pulkovo and Ottawa in each of which P, S and L are given, the mean velocity of 228 km. per minute, or 3·8 km. per second, has been adopted.

Plotting the velocities for the respective distances, the variation in velocity is found—as was expected—to be quite independent of the distance. Leaving out of account the uncertainty of reading eL, observations show that the velocity of L waves is not constant for different earthquakes and traversing different paths from the epicentre to the station, involving probably too, different depths of hearths. The velocities were examined too with reference to the paths over land and water; for it was believed that the paths under the ocean would dampen or reduce the velocity. This was found not to be the case. However, from a larger number of earthquakes and a careful analysis, this *a priori* conclusion may be ratified.

Hitherto the generally accepted value has been 3·5 km. per second, or 210 km. per minute, but this is decidedly too low for an average velocity. The identification of the first L waves, on which P and S waves are superimposed, is not easy. The long period, often 40 seconds, of the first L waves helps to identify them.

Table 10. This table is a counterpart of the immediately preceding table, and is based on table 6, and the time interval for L waves, $L-O$ or I_L, from the epicentre, given in the next following table.

Table 11. This table gives the time interval, $L-O$ or I_L, between the arrival of the L or surface waves and the time O of the earthquake at the epicentre; in short, it gives the transmission time of L waves for the various distances of the table from 2,000 km. onwards for intervals of 100 km. The table is based on a uniform velocity of 228 km. per minute as explained under table 9.

Table 12. This table was originally published by Zöppritz & Geiger, and gives the angle of emergence of the seismic ray of the longitudinal waves. The other angle ϵ is the angle made by the chord, epicentre to station, with the tangent to the earth at the station, and it is equal to half the angle subtended by the chord at the centre of the earth.

Table 13. This table gives the value of the chord and its middle ordinate in kilometres for the corresponding arc of the earth; computed with mean radius of the earth 6,370 km.

Table 14. This table gives the values of d and r for the principal seismological stations, for plotting by means of the stereographic projection method (described by the writer in 1910) the position—in latitude and longitude—of an epicentre. It is an extension of the one issued in 1913 as Vol. I, No. 1, of the "Publications of the Dominion Observatory."

Magnification Curves.—These curves are for converting the measurement of the amplitude on the seismogram to the actual amplitude of the earth particle by applying the particular ratio of $\mathcal{M}_a$ to $\mathcal{M}$ that obtains. The curves were drawn from Wiechert's adopted formula:—

$$\mathcal{M}_a = \frac{\mathcal{M}}{\sqrt{\left\{1 - \left(\frac{T_e}{T_o}\right)^2\right\}^2 + 4\ \frac{\cdot 537(\log \epsilon)^2}{1 + \cdot 537\ (\log \epsilon)^2}\ \left(\frac{T_e}{T_o}\right)^2}}$$

where $\mathcal{M}_a$ is the actual magnification, $\mathcal{M}$ the theoretical magnification, T_e and T_o respectively the period of the earth particle and of the undamped pendulum, and ϵ the damping ratio. $\mathcal{M}$ is a constant, $\mathcal{M}_a$ is not.

Velocity Curves.—These have been plotted on a large scale from the preceding tables and then reduced by photography one-half. The plotting was all done from the zero base line of time. The velocity curves will be found useful for co-ordinating the various phases read on the seismogram. One plots on a strip of paper the times of the various phases read, on a time-scale equal to that of the velocity curves; then sliding the strip along the Δ ordinates until co-incidence with two or more of the phases is found. This gives a preliminary value for Δ. Accordance or large discrepancy will then lead to confirmation of the Δ or to a further examination of the seismogram and interpretation of the phases. With regard to the latter it may be pointed out that for distant earthquakes P is frequently missing, and PR_1 or PR_2 read therefor, due to the fact that the horizontal component of P is weak, more so than of PR_1 and PR_2, although these last suffer more from absorption than does P. The application of the curves to readings of the seismogram will prevent incompatible or impossible interpretation of phases, for within narrow limits the various phases, if properly read, will fall simultaneously on the curves for a given distance. It is suggested that this diagram be taken out and mounted on stiff card-board, so as not to warp, it will then be more available for measurement.

TABLE 1.

P–O or I_P

Δ 100 km.	00	Diff. for 20 km.	20	Diff. for 20 km.	40	Diff. for 20 km.	60	Diff. for 20 km.	80	Diff. for 20 km.	Δ 100 km.
	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	
2	0 30·6	2·5	0 33·1	2·5	0 35·6	2·6	0 38·2	2·5	0 40·7	2·5	2
3	0 43·2	2·5	0 45·7	2·6	0 48·3	2·5	0 50·8	2·5	0 53·3	2·5	3
4	0 55·8	2·6	0 58·4	2·5	1 00·9	2·5	1 03·4	2·6	1 06·0	2·5	4
5	1 08·5	2·6	1 11·1	2·5	1 13·6	2·5	1 16·1	2·6	1 18·7	2·5	5
6	1 21·2	2·6	1 23·8	2·5	1 26·3	2·6	1 28·9	2·6	1 31·5	2·5	6
7	1 34·0	2·6	1 36·6	2·5	1 39·1	2·5	1 41·6	2·6	1 44·2	2·5	7
8	1 46·7	2·5	1 49·2	2·6	1 51·8	2·5	1 54·3	2·5	1 56·8	2·5	8
9	1 59·3	2·5	2 01·8	2·6	2 04·4	2·5	2 06·9	2·5	2 09·4	2·5	9
10	2 11·9	2·5	2 14·4	2·5	2 16·9	2·5	2 19·4	2·5	2 21·9	2·5	10
11	2 24·4	2·5	2 26·9	2·5	2 29·4	2·5	2 31·9	2·5	2 34·4	2·5	11
12	2 36·9	2·5	2 39·4	2·5	2 41·9	2·4	2 44·3	2·5	2 46·8	2·5	12
13	2 49·3	2·4	2 51·7	2·5	2 54·2	2·5	2 56·7	2·4	2 59·1	2·5	13
14	3 01·6	2·4	3 04·0	2·5	3 06·5	2·4	3 08·9	2·4	3 11·3	2·4	14
15	3 13·7	2·4	3 16·1	2·3	3 18·4	2·4	3 20·8	2·4	2 23·2	2·4	15
16	3 25·6	2·4	3 28·0	2·3	3 30·3	2·4	3 32·7	2·4	3 35·1	2·4	16
17	3 37·5	2·3	3 39·8	2·4	3 42·2	2·4	3 44·6	2·3	3 46·9	2·4	17
18	3 49·3	2·3	3 51·6	2·4	3 54·0	2·3	3 56·3	2·3	3 58·6	2·3	18
19	4 00·9	2·3	4 03·2	2·3	4 05·6	2·2	4 07·8	2·3	4 10·1	2·3	19
20	4 12·4	2·3	4 14·7	2·3	4 17·0	2·2	4 19·2	2·3	4 21·5	2·2	20
21	4 23·7	2·2	4 25·9	2·3	4 28·2	2·2	4 30·4	2·2	4 32·6	2·2	21
22	4 34·8	2·2	4 37·0	2·2	4 39·2	2·2	4 41·4	2·2	4 43·6	2·2	22
23	4 45·8	2·1	4 47·9	2·2	4 50·1	2·2	4 52·3	2·1	4 54·4	2·2	23
24	4 56·6	2·1	4 58·7	2·2	5 00·9	2·1	5 03·0	2·1	5 05·1	2·1	24
25	5 07·2	2·1	5 09·3	2·0	5 11·3	2·1	5 13·4	2·1	5 15·5	2·0	25
26	5 17·5	2·0	5 19·5	2·0	5 21·5	2·1	5 23·6	2·0	5 25·6	2·0	26
27	5 27·6	2·0	5 29·6	2·0	5 31·6	1·9	5 33·5	2·0	5 35·5	2·0	27
28	5 37·5	2·0	5 39·5	1·9	5 41·4	1·9	5 43·3	2·0	5 45·3	1·9	28
29	5 47·2	1·9	5 49·1	1·9	5 51·0	1·9	5 52·9	1·9	5 54·8	1·9	29
30	5 56·7	1·9	5 58·6	1·8	6 00·4	1·9	6 02·3	1·8	6 04·1	1·9	30
31	6 06·0	1·8	6 07·8	1·8	6 09·6	1·9	6 11·5	1·8	6 13·3	1·8	31
32	6 15·1	1·8	6 16·9	1·8	6 18·7	1·8	6 20·5	1·8	6 22·3	1·8	32
33	6 24·1	1·7	6 25·8	1·7	6 27·5	1·7	6 29·1	1·6	6 30·7	1·6	33
34	6 32·3	1·6	6 33·9	1·6	6 35·5	1·6	6 37·1	1·6	6 38·7	1·6	34
35	6 40·3	1·6	6 41·9	1·6	6 43·5	1·6	6 45·1	1·5	6 46·6	1·5	35
36	6 48·1	1·6	6 49·7	1·5	6 51·2	1·5	6 52·7	1·5	6 54·2	1·5	36
37	6 55·7	1·5	6 57·2	1·5	6 58·7	1·5	7 00·2	1·5	7 01·7	1·5	37
38	7 03·2	1·5	7 04·7	1·5	7 06·2	1·5	7 07·7	1·5	7 09·2	1·5	38
39	7 10·7	1·5	7 12·2	1·5	7 13·7	1·5	7 15·2	1·5	7 16·7	1·4	39
40	7 18·1	1·5	7 19·6	1·5	7 21·1	1·4	7 22·5	1·5	7 24·0	1·4	40

TABLE 1—*Continued.*

P−*O* or *I*P

Δ 100 km.	00	Diff. for 20 km.	20	Diff. for 20 km.	40	Diff. for 20 km.	60	Diff. for 20 km.	80	Diff. for 20 km.	Δ 100 km.
	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	
41	7 25·4	1·5	7 26·9	1·5	7 28·4	1·4	7 29·8	1·5	7 31·3	1·4	41
42	7 32·7	1·4	7 34·1	1·5	7 35·6	1·4	7 37·0	1·4	7 38·4	1·5	42
43	7 39·9	1·4	7 41·3	1·4	7 42·7	1·5	7 44·2	1·4	7 45·6	1·4	43
44	7 47·0	1·4	7 48·4	1·4	7 49·8	1·4	7 51·2	1·4	7 52·6	1·4	44
45	7 54·0	1·4	7 55·4	1·4	7 56·8	1·4	7 58·2	1·4	7 59·6	1·4	45
46	8 01·0	1·4	8 02·4	1·4	8 03·8	1·3	8 05·1	1·4	8 06·5	1·4	46
47	8 07·9	1·3	8 09·2	1·4	8 10·6	1·4	8 12·0	1·3	8 13·3	1·4	47
48	8 14·7	1·4	8 16·1	1·4	8 17·5	1·3	8 18·8	1·3	8 20·1	1·3	48
49	8 21·4	1·4	8 22·8	1·3	8 24·1	1·3	8 25·4	1·3	8 26·7	1·3	49
50	8 28·0	1·3	8 29·3	1·3	8 30·6	1·3	8 31·9	1·3	8 33·2	1·3	50
51	8 34·5	1·3	8 35·8	1·3	8 37·1	1·3	8 38·4	1·3	8 39·7	1·3	51
52	8 41·0	1·3	8 42·3	1·3	8 43·6	1·2	8 44·8	1·3	8 46·1	1·3	52
53	8 47·4	1·3	8 48·7	1·2	8 49·9	1·3	8 51·2	1·3	8 52·5	1·2	53
54	8 53·7	1·3	8 55·0	1·3	8 56·3	1·2	8 57·5	1·3	8 58·8	1·3	54
55	9 00·0	1·2	9 01·3	1·3	9 02·6	1·2	9 03·8	1·3	9 05·1	1·2	55
56	9 06·3	1·3	9 07·6	1·3	9 08·9	1·2	9 10·1	1·3	9 11·4	1·2	56
57	9 12·6	1·2	9 13·8	1·3	9 15·1	1·2	9 16·3	1·3	9 17·6	1·2	57
58	9 18·8	1·2	9 20·0	1·2	9 21·2	1·2	9 22·4	1·2	9 23·6	1·2	58
59	9 24·8	1·2	9 26·0	1·2	9 27·2	1·1	9 28·3	1·2	9 29·5	1·2	59
60	9 30·7	1·2	9 31·9	1·2	9 33·1	1·1	9 34·2	1·2	9 35·4	1·2	60
61	9 36·6	1·2	9 37·8	1·1	9 38·9	1·2	9 40·1	1·2	9 41·3	1·1	61
62	9 42·4	1·2	9 43·6	1·1	9 44·7	1·2	9 45·9	1·2	9 47·1	1·1	62
63	9 48·2	1·2	9 49·4	1·2	9 50·6	1·1	9 51·7	1·2	9 52·9	1·1	63
64	9 54·0	1·1	9 55·1	1·2	9 56·3	1·1	9 57·4	1·1	9 58·5	1·2	64
65	9 59·7	1·1	10 00·8	1·2	10 02·0	1·1	10 03·1	1·1	10 04·2	1·2	65
66	10 05·4	1·1	10 06·5	1·1	10 07·6	1·2	10 08·8	1·1	10 09·9	1·1	66
67	10 11·0	1·1	10 12·1	1·1	10 13·2	1·2	10 14·4	1·1	10 15·5	1·1	67
68	10 16·6	1·1	10 17·7	1·1	10 18·8	1·1	10 19·9	1·1	10 21·0	1·1	68
69	10 22·1	1·1	10 23·2	1·1	10 24·3	1·1	10 25·4	1·1	10 26·5	1·1	69
70	10 27·6	1·1	10 28·7	1·1	10 29·8	1·1	10 30·9	1·1	10 32·0	1·1	70
71	10 33·1	1·1	10 34·2	1·1	10 35·3	1·0	10 36·3	1·1	10 37·4	1·1	71
72	10 38·5	1·1	10 39·6	1·1	10 40·7	1·0	10 41·7	1·1	10 42·8	1·1	72
73	10 43·9	1·1	10 45·0	1·1	10 46·1	1·0	10 47·1	1·1	10·48·2	1·1	73
74	10 49·3	1·1	10 50·4	1·0	10 51·4	1·1	10 52·5	1·1	10 53·6	1·0	74
75	10 54·6	1·1	10 55·7	1·1	10 56·8	1·0	10 57·8	1·1	10 58·9	1·0	75
76	10 59·9	1·1	11 01·0	1·0	11 02·0	1·1	11 03·1	1·1	11 04·2	1·0	76
77	11 05·2	1·1	11 06·3	1·1	11 07·4	1·0	11 08·4	1·1	11 09·5	1·0	77
78	11 10·5	1·1	11 11·6	1·0	11 12·6	1·1	11 13·7	1·1	11 14·8	1·0	78
79	11 15·8	1·1	11 16·9	1·1	11 18·0	1·0	11 19·0	1·1	11 20·1	1·0	79
80	11 21·1	1·0	11 22·1	1·1	11 23·2	1·0	11 24·2	1·0	11 25·2	1·1	80

TABLE 1—*Concluded.*

P–O or *Ip*

Δ 100 km.	00	Diff. for 20 km.	20	Diff. for 20 km.	40	Diff. for 20 km.	60	Diff. for 20 km.	80	Diff. for 20 km.	Δ 100 km.
	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	
81	11 26·3	1·0	11 27·3	1·0	11 28·3	1·1	11 29·4	1·0	11 30·4	1·1	81
82	11 31·5	1·0	11 32·5	1·1	11 33·6	1·0	11 34·6	1·0	11 35·6	1·1	82
83	11 36·7	1·0	11 37·7	1·0	11 38·7	1·1	11 39·8	1·0	11 40·8	1·1	83
84	11 41·9	1·0	11 42·9	1·1	11 44·0	1·0	11 45·0	1·0	11 46·0	1·1	84
85	11 47·1	1·0	11 48·1	1·0	11 49·1	1·1	11 50·2	1·0	11 51·2	1·0	85
86	11 52·2	1·0	11 53·2	1·0	11 54·2	1·1	11 55·3	1·0	11 56·3	1·0	86
87	11 57·3	1·0	11 58·3	1·0	11 59·3	1·1	12 00·4	1·0	12 01·4	1·0	87
88	12 02·4	1·0	12 03·4	1·0	12 04·4	1·1	12 05·5	1·0	12 06·5	1·0	88
89	12 07·5	1·0	12 08·5	1·0	12 09·5	1·1	12 10·6	1·0	12 11·6	1·0	89
90	12 12·6	1·0	12 13·6	1·0	12 14·6	1·0	12 15·6	1·0	12 16·6	1·0	90
91	12 17·6	1·0	12 18·6	1·0	12 19·6	1·0	12 20·6	1·0	12 21·6	1·0	91
92	12 22·6	1·0	12 23·6	1·0	12 24·6	1·0	12 25·6	1·0	12 26·6	1·0	92
93	12 27·6	1·0	12 28·6	1·0	12 29·6	1·0	12 30·6	1·0	12 31·6	1·0	93
94	12 32·6	1·0	12 33·6	1·0	12 34·6	1·0	12 35·6	1·0	12 36·6	1·0	94
95	12 37·6	1·0	12 38·6	1·0	12 39·6	0·9	12 40·5	1·0	12 41·5	1·0	95
96	12 42·5	1·0	12 43·5	1·0	12 44·5	0·9	12 45·4	1·0	12 46·4	1·0	96
97	12 47·4	1·0	12 48·4	1·0	12 49·4	0·9	12 50·3	1·0	12 51·3	1·0	97
98	12 52·3	1·0	12 53·3	1·0	12 54·3	0·9	12 55·2	1·0	12 56·2	1·0	98
99	12 57·2	1·0	12 58·2	1·0	12 59·2	0·9	13 00·1	1·0	13 01·1	1·0	99
100	13 02·1	1·0	13 03·1	1·0	13 04·1	0·9	13 05·0	1·0	13 06·0	0·9	100
101	13 06·9	1·0	13 07·9	0·9	13 08·8	1·0	13 09·8	1·0	13 10·8	0·9	101
102	13 11·7	1·0	13 12·7	1·0	13 13·7	0·9	13 14·6	1·0	13 15·6	0·9	102
103	13 16·5	1·0	13 17·5	0·9	13 18·4	1·0	13 19·4	1·0	13 20·4	0·9	103
104	13 21·3	1·0	13 22·3	1·0	13 23·3	0·9	13 24·2	1·0	13 25·2	0·9	104
105	13 26·1	0·9	13 27·0	1·0	13 28·0	0·9	13 28·9	0·9	13 29·8	1·0	105
106	13 30·8	0·9	13 31·7	0·9	13 32·6	1·0	13 33·6	0·9	13 34·5	1·0	106
107	13 35·4	0·9	13 36·3	1·0	13 37·3	0·9	13 38·2	0·9	13 39·1	1·0	107
108	13 40·1	0·9	13 41·0	0·9	13 41·9	1·0	13 42·9	0·9	13 43·8	1·0	108
109	13 44·8	0·9	13 45·7	1·0	13 46·7	0·9	13 47·6	0·9	13 48·5	1·0	109
110	13 49·5	0·9	13 50·4	0·9	13 51·3	1·0	13 52·3	0·9	13 53·2	0·9	110
111	13 54·1	0·9	13 55·0	0·9	13 55·9	1·0	13 56·9	0·9	13 57·8	0·9	111
112	13 58·7	0·9	13 59·6	0·9	14 00·5	1·0	14 01·5	0·9	14 02·4	0·9	112
113	14 03·3	0·9	14 04·2	0·9	14 05·1	1·0	14 06·1	0·9	14 07·0	0·9	113
114	14 07·9	0·9	14 08·8	0·9	14 09·7	1·0	14 10·7	0·9	14 11·7	0·9	114
115	14 12·5	0·9	14 13·4	0·9	14 14·3	1·0	14 15·3	0·9	14 16·2	0·9	115
116	14 17·1	0·9	14 18·0	0·9	14 18·9	1·0	14 19·9	0·9	14 20·8	0·9	116
117	14 21·7	0·9	14 22·6	0·9	14 23·5	0·9	14 24·4	0·9	14 25·3	0·9	117
118	14 26·3	0·9	14 27·1	0·9	14 28·0	0·9	14 28·9	0·9	14 29·8	0·9	118
119	14 30·7	0·9	14 31·6	0·9	14 32·5	0·9	14 33·4	0·9	14 34·3	0·9	119
120	14 35·2	0·9	14 36·1	0·9	14 37·0	0·9	14 37·9	0·9	14 38·8	0·9	120

TABLE 2.

$PR_1 - P$

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
2	11	13	14	16	17	19	21	23	26	28
3	31	33	36	39	43	47	51	55	59	63
4	67	71	75	79	83	87	91	95	99	103
5	106	110	114	118	122	125	129	132	136	139
6	143	146	150	153	156	160	163	166	168	171
7	173	176	178	180	182	184	187	189	191	193
8	195	197	199	202	204	206	208	210	212	214
9	215	217	219	221	223	225	227	229	231	232
10	234	236	237	239	241	242	244	246	247	249
11	250	252	254	256	257	259	261	262	263	265
12	266	268								

TABLE 3.

$PR_2 - P$

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
2	17	18	20	22	24	26	28	30	33	36
3	39	42	45	49	53	58	63	68	72	77
4	82	87	92	97	102	107	112	117	122	127
5	133	138	143	149	154	160	165	170	176	181
6	187	192	198	203	208	214	219	224	230	235
7	241	246	251	257	262	267	272	277	282	287
8	292	297	301	306	311	315	320	324	329	333
9	338	342	346	350	354	359	363	367	371	375
10	379	382	385	388	392	395	398	401	404	407
11	410	413	416	419	422	425	428	430	433	436
12	439	442								

TABLE 4.

$PS - P$

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
2	2 00	2 05	2 11	2 18	2 25	2 32	2 39	2 46	2 53	3 01
3	3 08	3 15	3 23	3 31	3 39	3 47	3 55	4 04	4 13	4 21
4	4 30	4 39	4 47	4 55	5 03	5 11	5 19	5 27	5 36	5 44
5	5 52	6 00	6 07	6 15	6 22	6 30	6 38	6 45	6 52	6 59
6	7 06	7 13	7 20	7 27	7 34	7 40	7 46	7 53	7 59	8 04
7	8 10	8 15	8 21	8 26	8 32	8 37	8 42	8 47	8 52	8 57
8	9 02	9 07	9 12	9 17	9 22	9 27	9 32	9 37	9 42	9 47
9	9 51	9 55	9 59	10 04	10·09	10 13	10 18	10 23	10 28	10 32
10	10 36	10 40	10 44	10 49	10 54	10 58	11 02	11 07	11 11	11 15
11	11 19	11 24	11 28	11 33	11 37	11 42	11 46	11 50	11 55	11 59
12	12 03	12 07								

TABLE 5.

S—P

		1000 km.	2000 km.	3000 km.	4000 km.	5000 km.	6000 km.	7000 km.	8000 km.	9000 km.	10000 km.	11000 km.	12000 km.
km.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
0	**0** 0	**1** 48	**3** 23	**4** 43	**5** 47	**6** 42	**7** 36	**8** 29	**9** 20	**10** 10	**10** 58	**11** 41	**12** 21
10	1	49	24	44	48	43	37	30	20	11	59	41	21
20	2	50	25	44	48	43	37	30	21	12	59	42	22
30	3	51	26	45	49	44	38	31	21	12	59	42	22
40	4	52	28	46	49	44	38	31	22	13	**11** 0	43	22
50	6	53	28	47	50	45	39	32	22	13	0	43	23
60	7	54	28	47	51	45	39	32	23	14	1	43	23
70	8	55	29	48	51	46	40	33	23	14	1	44	24
80	9	56	30	49	52	47	40	33	24	15	2	44	24
90	10	57	31	50	52	47	41	34	24	15	2	45	24
100	11	58	32	50	53	48	41	34	25	16	2	45	25
10	12	59	33	51	53	48	42	35	25	16	3	45	25
20	13	**2** 0	34	52	54	49	43	35	26	17	3	46	25
30	15	1	35	52	55	49	43	36	26	17	4	46	26
40	16	2	35	53	55	50	44	36	27	18	4	47	26
50	17	3	36	54	56	50	44	37	27	18	5	47	26
60	18	4	37	54	56	51	45	37	28	19	5	47	27
70	19	5	38	55	57	51	45	38	28	19	6	48	27
80	20	6	39	56	57	52	46	38	29	20	6	48	28
90	21	7	39	57	58	53	46	39	29	20	7	49	28
200	22	8	40	58	58	53	47	39	30	20	7	49	28
10	23	9	41	58	59	54	47	40	30	21	7	50	29
20	24	10	42	58	**6** 0	54	48	40	31	21	8	50	29
30	26	11	43	59	0	55	48	41	31	22	8	50	30
40	27	12	44	0	1	55	49	41	32	23	9	51	30
50	28	13	44	1	1	56	50	42	32	23	9	51	30
60	29	14	45	1	2	56	50	42	33	23	10	51	31
70	30	15	46	2	2	57	51	43	33	23	10	52	31
80	31	16	47	3	3	57	51	43	34	24	11	52	31
90	32	17	48	4	4	58	52	44	34	25	11	53	32
300	33	18	49	5	4	58	52	44	35	25	11	53	32
10	34	19	49	5	5	59	53	45	35	26	12	53	32
20	36	20	50	5	5	**7** 0	53	45	36	26	12	54	33
30	37	21	51	6	6	0	54	46	36	27	13	54	33
40	38	22	52	7	6	1	54	46	37	27	13	55	34
50	39	23	53	7	7	1	55	47	37	28	14	55	34
60	40	24	54	8	7	2	55	47	38	28	14	55	34
70	41	25	55	9	8	2	56	48	38	29	15	56	35
80	42	25	55	9	9	3	57	48	39	29	15	56	35
90	43	26	56	10	10	3	57	49	40	30	15	57	35
400	44	27	57	10	10	4	58	50	40	30	16	57	36
10	45	28	58	11	10	4	58	50	40	31	16	57	36
20	46	29	59	12	11	5	59	51	41	31	17	58	36
30	47	30	59	13	11	5	59	51	42	32	17	58	37
40	49	31	**4** 0	13	12	6	**8** 0	52	42	32	18	59	37
50	50	32	1	14	12	7	0	52	43	33	18	59	37
60	51	33	2	14	13	7	1	53	43	33	18	**12** 0	38
70	52	34	3	15	13	8	1	53	44	34	19	0	38
80	53	35	4	16	14	8	2	54	44	34	19	0	38
90	54	36	4	16	15	9	2	54	45	35	20	1	39

TABLE 5—*Concluded.*

S—P

		1000 km.	2000 km.	3000 km.	4000 km.	5000 km.	6000 km.	7000 km.	8000 km.	9000 km.	10000 km.	11000 km.	12000 km.
km.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
500	**0** 55	**2** 37	**4** 5	**5** 17	**6** 15	**7** 9	**8** 3	**8** 55	**9** 45	**10** 35	**11** 20	**12** 1	**12** 39
10	56	38	6	18	15	10	3	55	46	36	20	1	39
20	57	39	7	18	16	10	4	55	46	36	21	2	40
30	58	40	7	19	16	11	5	56	46	37	21	2	40
40	59	41	8	20	17	12	5	57	47	37	22	3	40
50	**1** 1	42	9	20	17	12	6	57	48	37	22	3	41
60	2	43	10	21	18	13	6	58	48	38	23	3	41
70	3	44	11	21	19	13	7	58	49	38	23	4	42
80	4	45	11	22	19	14	7	59	49	39	24	4	42
90	5	45	12	23	20	14	8	59	50	39	24	5	42
600	6	46	13	24	20	15	8	**9** 0	50	40	24	5	43
10	7	47	14	24	21	15	9	0	51	40	25	5	43
20	8	48	15	25	21	16	9	1	51	41	25	6	43
30	9	49	15	26	22	16	10	1	52	41	26	6	44
40	10	50	16	26	23	17	10	2	52	42	26	7	44
50	11	51	17	26	23	17	11	2	53	42	27	7	44
60	12	52	18	27	24	18	11	3	53	43	27	7	45
70	13	53	18	28	24	18	12	3	54	43	27	8	45
80	15	54	19	28	25	19	12	4	54	44	28	8	45
90	16	55	20	29	25	20	13	4	55	44	28	9	46
700	16	56	21	30	26	20	13	5	55	45	29	9	46
10	18	57	21	30	26	21	14	5	56	45	29	10	46
20	19	58	22	31	27	21	15	6	56	45	30	10	47
30	20	59	23	31	28	22	15	6	57	46	30	10	47
40	21	**3** 0	24	32	28	22	15	7	57	46	30	11	47
50	22	0	24	33	29	23	16	7	58	47	31	11	48
60	23	1	25	33	29	23	17	8	58	47	31	12	48
70	24	2	26	34	30	24	17	8	59	48	32	12	48
80	25	3	27	34	30	24	18	9	59	48	32	12	49
90	26	4	28	35	31	25	18	9	**10** 0	49	32	13	49
800	27	5	28	35	31	25	19	10	0	49	33	13	49
10	28	6	29	36	32	26	19	10	0	49	33	14	50
20	29	7	30	37	32	26	20	11	1	50	34	14	50
30	30	8	30	37	33	27	20	11	2	50	34	14	50
40	31	9	31	38	34	27	21	12	2	51	34	15	51
50	32	10	32	39	34	28	21	12	3	51	35	15	51
60	33	11	33	39	35	28	22	13	3	52	35	15	51
70	34	12	34	40	35	29	22	13	4	52	36	16	52
80	36	12	34	40	36	30	23	14	4	53	36	16	52
90	37	13	35	41	36	30	23	14	5	53	36	17	53
900	38	14	36	41	37	31	24	15	5	54	37	17	53
10	39	15	36	42	37	31	24	15	6	54	37	17	53
20	40	16	37	43	38	32	25	16	6	54	38	18	54
30	41	17	38	43	38	32	25	16	7	55	38	18	54
40	42	18	39	44	39	33	26	17	7	55	38	19	54
50	43	19	39	44	39	33	26	17	8	56	39	19	55
60	44	19	40	45	40	34	27	18	8	56	39	19	55
70	45	20	41	45	41	34	27	18	9	57	40	20	55
80	46	21	42	46	41	35	28	19	9	57	40	20	55
90	47	22	42	47	42	35	28	19	10	58	41	21	56
1000	48	23	43	47	42	36	29	20	10	58	41	21	56

TABLE 6.

S–O or *Is*

Δ in 100 km.	00	20	40	60	80	Δ in 100 km.
	m. s.	m. s.	m. s.	m. s.	m. s.	
2	52	57	1 02	1 07	1 12	2
3	1 16	1 21	1 26	1 31	1 35	3
4	1 40	1 44	1 49	1 54	1 59	4
5	2 03	2 08	2 13	2 18	2 23	5
6	2 27	2 32	2 36	2 41	2 46	6
7	2 50	2 55	3 00	3 05	3 09	7
8	3 14	3 18	3 23	3 27	3 32	8
9	3 37	3 42	3 46	3 51	3 55	9
10	4 00	4 01	4 09	4 13	4 18	10
11	4 22	4 27	4 31	4 36	4 40	11
12	4 45	4 49	4 54	4 58	5 03	12
13	5 07	5 12	5 16	5 21	5 25	13
14	5 29	5 33	5 38	5 42	5 46	14
15	5 51	5 55	5 59	6 04	6 08	15
16	6 12	6 16	6 20	6 25	6 29	16
17	6 34	6 38	6 42	6 46	6 50	17
18	6 54	6 59	7 03	7 07	7 11	18
19	7 15	7 19	7 23	7 27	7 31	19
20	7 35	7 40	7 44	7 48	7 52	20
21	7 56	8 00	8 04	8 07	8 11	21
22	8 15	8 19	8 23	8 27	8 31	22
23	8 35	8 38	8 42	8 46	8 50	23
24	8 54	8 58	9 01	9 05	9 09	24
25	9 13	9 16	9 19	9 23	9 27	25
26	9 31	9 35	9 38	9 42	9 45	26
27	9 49	9 52	9 56	9 59	10 03	27
28	10 06	10 10	10 13	10 16	10 19	28
29	10 23	10 26	10 30	10 33	10 37	29
30	10 40	10 43	10 46	10 49	10 53	30
31	10 56	11 00	11 03	11 06	11 09	31
32	11 13	11 16	11 19	11 22	11 25	32
33	11 28	11 31	11 34	11 37	11 40	33
34	11 42	11 45	11 48	11 51	11 54	34
35	11 57	12 00	12 03	12 06	12 09	35
36	12 12	12 15	12 17	12 19	12 22	36
37	12 25	12 28	12 31	12 33	12 36	37
38	12 38	12 41	12 44	12 47	12 49	38
39	12 52	12 55	12 58	13 00	13 03	39
40	13 05	13 08	13 10	13 13	13 16	40

TABLE 6—*Continued.*

S–O or *Is*

Δ in 100 km.	00	20	40	60	80	Δ in 100 km.
	m. s.	m. s.	m. s.	m. s.	m. s.	
41	13 18	13 21	13 23	13 26	13 28	41
42	13 31	13 34	13 37	13 39	13 41	42
43	13 44	13 46	13 49	13 51	13 54	43
44	13 57	13 59	14 02	14 04	14 07	44
45	14 09	14 11	14 14	14 16	14 19	45
46	14 21	14 23	14 26	14 29	14 31	46
47	14 34	14 36	14 39	14 41	14 43	47
48	14 46	14 48	14 51	14 54	14 56	48
49	14 58	15 01	15 03	15 05	15 08	49
50	15 10	15 12	15 15	15 17	15 20	50
51	15 22	15 25	15 27	15 29	15 32	51
52	15 34	15 36	15 39	15 41	15 43	52
53	15 45	15 48	15 51	15 53	15 55	53
54	15 58	16 00	16 02	16 04	16 07	54
55	16 09	16 11	16 14	16 17	16 19	55
56	16 21	16 24	16 26	16 28	16 30	56
57	16 33	16 35	16 37	16 39	16 42	57
58	16 44	16 46	16 48	16 50	16 53	58
59	16 56	16 58	17 00	17 02	17 04	59
60	17 07	17 09	17 11	17 13	17 15	60
61	17 18	17 21	17 23	17 25	17 27	61
62	17 29	17 32	17 34	17 36	17 38	62
63	17 40	17 42	17 45	17 47	17 50	63
64	17 52	17 54	17 56	17 58	18 00	64
65	18 03	18 05	18 07	18 09	18 11	65
66	18 13	18 15	18 18	18 20	18 22	66
67	18 24	18 26	18 28	18 31	18 33	67
68	18 36	18 38	18 40	18 42	18 44	68
69	18 46	18 48	18 50	18 52	18 54	69
70	18 57	18 59	19 01	19 03	19 05	70
71	19 07	19 09	19 11	19 13	19 15	71
72	19 17	19 20	19 22	19 24	19 26	72
73	19 28	19 30	19 32	19 34	19 36	73
74	19 39	19 41	19 43	19 45	19 48	74
75	19 50	19 52	19 54	19 56	19 58	75
76	20 00	20 02	20 04	20 06	20 08	76
77	20 10	20 12	20 14	20 16	20 18	77
78	20 20	20 23	20 25	20 27	20 29	78
79	20 31	20 33	20 35	20 37	20 39	79
80	20 41	20 43	20 45	20 47	20 49	80

TABLE 6—*Concluded.*

S—O or *Is*

Δ in 100 km.	00	20	40	60	80	Δ in 100 km.
	m. s.	m. s.	m. s.	m. s.	m. s.	
81	20 51	20 53	20 55	20 57	20 59	81
82	21 01	21 03	21 06	21 08	21 10	82
83	21 12	21 14	21 16	21 18	21 20	83
84	21 22	21 24	21 26	21 28	21 30	84
85	21 32	21 34	21 36	21 38	21 40	85
86	21 42	21 44	21 46	21 48	21 50	86
87	21 52	21 54	21 56	21 58	22 00	87
88	22 02	22 04	22 06	22 08	22 10	88
89	22 12	22 14	22 16	22 19	22 21	89
90	22 23	22 26	22 28	22 30	22 32	90
91	22 34	22 36	22 38	22 40	22 42	91
92	22 43	22 45	22 47	22 49	22 51	92
93	22 53	22 55	22 57	22 59	23 01	93
94	23 03	23 05	23 07	23 09	23 11	94
95	23 13	23 15	23 17	23 18	23 20	95
96	23 22	23 24	23 26	23 28	23 30	96
97	23 32	23 34	23 35	23 37	23 39	97
98	23 41	23 43	23 45	23 47	23 49	98
99	23 51	23 53	23 54	23 56	23 58	99
100	24 00	24 02	24 04	24 06	24 08	100
101	24 09	24 11	24 13	24 15	24 17	101
102	24 19	24 21	24 23	24 25	24 27	102
103	24 28	24 30	24 31	24 33	24 35	103
104	24 37	24 39	24 41	24 43	24 44	104
105	24 46	24 48	24 50	24 52	24 54	105
106	24 55	24 57	24 59	25 01	25 03	106
107	25 04	25 06	25 08	25 10	25 11	107
108	25 13	25 15	25 16	25 18	25 20	108
109	25 22	25 24	25 25	25 27	25 29	109
110	25 31	25 32	25 34	25 36	25 37	110
111	25 39	25 41	25 43	25 44	25 46	111
112	25 48	25 50	25 52	25 53	25 54	112
113	25 56	25 58	26 00	26 01	26 03	113
114	26 05	26 07	26 09	26 11	26 12	114
115	26 14	26 15	26 17	26 19	26 20	115
116	26 22	26 24	26 26	26 27	26 29	116
117	26 31	26 33	26 35	26 36	26 38	117
118	26 39	26 41	26 43	26 44	26 46	118
119	26 48	26 50	26 52	26 53	26 54	119
120	26 56	26 58	26 59	27 01	27 03	120

TABLE 7.

$SR_1 - S$

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
2	24	27	30	33	36	40	44	48	52	57
3	62	67	72	78	84	90	97	105	112	119
4	126	134	141	147	154	161	168	175	182	188
5	194	200	206	212	219	225	231	237	242	247
6	253	258	263	268	273	278	283	287	291	295
7	299	303	307	310	313	316	319	322	325	327
8	329	332	335	338	340	343	346	348	351	354
9	356	358	360	363	366	368	370	373	376	378
10	380	383	386	389	391	394	397	400	403	406
11	409	412	415	418	420	423	426	429	432	435
12	437	440								

TABLE 8.

$SR_2 - S$

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
2	32	36	40	44	48	52	57	62	68	74
3	80	86	92	99	107	115	123	131	140	149
4	159	168	177	185	194	203	213	222	230	239
5	249	258	268	277	286	295	304	312	321	329
6	338	348	358	367	376	384	392	400	409	418
7	426	435	443	452	460	467	475	483	491	499
8	507	515	522	529	536	543	550	557	564	570
9	576	582	589	595	602	608	614	621	627	633
10	639	644	649	654	659	665	671	677	682	687
11	692	697	702	706	710	715	720	725	730	735
12	739	743								

TABLE 9.

L−*P*

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
2	4 34	4 49	5 04	5 19	5 34	5 50	6 06	6 22	6 39	6 56
3	7 12	7 29	7 47	8 04	8 22	8 41	8 59	9 17	9 36	9 55
4	10 15	10 34	10 53	11 12	11 31	11 51	12 10	12 29	12 49	13 09
5	13 28	13 48	14 08	14 28	14 47	15 08	15 28	15 48	16 08	16 28
6	16 48	17 08	17 29	17 50	18 10	18 31	18 52	19 12	19 33	19 54
7	20 14	20 35	20 56	21 17	21 38	21 59	22 20	22 41	23 02	23 23
8	23 44	24 05	24 26	24 47	25 08	25 30	25 51	26 12	26 34	26 55
9	27 16	27 37	27 58	28 19	28 40	29 02	29 23	29 45	30 07	30 28
10	30 50	31 11	31 33	31 55	32 16	32 38	32 59	33 21	33 43	34 04
11	34 26	34 47	35 09	35 31	35 52	36 14	36 36	36 57	37 19	37 41
12	38 03	38 24								

TABLE 10.

L−*S*

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
2	1 11	1 17	1 24	1 30	1 37	1 45	1 53	2 02	2 11	2 20
3	2 29	2 39	2 49	3 00	3 12	3 24	3 36	3 48	4 01	4 14
4	4 28	4 41	4 55	5 08	5 22	5 36	5 50	6 04	6 18	6 32
5	6 46	7 00	7 15	7 30	7 44	7 59	8 13	8 27	8 42	8 57
6	9 12	9 27	9 43	9 58	10 13	10 28	10 44	10 59	11 14	11 30
7	11 45	12 01	12 17	12 33	12 49	13 04	13 20	13 36	13 52	14 08
8	14 24	14 40	14 56	15 12	15 28	15 45	16 01	16 17	16 34	16 50
9	17 06	17 22	17 38	17 54	18 10	18 27	18 44	19 00	19 17	19 34
10	19 52	20 09	20 26	20 43	21 00	21 18	21 35	21 52	22 10	22 27
11	22 44	23 02	23 20	23 38	23 55	24 13	24 31	24 48	25 06	25 24
12	25 42	25 59								

TABLE 11.

L–O or I_L

Δ in 1000 km.	0		1		2		3		4		5		6		7		8		9	
	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.
2	8	46	9	12	9	39	10	05	10	31	10	58	11	24	11	50	12	17	12	43
3	13	09	13	35	14	02	14	28	14	54	15	21	15	47	16	13	16	40	17	06
4	17	33	17	59	18	26	18	52	19	18	19	45	20	11	20	37	21	04	21	30
5	21	56	22	22	22	49	23	15	23	41	24	08	24	34	25	00	25	27	25	53
6	26	19	26	45	27	12	27	38	28	04	28	31	28	57	29	23	29	50	30	16
7	30	42	31	08	31	35	32	01	32	27	32	54	33	20	33	46	34	13	34	39
8	35	05	35	31	35	58	36	24	36	50	37	17	37	43	38	09	38	36	39	02
9	39	28	39	54	40	21	40	47	41	13	41	40	42	06	42	32	42	59	43	25
10	43	52	44	18	44	45	45	11	45	37	46	04	46	30	46	56	47	23	47	49
11	48	15	48	41	49	08	49	34	50	00	50	27	50	53	51	19	51	46	52	12
12	52	38	53	04																

TABLE 12.

ANGLE OF EMERGENCE.

Δ in 100 km.	e_0		ϵ		$e_0-\epsilon$		Δ in 100 km.	e_0		ϵ		$e_0-\epsilon$	
	°	′	°	′	°	′		°	′	°	′	°	′
0	0	00	0	00	0	00	65	64	59	29	14	35	45
5	10	40	2	15	8	25	70	65	18	31	29	33	49
10	20	40	4	30	16	12	75	65	42	33	43	31	59
15	29	37	6	45	22	52	80	66	11	35	58	30	13
20	37	15	9	00	28	15	85	66	45	38	13	28	32
25	43	40	11	14	32	26	90	67	22	40	28	26	54
30	49	03	13	29	35	34	95	68	03	42	43	25	20
35	53	16	15	44	37	32	100	68	48	44	58	23	50
40	56	47	17	59	38	48	105	69	34	47	13	22	21
45	60	01	20	14	39	47	110	70	23	49	28	20	55
50	62	48	22	29	40	19	115	71	17	51	43	19	34
55	64	42	24	44	39	58	120	72	13	53	58	18	15
60	64	47	26	59	37	48	125	73	11	56	12	16	59

TABLE 13.

CHORD AND MIDDLE ORDINATE.

Arc.		Chord.	Middle Ordinate.	Arc.		Chord.	Middle Ordinate.
1000 km.	Angle.			1000 km.	Angle.		
	° ′				° ′		
·25	2 15	250	2	10·25	92 15	9,183	1,955
·5	4 30	500	5	10·5	94 30	9,355	2,046
·75	6 45	750	11	10·75	96 45	9,524	2,138
1	9 00	1,000	20	11	99 00	9,688	2,233
1·25	11 15	1,249	31	11·25	101 15	9,849	2,329
1·5	13 30	1,497	44	11·5	103 30	10,005	2,426
1·75	15 45	1,745	60	11·75	105 45	10,158	2,525
2	18 00	1,993	78	12	108 00	10,307	2,626
2·25	20 15	2,240	99	12·25	110 15	10,452	2,728
2·5	22 30	2,486	122	12·5	112 30	10,593	2,831
2·75	24 45	2,730	148	12·75	114 45	10,730	2,936
3	27 00	2,974	176	13	117 00	10,863	3,042
3·25	29 15	3,217	207	13·25	119 15	10,991	3,149
3·5	31 30	3,458	239	13·5	121 30	11,116	3,257
3·75	33 45	3,698	274	13·75	123 45	11,236	3,367
4	36 00	3,937	312	14	126 00	11,351	3,478
4·25	38 15	4,175	352	14·25	128 15	11,463	3,590
4·5	40 30	4,410	394	14·5	130 30	11,570	3,703
4·75	42 45	4,644	438	14·75	132 45	11,672	3,817
5	45 00	4,876	485	15	135 00	11,770	3,932
5·25	47 15	5,106	534	15·25	137 15	11,864	4,048
5·5	49 30	5,334	585	15·5	139 30	11,953	4,165
5·75	51 45	5,560	639	15·75	141 45	12,037	4,283
6	54 00	5,784	694	16	144 00	12,117	4,402
6·25	56 15	6,006	752	16·25	146 15	12,191	4,521
6·5	58 30	6,225	812	16·5	148 30	12,262	4,641
6·75	60 45	6,442	875	16·75	150 45	12,327	4,762
7	63 00	6,657	939	17	153 00	12,388	4,883
7·25	65 15	6,869	1,005	17·25	155 15	12,445	5,005
7·5	67 30	7,078	1,073	17·5	157 30	12,495	5,127
7·75	69 45	7,285	1,144	17·75	159 45	12,541	5,250
8	72 00	7,489	1,217	18	162 00	12,583	5,374
8·25	74 15	7,690	1,291	18·25	164 15	12,620	5,497
8·5	76 30	7,887	1,367	18·5	166 30	12,652	5,622
8·75	78 45	8,082	1,446	18·75	168 45	12,679	5,746
9	81 00	8,274	1,526	19	171 00	12,701	5,870
9·25	83 15	8,463	1,608	19·25	173 15	12,718	5,995
9·5	85 30	8,648	1,692	19·5	175 30	12,730	6,120
9·75	87 45	8,830	1,778	19·75	177 45	12,737	6,245
10	90 00	9,008	1,866	20	180 00	12,740	6,370

TABLE 14.

STEREOGRAPHIC PROJECTION TABLES.

The following tables are for facilitating the plotting of epicentres, that is, determining their geographical position, by means of the stereographic projection. The distance, Δ, from any station to the epicentre is obtained from the seismogram, from the difference of time of arrival of the first and second preliminary tremors.

In the tables $d = \dfrac{\cos \varphi}{\sin \varphi + \cos \Delta}$ $\qquad r = \dfrac{\sin \Delta}{\sin \varphi + \cos \Delta}$

φ = latitude, Δ = distance expressed in arc, 10,000 km. = 90°. The modus operandi is very simple. A circle is described with a radius, say of 10 cm. A radius is taken as the meridian of Greenwich, to which all longitudes are referred. Other radii, generally three, are drawn representing the meridians of the stations utilized for locating the epicentre. Along each is then laid off its respective d from the centre, and from the point so found an arc is described with radius r for that station. The intersection of the arcs gives the position of the epicentre. The longitude of the latter is obtained directly by reading the angle between the radius running through it, and the Greenwich meridian; while the latitude is found by measuring the distance from the centre of the primary circle to the epicentre, and this distance is equal to $\tan\,(45° - \tfrac{1}{2}\varphi_{o})$, where φ_{o} is the latitude of the epicentre.

It may be stated that the numbers given for d and r in the table are in units of the radius, taken at 1000 units, of the primary circle.

Distance.	Aachen $\varphi=50° 46'$ $\lambda=6° 05'$ E.		Agram $\varphi=45° 49'$ $\lambda=15° 59'$ E.		Albany $\varphi=42° 39'$ $\lambda=73° 45'$ W.		Ann Arbor $\varphi=42° 17'$ $\lambda=83° 44'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	359	89	409	92	442	94	446	94
1,250	360	111	411	115	444	118	447	118
1,500	362	134	413	138	446	141	450	142
1,750	364	156	415	162	448	165	452	166
2,000	367	179	418	185	452	190	456	190
2,250	369	202	421	209	455	214	459	215
2,500	372	225	425	233	459	239	463	240
2,750	376	249	429	258	464	264	468	265
3,000	380	273	433	282	469	289	473	290
3,250	384	297	438	307	475	315	479	316
3,500	389	321	444	333	481	341	485	343
3,750	394	346	450	359	487	368	492	369
4,000	399	371	457	385	495	395	499	397
4,250	405	397	464	412	503	423	507	425
4,500	412	423	472	440	512	452	516	453
4,750	419	450	480	468	521	481	526	482
5,000	426	477	489	496	531	511	536	512
5,250	435	505	499	526	542	541	547	543
5,500	444	534	510	556	554	573	560	575
5,750	454	563	522	588	567	606	573	608
6,000	464	594	534	620	581	639	587	642
6,250	475	625	548	653	596	674	602	677
6,500	488	657	562	688	613	710	619	713
6,750	501	691	578	724	631	748	637	751
7,000	515	725	595	761	650	787	657	791
7,250	530	761	614	800	671	828	678	832
7,500	546	798	634	840	694	871	701	875
7,750	564	837	656	882	719	917	726	921
8,000	584	878	679	927	746	964	754	969
8,250	605	920	705	974	775	1,014	784	1,019
8,500	627	965	733	1,023	807	1,067	816	1,073
8,750	652	1,011	764	1,075	843	1,124	852	1,130
9,000	679	1,061	798	1,131	882	1,184	892	1,191
9,250	709	1,113	835	1,190	925	1,249	936	1,257
9,500	741	1,169	876	1,253	973	1,319	985	1,327
9,750	777	1,228	921	1,321	1,026	1,394	1,039	1,403
10,000	817	1,291	972	1,395	1,086	1,476	1,100	1,486
10,250	860	1,359	1,028	1,474	1,152	1,566	1,168	1,577
10,500	909	1,433	1,091	1,561	1,228	1,664	1,245	1,677
10,750	963	1,511	1,162	1,656	1,313	1,773	1,332	1,788
11,000	1,023	1,598	1,243	1,762	1,411	1,895	1,433	1,913
11,250	1,091	1,692	1,335	1,879	1,525	2,033	1,549	2,053
11,500	1,169	1,797	1,441	2,010	1,656	2,190	1,684	2,213
11,750	1,257	1,913	1,564	2,160	1,811	2,370	1,843	2,398
12,000	1,358	2,043	1,708	2,331	1,996	2,581	2,034	2,614
12,250	1,476	2,189	1,879	2,529	2,219	2,831	2,264	2,872
12,500	1,614	2,357	2,084	2,763	2,495	3,134	2,550	3,185
12,750	1,777	2,552	2,336	3,043	2,842	3,509	2,911	3,574
13,000	1,973	2,779	2,649	3,387	3,291	3,987	3,381	4,072

Distance.	Athens $\varphi=37° 58'$ $\lambda=23° 43'$ E.		Baku $\varphi=40° 23'$ $\lambda=49° 54'$ E.		Balboa Heights $\varphi=8° 58'$ $\lambda=79° 33'$ W.		Barcelona $\varphi=41° 25'$ $\lambda=2° 08'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	492	98	466	96	864	137	454	95
1,250	494	122	468	120	869	172	456	119
1,500	497	147	470	144	876	207	459	143
1,750	500	172	473	169	883	243	462	167
2,000	503	197	476	193	892	279	465	192
2,250	508	223	480	218	903	316	469	216
2,500	512	249	485	243	915	354	473	241
2,750	518	275	490	269	928	393	478	267
3,000	523	301	495	295	944	434	483	292
3,250	530	328	501	321	961	475	489	318
3,500	537	356	508	348	979	518	495	345
3,750	545	384	515	376	1,001	563	502	372
4,000	554	413	523	403	1,024	609	510	399
4,250	563	442	531	432	1,050	658	518	428
4,500	573	472	541	461	1,078	709	527	456
4,750	584	503	551	491	1,110	763	537	486
5,000	596	535	562	522	1,145	819	548	516
5,250	609	567	574	553	1,183	880	559	547
5,500	623	601	587	586	1,227	944	572	580
5,750	639	636	601	620	1,275	1,013	585	613
6,000	655	672	616	655	1,328	1,088	601	647
6,250	673	710	633	691	1,388	1,169	616	683
6,500	693	749	650	728	1,456	1,257	633	720
6,750	714	790	670	768	1,533	1,354	652	758
7,000	737	833	691	809	1,620	1,461	672	798
7,250	763	878	714	851	1,719	1,581	694	840
7,500	790	926	739	896	1,834	1,716	718	884
7,750	820	976	766	944	1,968	1,869	744	930
8,000	853	1,029	796	994	2,125	2,046	773	979
8,250	889	1,086	829	1,047	2,312	2,252	804	1,032
8,500	929	1,146	864	1,103	2,537	2,498	838	1,087
8,750	973	1,210	904	1,163	2,815	2,795	875	1,145
9,000	1,022	1,280	947	1,228	3,163	3,163	916	1,207
9,250	1,076	1,355	995	1,297	3,613	3,632	962	1,275
9,500	1,137	1,437	1,049	1,372	4,216	4,255	1,013	1,347
9,750	1,205	1,527	1,109	1,454	5,062	5,121	1,069	1,425
10,000	1,282	1,625	1,176	1,543	6,338	6,416	1,133	1,511
10,250	1,369	1,735	1,252	1,642	....	....	1,204	1,605
10,500	1,469	1,857	1,338	1,751	....	....	1,286	1,709
10,750	1,584	1,995	1,436	1,872	....	....	1,377	1,825
11,000	1,718	2,153	1,550	2,010	....	....	1,484	1,955
11,250	1,877	2,335	1,682	2,166	....	....	1,606	2,102
11,500	2,065	2,547	1,838	2,346	....	....	1,750	2,271
11,750	2,293	2,800	2,023	2,557	....	....	1,920	2,467
12,000	2,575	3,106	2,248	2,806	....	....	2,128	2,698
12,250	2,930	3,486	2,524	3,109	....	....	2,377	2,975
12,500	3,391	3,974	2,872	3,483	....	....	2,688	3,312
12,750	4,012	4,621	3,323	3,962	....	....	3,090	3,740
13,000	4,891	5,527	3,920	4,595	....	....	3,630	4,293

Distance.	Basel $\varphi=47° 34'$ $\lambda=7° 35'$ E.		Batavia $\varphi=6° 11'$ S. $\lambda=106° 50'$ E.		Belgrade $\varphi=44° 49'$ $\lambda=20° 27'$ E.		Berkeley $\varphi=37° 52'$ $\lambda=122° 16'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	391	91	1,130	178	419	92	493	98
1,250	393	114	1,139	223	421	116	495	122
1,500	394	136	1,150	270	423	139	498	147
1,750	397	160	1,163	318	425	163	501	172
2,000	399	183	1,179	366	428	187	504	197
2,250	402	206	1,197	417	432	211	509	223
2,500	406	230	1,218	469	436	235	513	249
2,750	410	254	1,242	523	440	260	519	275
3,000	414	279	1,269	580	445	284	525	302
3,250	419	303	1,300	639	450	310	531	329
3,500	424	328	1,335	701	455	335	538	356
3,750	430	354	1,374	768	462	362	546	384
4,000	436	380	1,418	838	469	388	555	413
4,250	443	406	1,467	914	476	415	564	442
4,500	450	433	1,523	995	484	443	574	473
4,750	458	461	1,587	1,083	493	472	586	504
5,000	467	489	1,659	1,180	502	501	598	535
5,250	476	518	1,741	1,286	513	531	611	568
5,500	486	548	1,835	1,404	524	561	625	602
5,750	497	579	1,944	1,536	536	593	640	637
6,000	509	610	2,071	1,685	549	626	657	673
6,250	522	643	2,220	1,857	563	660	675	711
6,500	535	676	2,397	2,055	578	695	695	750
6,750	550	711	2,610	2,291	594	731	716	791
7,000	566	747	2,871	2,573	612	769	739	834
7,250	583	785	3,197	2,920	631	808	765	880
7,500	602	824	3,616	3,360	652	850	792	927
7,750	622	865	4,170	3,935	675	893	822	977
8,000	644	908	4,939	4,725	700	938	855	1,031
8,250	668	953	...	...	727	986	892	1,087
8,500	694	1,001	...	...	756	1,036	932	1,148
8,750	723	1,051	...	...	788	1,090	976	1,213
9,000	754	1,104	...	...	824	1,147	1,025	1,282
9,250	789	1,161	...	...	863	1,208	1,079	1,358
9,500	826	1,221	...	...	906	1,273	1,140	1,440
9,750	868	1,285	...	...	953	1,343	1,209	1,530
10,000	914	1,355	...	...	1,006	1,419	1,286	1,629
10,250	966	1,430	...	...	1,066	1,501	1,374	1,739
10,500	1,023	1,511	...	...	1,133	1,592	1,475	1,862
10,750	1,087	1,600	...	...	1,208	1,691	1,591	2,001
11,000	1,160	1,698	...	...	1,294	1,801	1,726	2,159
11,250	1,243	1,806	...	...	1,392	1,924	1,885	2,342
11,500	1,337	1,927	...	...	1,505	2,063	2,075	2,556
11,750	1,446	2,062	...	...	1,637	2,221	2,305	2,811
12,000	1,572	2,216	...	...	1,792	2,403	2,590	3,120
12,250	1,721	2,393	...	...	1,978	2,616	2,949	3,505
12,500	1,898	2,600	...	...	2,202	2,868	3,416	3,998
12,750	2,112	2,843	...	...	2,479	3,174	4,046	4,655
13,000	2,375	3,136	...	...	2,828	3,553	4,940	5,576

Distance.	de Bilt $\varphi=52° 06'$ $\lambda=5° 11'$ E.		Budapest $\varphi=47° 29'$ $\lambda=19° 04'$ E.		Capetown $\varphi=33° 56'$ S $\lambda=18° 29'$ E.		Cartuja $\varphi=37° 11'$ $\lambda=3° 36'$ W.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	346	88	392	91	1,932	364	500	98
1,250	347	110	393	114	1,963	462	503	123
1,500	349	133	395	137	2,003	563	505	148
1,750	351	155	398	160	2,052	671	508	173
2,000	353	178	400	183	2,112	786	512	199
2,250	356	200	403	207	2,183	911	516	224
2,500	359	223	407	230	2,269	1,046	521	250
2,750	362	247	411	254	2,371	1,197	527	277
3,000	366	270	415	279	2,493	1,364	533	304
3,250	370	294	420	304	2,640	1,555	539	331
3,500	374	318	425	329	2,818	1,775	547	359
3,750	379	343	431	354	3,036	2,033	555	387
4,000	384	368	437	380	3,308	2,344	564	416
4,250	390	393	444	407	3,653	2,726	573	445
4,500	396	419	451	434	4,103	3,212	584	476
4,750	403	446	459	461	....	....	595	507
5,000	411	473	468	490	....	....	607	539
5,250	418	500	477	519	....	....	621	572
5,500	427	529	487	548	....	....	635	606
5,750	436	558	498	579	....	....	651	642
6,000	446	588	510	611	....	....	668	679
6,250	457	618	523	643	....	....	687	717
6,500	468	650	537	677	....	....	707	757
6,750	481	683	551	712	....	....	729	798
7,000	494	717	567	748	....	....	753	842
7,250	509	752	585	786	....	....	779	888
7,500	524	788	604	825	....	....	807	936
7,750	541	826	624	866	....	....	838	987
8,000	559	866	646	909	....	....	872	1,041
8,250	579	908	670	954	....	....	909	1,098
8,500	601	951	696	1,002	....	....	951	1,161
8,750	624	997	725	1,052	....	....	996	1,227
9,000	650	1,045	756	1,105	....	....	1,047	1,298
9,250	678	1,095	791	1,162	....	....	1,104	1,376
9,500	708	1,149	829	1,222	....	....	1,167	1,466
9,750	742	1,206	870	1,287	....	....	1,238	1,552
10,000	778	1,267	917	1,357	....	....	1,318	1,654
10,250	819	1,333	971	1,432	....	....	1,410	1,768
10,500	864	1,403	1,026	1,514	....	....	1,515	1,896
10,750	915	1,479	1,091	1,603	....	....	1,636	2,040
11,000	971	1,561	1,164	1,701	....	....	1,778	2,205
11,250	1,034	1,651	1,247	1,810	....	....	1,946	2,396
11,500	1,105	1,750	1,342	1,931	....	....	2,147	2,621
11,750	1,187	1,859	1,451	2,067	....	....	2,392	2,890
12,000	1,280	1,981	1,579	2,222	....	....	2,697	3,220
12,250	1,387	2,118	1,728	2,391	....	....	3,084	3,632
12,500	1,512	2,273	1,907	2,607	....	....	3,594	4,167
12,750	1,658	2,452	2,122	2,852	....	....	4,290	4,890
13,000	1,833	2,659	2,387	3,147	....	....	5,297	5,924

Distance.	Cleveland $\varphi=41° 29'$ $\lambda=81° 42'$ W.		Czernowitz $\varphi=48° 18'$ $\lambda=25° 56'$ E.		Denver $\varphi=39° 41'$ $\lambda=104° 57'$ W.		Disko $\varphi=69° 15'$ $\lambda=53° 23'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	454	95	384	90	473	96	184	81
1,250	456	119	385	113	476	120	185	102
1,500	458	143	387	136	478	145	186	122
1,750	461	167	389	159	481	169	187	143
2,000	464	192	392	182	484	194	188	164
2,250	468	216	395	205	488	219	189	185
2,500	472	241	398	229	493	245	191	206
2,750	477	267	402	253	498	271	192	227
3,000	482	292	406	277	503	297	194	249
3,250	488	318	411	302	509	323	196	270
3,500	494	345	416	327	516	350	198	292
3,750	501	372	422	352	524	378	201	315
4,000	509	399	428	378	532	406	203	337
4,250	517	428	434	404	540	435	206	360
4,500	526	456	441	431	550	464	209	383
4,750	536	486	449	458	561	494	212	407
5,000	547	516	458	486	572	525	216	431
5,250	558	547	467	515	584	557	220	455
5,500	571	580	477	545	598	590	224	480
5,750	585	613	487	575	612	624	228	505
6,000	599	647	499	606	628	660	233	531
6,250	615	683	511	639	645	696	238	558
6,500	632	720	524	672	663	734	243	585
6,750	651	758	539	706	683	774	249	613
7,000	671	798	554	742	704	816	255	641
7,250	693	840	571	779	728	859	262	671
7,500	717	884	589	818	754	905	269	701
7,750	743	930	609	859	782	953	277	732
8,000	771	979	630	901	812	1,004	285	764
8,250	801	1,030	653	945	846	1,058	294	798
8,500	836	1,086	679	992	883	1,115	303	832
8,750	874	1,144	706	1,042	923	1,176	313	868
9,000	915	1,206	737	1,094	968	1,242	325	905
9,250	961	1,273	770	1,149	1,018	1,313	337	943
9,500	1,011	1,346	806	1,208	1,073	1,390	350	984
9,750	1,068	1,424	846	1,271	1,135	1,474	364	1,025
10,000	1,131	1,510	891	1,340	1,205	1,566	379	1,069
10,250	1,202	1,604	940	1,413	1,284	1,667	396	1,115
10,500	1,283	1,707	996	1,492	1,374	1,780	414	1,164
10,750	1,375	1,822	1,057	1,579	1,477	1,906	433	1,215
11,000	1,480	1,952	1,127	1,674	1,596	2,049	455	1,268
11,250	1,603	2,099	1,206	1,778	1,735	2,212	479	1,325
11,500	1,746	2,267	1,296	1,894	1,900	2,400	505	1,386
11,750	1,916	2,462	1,400	2,026	2,096	2,622	534	1,450
12,000	2,120	2,691	1,520	2,173	2,335	2,886	566	1,519
12,250	2,368	2,966	1,661	2,343	2,632	3,208	602	1,593
12,500	2,678	3,303	1,828	2,539	3,008	3,611	641	1,673
12,750	3,074	3,726	2,029	2,769	3,502	4,130	686	1,759
13,000	3,595	4,275	2,281	3,045	4,170	4,828	736	1,852

Distance.	Durlach $\varphi=49° 00'$ $\lambda=8° 29'$ E.		Ekaterinburg $\varphi=56° 49'$ $\lambda=60° 38'$ E.		Eskdalemuir $\varphi=55° 19'$ $\lambda=3° 12'$ W.		Firenze $\varphi=43° 47'$ $\lambda=11° 15'$ E.	
Δ in km.	*d*	*r*	**d**	*r*	*d*	*r*	*d*	*r*
1,000	377	90	300	86	314	86	430	93
1,250	378	112	301	107	315	108	432	117
1,500	380	135	302	129	317	130	434	140
1,750	382	158	304	151	319	152	436	164
2,000	385	181	306	173	321	174	439	188
2,250	388	204	308	195	323	197	443	212
2,500	391	228	311	217	326	219	447	237
2,750	395	252	314	240	329	242	451	262
3,000	399	276	317	263	332	265	456	287
3,250	403	300	320	286	336	289	462	312
3,500	408	325	324	309	340	312	467	338
3,750	414	350	328	333	344	336	474	365
4,000	420	376	333	357	348	360	481	392
4,250	426	402	337	382	353	385	489	419
4,500	433	429	343	407	359	410	497	447
4,750	441	456	348	432	365	436	506	476
5,000	449	484	354	458	371	462	516	505
5,250	458	512	361	484	378	489	527	536
5,500	467	542	368	512	386	517	538	567
5,750	478	572	376	539	394	545	551	599
6,000	489	603	384	568	402	574	564	632
6,250	501	635	393	597	412	603	579	667
6,500	514	668	403	627	422	634	595	702
6,750	528	702	413	658	433	665	612	739
7,000	543	737	424	690	445	698	630	778
7,250	559	774	436	723	458	731	650	818
7,500	577	812	449	758	472	766	672	860
7,750	596	852	463	793	487	802	696	904
8,000	617	894	478	830	503	840	721	950
8,250	639	938	494	868	520	880	750	999
8,500	664	984	511	909	539	922	780	1,051
8,750	691	1,033	530	950	559	965	814	1,106
9,000	720	1,084	551	994	582	1,010	851	1,164
9,250	752	1,139	573	1,041	606	1,056	892	1,227
9,500	787	1,196	598	1,089	632	1,105	937	1,294
9,750	826	1,258	625	1,140	661	1,159	987	1,367
10,000	869	1,325	654	1,195	692	1,217	1,044	1,445
10,250	917	1,397	686	1,253	727	1,276	1,106	1,531
10,500	970	1,474	722	1,314	765	1,339	1,177	1,625
10,750	1,030	1,559	761	1,380	807	1,407	1,257	1,729
11,000	1,097	1,651	804	1,451	855	1,483	1,348	1,844
11,250	1,172	1,753	853	1,528	908	1,563	1,453	1,974
11,500	1,259	1,865	907	1,611	966	1,650	1,575	2,121
11,750	1,358	1,992	969	1,702	1,032	1,746	1,717	2,289
12,000	1,472	2,134	1,037	1,801	1,109	1,853	1,886	2,484
12,250	1,606	2,296	1,115	1,912	1,195	1,969	2,088	2,713
12,500	1,764	2,484	1,204	2,034	1,294	2,100	2,335	2,988
12,750	1,953	2,703	1,309	2,173	1,410	2,250	2,643	3,324
13,000	2,182	2,963	1,434	2,334	1,545	2,419	3,035	3,745

Distance.	Göttingen $\varphi = 51° 33'$ $\lambda = 9° 58'$ E.		Graz $\varphi = 47° 05'$ $\lambda = 15° 27'$ E.		Guildford $\varphi = 51° 15'$ $\lambda = 0° 36'$ W.		Halifax $\varphi = 44° 38'$ $\lambda = 63° 36'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	351	88	396	91	354	89	421	93
1,250	352	111	397	114	355	111	423	116
1,500	354	133	399	137	357	133	425	139
1,750	356	155	402	160	359	156	427	163
2,000	359	178	404	184	362	178	430	187
2,250	361	201	408	207	364	201	434	211
2,500	364	224	411	231	367	224	438	235
2,750	368	248	415	255	370	248	442	260
3,000	371	271	419	280	374	272	447	285
3,250	376	295	424	304	378	296	452	310
3,500	380	319	430	330	383	320	458	336
3,750	385	344	435	355	388	345	464	362
4,000	391	369	442	381	394	370	471	389
4,250	396	395	449	408	400	396	478	416
4,500	403	421	456	435	406	422	486	444
4,750	410	447	464	463	413	449	495	473
5,000	417	474	473	491	421	476	505	502
5,250	425	502	483	520	429	504	515	532
5,500	434	531	493	550	438	532	526	563
5,750	443	560	504	581	447	561	538	595
6,000	453	590	516	613	457	591	551	627
6,250	464	621	529	646	468	622	565	661
6,500	476	653	543	679	480	654	581	696
6,750	489	686	558	715	493	688	598	732
7,000	503	720	574	751	507	722	615	770
7,250	517	756	592	789	522	758	635	810
7,500	533	792	611	829	538	794	656	852
7,750	551	831	631	870	555	833	679	895
8,000	569	871	654	913	574	874	703	940
8,250	590	913	678	959	595	916	731	988
8,500	612	956	705	1,007	618	960	760	1,039
8,750	636	1,003	734	1,058	642	1,005	793	1,093
9,000	662	1,051	766	1,111	669	1,054	828	1,150
9,250	690	1,103	801	1,169	698	1,105	868	1,211
9,500	722	1,157	840	1,230	729	1,160	911	1,277
9,750	756	1,215	882	1,295	764	1,218	959	1,347
10,000	794	1,277	930	1,366	803	1,281	1,013	1,423
10,250	836	1,343	983	1,442	845	1,348	1,073	1,506
10,500	882	1,415	1,041	1,525	892	1,419	1,140	1,597
10,750	934	1,492	1,108	1,615	945	1,498	1,216	1,698
11,000	992	1,576	1,182	1,715	1,003	1,581	1,303	1,809
11,250	1,057	1,668	1,267	1,826	1,069	1,676	1,402	1,933
11,500	1,131	1,769	1,365	1,949	1,144	1,778	1,517	2,073
11,750	1,215	1,881	1,477	2,088	1,230	1,891	1,651	2,232
12,000	1,311	2,006	1,609	2,247	1,328	2,020	1,808	2,417
12,250	1,423	2,146	1,763	2,429	1,443	2,162	1,996	2,632
12,500	1,553	2,307	1,948	2,643	1,574	2,325	2,225	2,888
12,750	1,706	2,491	2,171	2,896	1,734	2,512	2,506	3,198
13,000	1,889	2,707	2,447	3,202	1,920	2,734	2,863	3,584

Distance.	Hamburg $\varphi=53°\ 34'$ $\lambda=9°\ 59'$ E.		Harvard $\varphi=42°\ 23'$ $\lambda=71°\ 07'$ W.		Helwan $\varphi=29°\ 52'$ $\lambda=31°\ 21'$ E.		Hohenheim $\varphi=48°\ 43'$ $\lambda=9°\ 14'$ E.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	331	87	445	94	584	105	379	90
1,250	333	109	446	118	586	132	381	113
1,500	334	131	449	142	590	159	383	135
1,750	336	154	451	166	594	186	385	158
2,000	338	176	455	190	598	213	388	181
2,250	341	199	458	215	604	241	390	205
2,500	344	221	462	239	610	269	394	228
2,750	347	244	467	265	617	298	398	252
3,000	350	268	472	290	624	327	402	276
3,250	354	291	478	316	633	357	406	301
3,500	358	315	484	342	642	387	411	326
3,750	363	340	491	369	652	418	417	351
4,000	368	364	498	396	664	450	423	377
4,250	374	389	506	424	676	482	429	403
4,500	380	415	515	453	689	516	436	430
4,750	386	441	524	482	704	551	444	457
5,000	393	468	535	512	720	587	452	485
5,250	400	495	546	543	737	624	461	513
5,500	408	523	558	574	756	663	471	543
5,750	417	552	571	607	776	703	481	573
6,000	427	581	585	641	799	745	493	604
6,250	437	611	601	676	823	789	505	636
6,500	448	643	617	713	850	835	518	669
6,750	459	675	635	750	879	884	532	704
7,000	472	708	655	790	911	936	547	739
7,250	486	742	676	831	946	991	564	776
7,500	500	778	699	874	985	1,049	582	815
7,750	516	815	724	920	1,027	1,111	601	855
8,000	533	854	751	967	1,075	1,179	622	897
8,250	551	894	781	1,018	1,127	1,251	645	941
8,500	572	937	815	1,073	1,186	1,330	670	987
8,750	594	981	850	1,128	1,251	1,415	697	1,036
9,000	618	1,028	889	1,189	1,325	1,509	727	1,088
9,250	644	1,077	933	1,255	1,409	1,613	759	1,143
9,500	673	1,129	982	1,325	1,504	1,729	795	1,201
9,750	704	1,184	1,035	1,401	1,614	1,860	834	1,264
10,000	738	1,243	1,096	1,483	1,741	2,008	878	1,331
10,250	776	1,306	1,164	1,574	1,891	2,178	926	1,403
10,500	818	1,373	1,240	1,674	2,067	2,377	980	1,481
10,750	864	1,445	1,327	1,784	2,279	2,610	1,041	1,566
11,000	916	1,524	1,427	1,908	2,539	2,891	1,109	1,660
11,250	975	1,609	1,542	2,048	2,863	3,238	1,186	1,763
11,500	1,040	1,703	1,676	2,206	3,277	3,675	1,273	1,877
11,750	1,114	1,805	1,834	2,390	3,827	4,248	1,374	2,005
12,000	1,199	1,919	2,023	2,605	4,588	5,032	1,491	2,149
12,250	1,296	2,047	2,252	2,860			1,628	2,314
12,500	1,408	2,190	2,535	3,171			1,789	2,505
12,750	1,539	2,354	2,892	3,556			1,983	2,729
13,000	1,694	2,542	3,356	4,048			2,218	2,995

Distance.	Honolulu $\varphi = 21° \ 19'$ $\lambda = 158° \ 04'$ W.		Innsbruck $\varphi = 47° \ 16'$ $\lambda = 11° \ 24'$ E.		Irkutsk $\varphi = 52° \ 16'$ $\lambda = 104° \ 19'$ E.		Ithaca $\varphi = 42° \ 27'$ $\lambda = 76° \ 29'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	689	116	394	91	344	88	444	94
1,250	693	145	396	114	345	110	446	118
1,500	697	175	398	137	347	133	448	142
1,750	703	205	400	160	349	155	450	166
2,000	709	235	403	183	351	177	453	190
2,250	716	266	406	207	354	200	457	215
2,500	724	297	409	231	357	223	461	239
2,750	733	329	413	255	360	246	466	264
3,000	743	362	417	279	364	270	471	290
3,250	754	395	422	304	368	294	477	316
3,500	766	430	428	329	372	318	483	342
3,750	780	465	433	355	377	342	489	369
4,000	795	501	440	381	383	367	497	396
4,250	811	539	447	407	388	393	505	424
4,500	829	578	454	434	395	419	514	453
4,750	849	618	462	462	401	445	523	482
5,000	870	660	471	491	409	472	533	511
5,250	894	704	480	520	416	500	543	540
5,500	920	751	490	549	425	528	556	574
5,750	948	799	501	580	434	557	570	607
6,000	979	850	513	612	444	587	584	641
6,250	1,014	905	526	645	455	617	599	675
6,500	1,051	962	540	678	466	649	616	711
6,750	1,093	1,024	555	713	478	682	634	750
7,000	1,140	1,090	571	750	491	715	653	788
7,250	1,191	1,161	588	787	506	751	674	830
7,500	1,248	1,238	607	827	521	787	696	874
7,750	1,313	1,322	628	868	538	825	720	919
8,000	1,385	1,414	650	911	556	865	748	967
8,250	1,467	1,516	675	957	576	906	778	1,017
8,500	1,561	1,629	701	1,005	597	949	810	1,070
8,750	1,668	1,756	730	1,055	621	995	845	1,128
9,000	1,792	1,900	762	1,109	646	1,043	885	1,187
9,250	1,937	2,065	796	1,166	674	1,093	930	1,253
9,500	2,108	2,255	835	1,226	704	1,147	980	1,323
9,750	2,313	2,481	877	1,291	737	1,204	1,033	1,399
10,000	2,563	2,751	924	1,361	774	1,264	1,092	1,482
10,250	2,874	3,082	976	1,437	814	1,329	1,160	1,572
10,500	3,269	3,498	1,034	1,520	859	1,399	1,236	1,672
10,750	3,787	4,037	1,100	1,610	909	1,475	1,323	1,782
11,000	4,498	4,769	1,174	1,709	965	1,557	1,421	1,905
11,250	....	....	1,258	1,818	1,027	1,646	1,538	2,044
11,500	....	....	1,354	1,941	1,098	1,744	1,671	2,203
11,750	....	....	1,465	2,078	1,178	1,853	1,827	2,386
12,000	....	....	1,595	2,235	1,270	1,974	2,016	2,599
12,250	....	....	1,747	2,416	1,376	2,109	2,243	2,847
12,500	....	....	1,929	2,626	1,499	2,263	2,525	3,162
12,750	....	....	2,148	2,876	1,644	2,440	2,880	3,544
13,000	....	....	2,419	3,176	1,817	2,645	3,340	4,034

Distance.	Jugenheim $\varphi = 49° 46'$ $\lambda = 8° 39'$ E.		Jurjew $\varphi = 58° 23'$ $\lambda = 26° 43'$ E.		Königsberg $\varphi = 54° 43'$ $\lambda = 20° 30'$ E.		Königstuhl $\varphi = 49° 25'$ $\lambda = 8° 42'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	369	89	285	85	320	87	372	90
1,250	370	112	286	106	321	109	374	112
1,500	372	134	287	128	323	130	376	135
1,750	374	157	289	150	325	153	377	158
2,000	377	180	291	171	327	175	380	181
2,250	380	203	293	193	329	197	383	204
2,500	383	227	295	216	332	220	386	227
2,750	386	250	298	238	335	243	390	251
3,000	390	274	301	261	338	266	394	275
3,250	395	299	304	283	342	289	399	299
3,500	400	323	308	307	346	313	404	324
3,750	405	348	311	330	351	337	409	349
4,000	411	374	316	354	355	362	415	375
4,250	417	400	320	378	361	387	421	401
4,500	424	426	325	403	366	412	428	427
4,750	431	453	331	428	373	438	436	454
5,000	439	481	336	454	379	464	443	482
5,250	448	509	343	480	386	491	452	511
5,500	457	538	349	507	394	519	462	540
5,750	467	568	356	534	402	547	472	570
6,000	478	599	364	562	411	576	483	600
6,250	490	630	373	591	421	606	495	632
6,500	502	663	381	620	431	637	507	665
6,750	516	697	391	651	443	669	521	699
7,000	531	732	402	682	455	701	536	734
7,250	546	768	413	715	468	735	552	771
7,500	564	806	425	749	482	771	569	809
7,750	582	846	438	783	497	807	588	849
8,000	602	887	452	819	513	845	609	890
8,250	624	930	467	857	531	885	631	934
8,500	648	975	483	896	550	926	655	979
8,750	674	1,023	501	937	571	970	682	1,027
9,000	702	1,074	520	980	594	1,015	710	1,078
9,250	733	1,127	541	1,025	619	1,064	742	1,132
9,500	767	1,184	564	1,072	646	1,114	776	1,190
9,750	805	1,245	588	1,122	675	1,168	814	1,251
10,000	846	1,309	616	1,174	708	1,225	857	1,317
10,250	892	1,380	645	1,230	743	1,286	903	1,387
10,500	943	1,455	678	1,289	783	1,351	955	1,464
10,750	1,000	1,538	714	1,353	827	1,421	1,013	1,547
11,000	1,064	1,627	754	1,421	875	1,497	1,079	1,638
11,250	1,137	1,726	798	1,494	930	1,579	1,153	1,738
11,500	1,219	1,835	848	1,573	991	1,668	1,236	1,848
11,750	1,313	1,956	903	1,659	1,060	1,766	1,333	1,972
12,000	1,421	2,093	966	1,753	1,139	1,875	1,444	2,111
12,250	1,548	2,248	1,037	1,856	1,228	1,995	1,574	2,269
12,500	1,697	2,427	1,118	1,970	1,332	2,131	1,727	2,452
12,750	1,874	2,634	1,211	2,098	1,453	2,284	1,909	2,665
13,000	2,088	2,880	1,318	2,241	1,594	2,459	2,130	2,917

Distance.	Krakau $\varphi=50° 04'$ $\lambda=19° 58'$ E.		Ksara $\varphi=33° 49'$ $\lambda=35° 52'$ E.		Laibach $\varphi=46° 03'$ $\lambda=14° 31'$ E.		La Paz $\varphi=16° 30'$ S. $\lambda=68° 09'$ W.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	366	89	538	101	406	92	1,363	222
1,250	367	112	540	127	408	115	1,376	280
1,500	369	134	543	153	410	138	1,393	339
1,750	371	157	547	179	413	161	1,413	400
2,000	374	180	551	205	415	185	1,437	463
2,250	376	203	556	232	419	209	1,466	529
2,500	380	226	561	259	422	233	1,498	598
2,750	383	250	567	286	426	257	1,536	671
3,000	387	274	574	314	431	282	1,579	748
3,250	392	298	581	342	436	307	1,629	830
3,500	396	323	590	371	441	332	1,686	919
3,750	402	348	599	400	447	358	1,751	1,015
4,000	407	373	608	430	454	384	1,826	1,119
4,250	414	399	619	461	461	411	1,912	1,235
4,500	420	425	631	493	469	439	2,012	1,363
4,750	428	452	644	526	477	467	2,129	1,507
5,000	436	480	657	560	486	496	2,266	1,672
5,250	444	508	673	594	496	525	2,428	1,860
5,500	453	537	689	631	507	555	2,623	2,081
5,750	463	567	707	668	518	586	2,861	2,343
6,000	474	597	726	707	531	619	3,156	2,663
6,250	485	629	747	748	544	652	3,530	3,061
6,500	498	661	770	790	559	686	4,020	3,575
6,750	511	695	795	835	574	722	4,686	4,265
7,000	526	730	822	882	591	759	5,640	5,242
7,250	541	766	852	931	609	798		
7,500	558	804	885	984	629	838		
7,750	577	843	920	1,039	651	880		
8,000	597	884	960	1,099	674	924		
8,250	618	927	1,004	1,163	700	971		
8,500	642	972	1,052	1,231	728	1,020		
8,750	667	1,020	1,105	1,305	758	1,072		
9,000	695	1,070	1,165	1,385	792	1,127		
9,250	726	1,123	1,233	1,473	829	1,186		
9,500	759	1,179	1,308	1,570	869	1,249		
9,750	796	1,240	1,394	1,677	914	1,316		
10,000	837	1,304	1,493	1,797	964	1,389		
10,250	882	1,373	1,606	1,932	1,020	1,468		
10,500	933	1,448	1,738	2,086	1,082	1,554		
10,750	989	1,529	1,892	2,262	1,152	1,649		
11,000	1,052	1,618	2,076	2,469	1,231	1,753		
11,250	1,123	1,716	2,299	2,714	1,322	1,869		
11,500	1,203	1,823	2,571	3,010	1,427	1,999		
11,750	1,296	1,943	2,914	3,376	1,547	2,146		
12,000	1,402	2,078	3,357	3,843	1,688	2,315		
12,250	1,526	2,230	....	....	1,857	2,510		
12,500	1,671	2,405	....	....	2,058	2,740		
12,750	1,844	2,609	....	....	2,304	3,015		
13,000	2,052	2,848	....	....	2,610	3,351		

Distance.	Lemberg $\varphi=49° 50'$ $\lambda=24° 01'$ E.		Madras $\varphi=10° 14'$ $\lambda=77° 28'$ E.		Makejevka $\varphi=48° 02'$ $\lambda=37° 59'$ E.		Manila $\varphi=14° 35'$ $\lambda=120° 59'$ E.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	368	89	844	134	386	90	781	126
1,250	370	112	849	168	388	113	785	158
1,500	371	134	856	203	390	136	791	191
1,750	374	157	863	238	392	159	797	224
2,000	376	180	872	274	395	182	805	257
2,250	379	203	882	310	398	205	813	291
2,500	382	227	893	347	401	229	823	326
2,750	386	250	906	386	405	253	834	361
3,000	390	274	921	425	409	277	847	397
3,250	394	299	937	465	414	302	861	435
3,500	399	323	955	507	419	327	876	473
3,750	404	348	975	551	425	352	893	513
4,000	410	374	997	596	431	378	912	554
4,250	416	400	1,022	643	438	405	933	597
4,500	423	426	1,049	692	445	432	956	642
4,750	430	453	1,079	744	453	459	981	688
5,000	438	481	1,112	799	461	487	1,009	737
5,250	447	509	1,149	857	470	516	1,040	789
5,500	456	538	1,190	919	480	545	1,074	844
5,750	466	568	1,235	986	491	576	1,111	902
6,000	477	598	1,286	1,057	502	608	1,153	964
6,250	489	630	1,342	1,134	515	640	1,199	1,030
6,500	501	663	1,405	1,218	528	674	1,250	1,101
6,750	515	696	1,477	1,309	543	708	1,307	1,178
7,000	529	731	1,558	1,410	559	744	1,371	1,262
7,250	545	768	1,650	1,523	576	781	1,443	1,354
7,500	562	806	1,756	1,649	594	820	1,525	1,456
7,750	581	845	1,879	1,791	614	861	1,619	1,569
8,000	601	886	2,022	1,954	636	904	1,726	1,696
8,250	623	929	2,191	2,143	659	948	1,850	1,840
8,500	647	975	2,394	2,365	684	995	1,995	2,004
8,750	672	1,022	2,640	2,631	712	1,045	2,166	2,195
9,000	701	1,073	2,946	2,956	742	1,097	2,371	2,420
9,250	732	1,126	3,334	3,364	777	1,153	2,621	2,689
9,500	765	1,183	3,841	3,891	814	1,213	2,930	3,018
9,750	803	1,244	4,535	4,605	855	1,276	3,325	3,432
10,000	844	1,309	....	....	899	1,345	3,844	3,971
10,250	890	1,378	....	....	949	1,419		
10,500	941	1,454	....	....	1,005	1,499		
10,750	997	1,536	....	....	1,067	1,586		
11,000	1,061	1,625	....	....	1,138	1,682		
11,250	1,133	1,723	....	....	1,219	1,788		
11,500	1,215	1,832	....	....	1,311	1,906		
11,750	1,309	1,953	....	....	1,417	2,039		
12,000	1,417	2,089	....	....	1,539	2,189		
12,250	1,543	2,244	....	....	1,683	2,361		
12,500	1,691	2,422	....	....	1,853	2,560		
12,750	1,867	2,628	....	....	2,058	2,795		
13,000	2,079	2,872	....	....	2,310	3,077		

Distance.	Messina $\varphi = 38° 12'$ $\lambda = 15° 33'$ E.		München $\varphi = 48° 09'$ $\lambda = 11° 37'$ E.		Osaka $\varphi = 34° 39'$ $\lambda = 135° 26'$ E.		Ottawa $\varphi = 45° 24'$ $\lambda = 75° 43'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	489	97	385	90	528	100	413	92
1,250	491	122	387	113	531	125	415	115
1,500	494	147	389	136	534	151	417	139
1,750	497	172	391	159	537	177	419	162
2,000	501	197	393	182	541	203	422	186
2,250	505	222	396	206	546	230	426	210
2,500	510	248	400	229	551	257	429	234
2,750	515	274	404	253	557	284	433	258
3,000	521	301	408	278	564	311	438	283
3,250	527	328	412	302	570	339	443	308
3,500	534	355	418	327	578	368	449	334
3,750	542	383	423	352	587	397	455	360
4,000	551	412	429	378	597	427	462	386
4,250	560	441	436	405	608	457	469	413
4,500	570	471	443	431	619	489	477	441
4,750	581	502	451	459	631	521	486	469
5,000	593	533	459	487	645	554	495	498
5,250	606	566	468	516	660	589	505	528
5,500	620	600	478	545	676	624	516	559
5,750	635	635	489	576	694	661	528	590
6,000	652	671	501	607	712	699	540	622
6,250	669	708	513	639	732	740	554	656
6,500	689	747	526	673	754	781	569	691
6,750	710	788	541	707	777	825	585	727
7,000	733	831	556	743	804	871	602	764
7,250	758	876	573	780	833	920	621	803
7,500	785	923	592	819	865	971	641	844
7,750	815	973	612	860	900	1,026	664	887
8,000	847	1,026	633	902	937	1,084	688	932
8,250	883	1,082	657	947	980	1,146	714	979
8,500	923	1,142	682	994	1,025	1,212	743	1,029
8,750	966	1,206	710	1,043	1,076	1,284	774	1,081
9,000	1,014	1,275	740	1,096	1,134	1,362	809	1,137
9,250	1,068	1,350	774	1,152	1,198	1,448	847	1,197
9,500	1,128	1,430	810	1,211	1,270	1,541	888	1,261
9,750	1,195	1,519	851	1,274	1,354	1,644	935	1,330
10,000	1,271	1,617	896	1,342	1,445	1,759	986	1,404
10,250	1,357	1,725	946	1,416	1,554	1,888	1,044	1,485
10,500	1,456	1,846	1,001	1,496	1,675	2,034	1,108	1,574
10,750	1,569	1,983	1,063	1,583	1,824	2,202	1,181	1,670
11,000	1,701	2,138	1,134	1,678	1,994	2,396	1,264	1,778
11,250	1,857	2,317	1,214	1,784	2,202	2,626	1,358	1,897
11,500	2,041	2,526	1,304	1,901	2,454	2,901	1,467	2,032
11,750	2,265	2,774	1,409	2,033	2,768	3,239	1,594	2,185
12,000	2,540	3,074	1,531	2,182	3,169	3,664	1,742	2,360
12,250	2,886	3,445	1,673	2,353	3,698	4,217	1,919	2,564
12,500	3,334	3,920	1,842	2,551	4,425	4,969	2,132	2,806
12,750	3,935	4,547	2,045	2,784	5,488	6,058	2,394	3,096
13,000	4,780	5,420	2,294	3,063	7,178	7,777	2,722	3,453

Distance.	Parc Saint-Maur $\varphi=48° 49'$ $\lambda=2° 29'$ E.		Pola $\varphi=44° 52'$ $\lambda=13° 51'$ E.		Pompeii $\varphi=40° 44'$ $\lambda=14° 30'$ E.		Potsdam $\varphi=52° 23'$ $\lambda=13° 04'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	378	90	419	92	462	96	343	88
1,250	380	113	420	116	464	120	344	110
1,500	382	135	422	139	466	144	346	132
1,750	384	158	425	163	469	168	348	155
2,000	387	181	428	187	473	193	350	177
2,250	389	205	431	211	476	218	353	200
2,500	393	228	435	235	480	243	356	223
2,750	397	252	439	259	485	268	359	246
3,000	401	276	444	284	490	294	363	270
3,250	405	301	449	310	496	320	367	294
3,500	410	326	455	335	503	347	371	318
3,750	416	351	461	361	510	374	376	342
4,000	422	376	468	388	518	402	381	367
4,250	428	403	475	415	527	431	387	392
4,500	435	429	484	443	536	460	393	418
4,750	443	457	492	471	546	490	400	445
5,000	451	484	502	501	557	520	407	472
5,250	460	513	512	530	569	552	415	499
5,500	470	542	523	561	582	584	423	528
5,750	480	573	535	593	596	617	433	556
6,000	491	604	548	626	610	652	442	586
6,250	503	636	562	659	627	688	453	617
6,500	516	669	577	694	645	725	464	649
6,750	531	703	594	731	664	764	477	681
7,000	546	738	611	768	684	805	490	715
7,250	562	775	630	808	707	848	504	750
7,500	580	814	651	849	732	892	520	786
7,750	599	854	674	892	758	940	536	824
8,000	620	896	699	938	788	989	554	864
8,250	643	940	726	985	820	1,041	574	905
8,500	668	986	755	1,036	855	1,097	595	948
8,750	695	1,035	787	1,089	894	1,157	618	994
9,000	724	1,087	822	1,146	936	1,221	644	1,041
9,250	757	1,141	861	1,207	983	1,290	671	1,092
9,500	792	1,199	904	1,272	1,036	1,364	701	1,145
9,750	832	1,262	952	1,342	1,095	1,445	734	1,202
10,000	875	1,329	1,005	1,417	1,161	1,533	771	1,262
10,250	923	1,401	1,064	1,500	1,235	1,629	811	1,327
10,500	977	1,479	1,130	1,590	1,319	1,736	855	1,397
10,750	1,037	1,564	1,205	1,689	1,415	1,856	905	1,472
11,000	1,104	1,657	1,291	1,799	1,526	1,991	960	1,554
11,250	1,181	1,759	1,389	1,922	1,655	2,144	1,022	1,643
11,500	1,268	1,873	1,501	2,060	1,807	2,320	1,093	1,740
11,750	1,368	2,000	1,633	2,217	1,988	2,525	1,172	1,848
12,000	1,484	2,144	1,788	2,399	2,204	2,770	1,264	1,969
12,250	1,620	2,308	1,972	2,610	2,470	3,059	1,369	2,104
12,500	1,780	2,498	2,196	2,862	2,805	3,421	1,491	2,257
12,750	1,972	2,720	2,471	3,166	3,236	3,880	1,635	2,432
13,000	2,205	2,984	2,818	3,543	3,811	4,482	1,805	2,635

Distance.	Pulkovo $\varphi = 59° 46'$ $\lambda = 30° 20'$ E.		Reykjavik $\varphi = 64° 09'$ $\lambda = 21° 57'$ W.		Rocca di Papa $\varphi = 41° 46'$ $\lambda = 12° 43'$ E.		Samoa (Apia) $\varphi = 13° 48'$ S. $\lambda = 171° 45'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	272	84	231	83	451	95	1,296	209
1,250	273	106	232	104	453	118	1,308	263
1,500	274	127	233	125	455	142	1,323	318
1,750	276	149	234	146	458	167	1,341	375
2,000	277	170	236	167	461	191	1,363	434
2,250	279	192	237	188	465	216	1,388	495
2,500	282	214	239	210	469	241	1,417	558
2,750	284	236	241	232	474	266	1,450	625
3,000	287	259	243	254	479	292	1,488	696
3,250	290	281	246	276	485	318	1,532	771
3,500	293	304	249	298	491	344	1,581	851
3,750	297	328	252	321	498	371	1,638	937
4,000	301	351	255	344	506	398	1,702	1,030
4,250	305	375	259	367	514	427	1,776	1,132
4,500	310	400	263	391	523	455	1,861	1,244
4,750	315	425	267	415	533	485	1,959	1,369
5,000	320	450	271	440	543	515	2,072	1,509
5,250	326	476	276	465	555	546	2,206	1,668
5,500	333	502	281	491	567	578	2,363	1,850
5,750	340	529	287	517	580	611	2,552	2,063
6,000	347	557	293	544	595	645	2,781	2,316
6,250	355	586	300	571	611	681	3,063	2,622
6,500	363	615	307	599	628	717	3,420	3,002
6,750	372	645	314	628	646	756	3,884	3,489
7,000	382	676	322	658	666	795	4,507	4,135
7,250	393	708	331	689	688	837		
7,500	404	741	340	720	711	881		
7,750	416	775	350	753	737	927		
8,000	429	811	361	787	765	975		
8,250	443	848	372	822	796	1,027		
8,500	459	886	385	858	829	1,081		
8,750	475	926	398	896	866	1,139		
9,000	493	968	413	935	907	1,201		
9,250	513	1,012	429	976	952	1,267		
9,500	534	1,058	446	1,019	1,002	1,339		
9,750	557	1,106	464	1,064	1,057	1,417		
10,000	583	1,157	484	1,111	1,120	1,501		
10,250	611	1,212	507	1,161	1,190	1,594		
10,500	641	1,269	531	1,214	1,269	1,697		
10,750	674	1,330	557	1,269	1,360	1,810		
11,000	712	1,396	586	1,328	1,463	1,938		
11,250	753	1,466	619	1,392	1,584	2,082		
11,500	798	1,542	654	1,459	1,724	2,247		
11,750	850	1,624	694	1,531	1,890	2,439		
12,000	907	1,714	738	1,610	2,089	2,663		
12,250	972	1,812	787	1,694	2,331	2,932		
12,500	1,046	1,920	843	1,786	2,632	3,260		
12,750	1,131	2,039	906	1,887	3,015	3,671		
13,000	1,228	2,173	978	1,998	3,517	4,201		

Distance.	Santa Clara $\varphi=37° 26'$ $\lambda=121° 57'$ W.		Saskatoon $\varphi=52° 08'$ $\lambda=106° 38'$ W.		Seattle $\varphi=47° 39'$ $\lambda=122° 18'$ W.		Simla $\varphi=31° 06'$ $\lambda=77° 12'$ E.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	498	98	345	88	390	91	569	104
1,250	500	122	346	110	392	113	572	130
1,500	503	147	348	133	394	136	575	157
1,750	506	173	350	155	396	160	579	184
2,000	509	198	352	177	399	183	583	211
2,250	513	224	355	200	402	206	589	238
2,500	518	250	358	223	405	230	594	266
2,750	524	276	361	247	409	254	601	294
3,000	530	303	365	270	413	279	608	323
3,250	536	330	369	294	418	303	616	352
3,500	543	358	374	318	423	328	625	382
3,750	551	386	379	343	428	354	635	412
4,000	560	415	384	368	435	380	646	443
4,250	570	444	390	393	442	406	658	476
4,500	580	474	396	419	449	433	671	509
4,750	592	506	402	446	457	461	685	543
5,000	604	538	409	473	466	489	700	578
5,250	617	571	418	500	475	519	716	614
5,500	631	605	427	528	485	548	734	652
5,750	647	640	436	557	496	578	754	692
6,000	664	677	445	587	508	610	775	733
6,250	682	715	456	618	520	642	799	776
6,500	702	754	468	650	534	676	824	821
6,750	724	795	480	683	549	711	852	868
7,000	748	839	493	717	565	747	882	918
7,250	774	884	508	752	582	784	916	971
7,500	802	932	523	788	601	824	952	1,027
7,750	833	984	540	826	621	865	993	1,088
8,000	867	1,037	559	866	643	908	1,037	1,152
8,250	903	1,094	579	907	667	953	1,087	1,222
8,500	944	1,155	600	950	693	1,000	1,142	1,297
8,750	990	1,221	624	996	721	1,050	1,203	1,378
9,000	1,038	1,291	649	1,044	752	1,103	1,273	1,468
9,250	1,094	1,368	677	1,094	787	1,159	1,351	1,566
9,500	1,155	1,450	707	1,148	824	1,219	1,439	1,675
9,750	1,226	1,543	740	1,205	865	1,284	1,541	1,798
10,000	1,306	1,645	777	1,266	912	1,353	1,658	1,936
10,250	1,396	1,756	818	1,331	963	1,428	1,794	2,094
10,500	1,500	1,880	863	1,402	1,019	1,509	1,955	2,276
10,750	1,618	2,028	913	1,478	1,084	1,598	2,146	2,489
11,000	1,760	2,189	969	1,560	1,156	1,695	2,378	2,743
11,250	1,924	2,377	1,033	1,650	1,239	1,803	2,664	3,052
11,500	2,121	2,597	1,104	1,749	1,332	1,923	3,025	3,435
11,750	2,361	2,861	1,185	1,858	1,441	2,058	3,494	3,927
12,000	2,658	3,183	1,278	1,980	1,567	2,212	4,127	4,584
12,250	3,034	3,586	1,385	2,116	1,715	2,388		
12,500	3,528	4,104	1,509	2,271	1,891	2,593		
12,750	4,199	4,802	1,656	2,449	2,103	2,835		
13,000	5,163	5,793	1,830	2,656	2,364	3,126		

Distance.	Sofia $\varphi=42°\ 42'$ $\lambda=23°\ 20'$ E.		Spring Hill $\varphi=30°\ 42'$ $\lambda=88°\ 09'$ W.		St. Boniface $\varphi=49°\ 54'$ $\lambda=97°\ 07'$ W.		St. Louis $\varphi=38°\ 38'$ $\lambda=90°\ 14'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	441	94	574	104	368	89	485	97
1,250	443	118	577	131	369	112	487	122
1,500	445	141	580	157	371	134	489	146
1,750	448	165	584	184	373	157	492	171
2,000	451	190	588	211	375	180	496	196
2,250	455	214	594	239	378	203	500	222
2,500	459	239	599	267	381	227	505	247
2,750	463	264	606	295	385	250	510	273
3,000	468	289	614	324	389	274	516	300
3,250	474	315	622	353	393	298	522	326
3,500	480	341	631	383	398	323	529	354
3,750	487	368	641	414	403	348	537	382
4,000	494	395	652	445	409	373	545	410
4,250	502	423	664	478	415	399	554	439
4,500	511	451	677	511	422	426	564	469
4,750	520	481	691	545	430	453	575	500
5,000	530	510	706	581	438	480	587	531
5,250	542	541	723	617	446	509	599	563
5,500	554	573	741	656	455	538	613	597
5,750	566	605	761	695	465	567	628	632
6,000	580	639	783	737	476	598	645	667
6,250	596	674	807	780	488	630	662	705
6,500	612	710	832	825	500	662	681	743
6,750	630	748	861	873	514	696	702	784
7,000	649	787	892	924	528	731	724	826
7,250	670	828	925	977	544	767	749	871
7,500	693	871	963	1,034	561	805	776	917
7,750	717	916	1,004	1,095	580	844	805	967
8,000	744	963	1,049	1,161	600	886	837	1,019
8,250	774	1,014	1,100	1,231	622	929	871	1,073
8,500	806	1,067	1,156	1,307	645	974	911	1,134
8,750	842	1,123	1,219	1,390	671	1,022	953	1,197
9,000	881	1,183	1,289	1,481	699	1,072	1,001	1,265
9,250	924	1,248	1,369	1,581	730	1,125	1,053	1,339
9,500	971	1,317	1,460	1,693	764	1,182	1,112	1,418
9,750	1,024	1,393	1,564	1,817	801	1,242	1,177	1,506
10,000	1,084	1,474	1,684	1,959	842	1,307	1,251	1,602
10,250	1,150	1,564	1,825	2,121	888	1,377	1,335	1,708
10,500	1,225	1,662	1,991	2,308	938	1,452	1,431	1,826
10,750	1,311	1,771	2,188	2,527	995	1,534	1,541	1,959
11,000	1,408	1,893	2,428	2,789	1,059	1,623	1,670	2,111
11,250	1,521	2,030	2,726	3,110	1,130	1,721	1,820	2,285
11,500	1,652	2,186	3,103	3,509	1,212	1,830	1,998	2,488
11,750	1,807	2,366	3,596	4,026	1,305	1,950	2,214	2,727
12,000	1,991	2,576	4,267	4,720	1,413	2,086	2,478	3,016
12,250	2,213	2,825	....	....	1,538	2,240	2,808	3,372
12,500	2,487	3,127	....	....	1,685	2,417	3,233	3,824
12,750	2,832	3,499	....	....	1,860	2,623	3,800	4,417
13,000	3,278	3,974	....	....	2,072	2,866	4,587	5,232

Distance.	Strassburg $\varphi=48° 35'$ $\lambda=7° 46'$ E.		Sydney $\varphi=33° 50'$ S. $\lambda=151° 10'$ E.		Tacubaya $\varphi=19° 24'$ $\lambda=99° 12'$ W.		Tashkent $\varphi=41° 20'$ $\lambda=69° 18'$ E.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	381	90	1,928	363	715	118	456	95
1,250	382	113	1,959	460	718	149	458	119
1,500	384	136	1,999	562	723	179	460	143
1,750	386	158	2,048	669	729	210	463	167
2,000	389	182	2,107	784	735	241	466	192
2,250	392	205	2,178	907	742	272	470	217
2,500	395	229	2,263	1,042	751	305	474	242
2,750	399	253	2,365	1,192	760	338	479	267
3,000	403	277	2,486	1,359	771	371	484	293
3,250	408	301	2,631	1,548	783	406	490	319
3,500	413	326	2,808	1,766	796	441	496	345
3,750	418	351	3,024	2,023	811	477	503	372
4,000	424	377	3,294	2,331	826	515	511	400
4,250	431	403	3,635	2,709	844	554	519	428
4,500	438	430	4,081	3,190	863	594	529	457
4,750	446	457	....	....	884	636	538	487
5,000	454	485	....	....	908	680	549	517
5,250	463	514	....	....	933	726	561	548
5,500	473	543	....	....	961	775	573	581
5,750	483	574	....	....	991	826	587	614
6,000	495	605	....	....	1,025	879	602	648
6,250	507	637	....	....	1,062	937	618	684
6,500	520	670	....	....	1,104	998	635	721
6,750	534	704	....	....	1,149	1,063	654	759
7,000	549	740	....	....	1,200	1,133	674	800
7,250	566	777	....	....	1,256	1,209	696	842
7,500	584	816	....	....	1,319	1,292	720	886
7,750	604	856	....	....	1,391	1,383	746	932
8,000	625	898	....	....	1,471	1,483	775	981
8,250	648	942	....	....	1,563	1,595	805	1,032
8,500	673	989	....	....	1,668	1,719	840	1,088
8,750	700	1,038	....	....	1,789	1,860	878	1,146
9,000	730	1,090	....	....	1,930	2,021	919	1,209
9,250	763	1,145	....	....	2,097	2,208	965	1,277
9,500	799	1,203	....	....	2,297	2,427	1,016	1,349
9,750	838	1,266	....	....	2,539	2,690	1,073	1,428
10,000	882	1,333	....	....	2,839	3,010	1,137	1,514
10,250	931	1,406	....	....	3,220	3,411	1,209	1,609
10,500	985	1,485	....	....	3,718	3,929	1,290	1,713
10,750	1,046	1,570	....	....	....	....	1,383	1,829
11,000	1,115	1,664	....	....	....	....	1,490	1,960
11,250	1,192	1,768	....	....	....	....	1,614	2,108
11,500	1,281	1,883	....	....	....	....	1,759	2,277
11,750	1,382	2,011	....	....	....	....	1,930	2,474
12,000	1,500	2,157	....	....	....	....	2,137	2,707
12,250	1,638	2,323	....	....	....	....	2,389	2,985
12,500	1,801	2,516	....	....	....	....	2,704	3,327
12,750	1,997	2,742	....	....	....	....	3,107	3,757
13,000	2,236	3,011	....	....	....	....	3,638	4,317

Distance.	Tiflis $\varphi=41° 43'$ $\lambda=44° 48'$ E.		Tokyo $\varphi=35° 42'$ $\lambda=139° 46'$ E.		Toronto $\varphi=43° 40'$ $\lambda=79° 24'$ W.		Trieste $\varphi=45° 38'$ $\lambda=13° 46'$ E.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	452	95	517	100	431	93	411	92
1,250	453	119	519	125	433	117	412	115
1,500	456	143	522	150	435	140	414	138
1,750	459	167	525	176	438	164	417	162
2,000	462	191	529	201	441	188	420	186
2,250	465	216	534	227	444	213	423	209
2,500	470	241	539	254	448	237	427	234
2,750	474	266	544	281	453	262	431	258
3,000	480	292	551	308	457	287	435	283
3,250	485	318	558	336	463	313	440	308
3,500	492	344	565	364	469	339	446	333
3,750	499	371	574	393	475	365	452	359
4,000	506	399	583	422	482	392	459	386
4,250	514	427	593	452	490	420	466	413
4,500	523	456	604	483	499	448	474	440
4,750	533	485	616	515	508	476	483	468
5,000	544	515	629	548	518	506	492	497
5,250	555	546	643	582	528	536	502	527
5,500	568	578	659	617	540	568	512	557
5,750	581	611	675	653	552	600	524	589
6,000	596	646	693	691	566	633	537	621
6,250	611	681	713	730	581	667	550	654
6,500	628	718	734	771	596	703	565	689
6,750	647	756	757	814	614	740	581	725
7,000	667	796	783	859	632	779	598	762
7,250	688	838	810	906	652	819	617	801
7,500	712	881	841	956	674	861	637	842
7,750	738	928	874	1,009	698	905	659	884
8,000	766	976	910	1,066	724	952	683	929
8,250	796	1,026	950	1,126	752	1,001	709	976
8,500	830	1,082	994	1,190	783	1,052	737	1,025
8,750	867	1,140	1,043	1,260	817	1,107	768	1,078
9,000	908	1,202	1,098	1,335	854	1,166	803	1,134
9,250	953	1,268	1,158	1,417	895	1,229	840	1,193
9,500	1,003	1,340	1,227	1,506	941	1,296	881	1,256
9,750	1,059	1,418	1,304	1,604	991	1,369	927	1,325
10,000	1,122	1,503	1,392	1,714	1,048	1,448	978	1,399
10,250	1,192	1,596	1,492	1,836	1,111	1,534	1,035	1,479
10,500	1,272	1,699	1,608	1,974	1,182	1,629	1,099	1,566
10,750	1,362	1,813	1,743	2,131	1,262	1,733	1,170	1,662
11,000	1,466	1,940	1,901	2,313	1,354	1,849	1,252	1,768
11,250	1,587	2,085	2,091	2,525	1,460	1,980	1,345	1,887
11,500	1,728	2,251	2,320	2,777	1,583	2,127	1,453	2,020
11,750	1,894	2,443	2,602	3,084	1,726	2,297	1,577	2,170
12,000	2,094	2,669	2,958	3,465	1,896	2,493	1,723	2,343
12,250	2,338	2,938	3,421	3,952	2,100	2,724	1,896	2,544
12,500	2,640	3,268	4,044	4,601	2,350	3,002	2,105	2,781
12,750	3,026	3,681	4,928	5,510	2,662	3,341	2,361	3,066
13,000	3,531	4,215	6,271	6,880	3,059	3,767	2,680	3,415

Distance.	Uccle $\varphi=50° 48'$ $\lambda=4° 22'$ E.		Vladivostok $\varphi=43° 07'$ $\lambda=131° 55'$ E.		Victoria $\varphi=48° 24'$ $\lambda=123° 19'$ W.		Vieques $\varphi=18° 09'$ $\lambda=65° 26'$ W.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	359	89	436	94	382	90	731	120
1,250	360	111	438	117	384	113	735	151
1,500	362	134	441	141	386	136	740	182
1,750	364	156	444	165	388	159	746	213
2,000	366	179	447	189	391	182	753	245
2,250	369	202	450	213	394	205	760	277
2,500	372	225	454	238	397	229	769	310
2,750	376	249	458	263	401	253	779	343
3,000	379	273	463	288	405	277	790	378
3,250	384	297	469	314	410	302	803	413
3,500	388	321	475	340	415	326	816	449
3,750	393	346	482	366	420	352	831	486
4,000	399	371	489	393	426	378	848	525
4,250	405	397	497	421	433	404	866	564
4,500	412	423	505	450	440	431	886	606
4,750	419	450	514	479	448	458	909	649
5,000	426	477	524	508	456	486	933	694
5,250	435	505	536	539	465	515	960	741
5,500	444	534	548	571	475	544	989	791
5,750	453	563	560	603	485	574	1,021	844
6,000	464	594	574	636	497	606	1,057	900
6,250	475	625	589	671	509	638	1,096	959
6,500	487	657	605	707	522	671	1,139	1,022
6,750	500	691	623	745	537	706	1,188	1,090
7,000	514	725	642	784	552	741	1,241	1,164
7,250	529	761	662	824	569	778	1,301	1,244
7,500	546	798	685	867	587	817	1,369	1,331
7,750	564	837	709	911	607	858	1,445	1,427
8,000	583	877	736	958	628	900	1,531	1,533
8,250	604	920	764	1,008	651	944	1,630	1,651
8,500	627	964	796	1,060	676	991	1,744	1,785
8,750	652	1,011	831	1,116	704	1,040	1,876	1,936
9,000	679	1,061	869	1,176	734	1,092	2,031	2,111
9,250	708	1,113	911	1,240	767	1,147	2,215	2,315
9,500	741	1,168	958	1,308	803	1,206	2,436	2,556
9,750	776	1,227	1,010	1,383	843	1,269	2,709	2,848
10,000	816	1,290	1,068	1,463	887	1,337	3,050	3,210
10,250	859	1,358	1,133	1,551	931	1,410	3,491	3,671
10,500	908	1,432	1,207	1,648	991	1,489	4,078	4,279
10,750	961	1,511	1,290	1,755	1,053	1,575		
11,000	1,022	1,597	1,385	1,874	1,122	1,670		
11,250	1,090	1,692	1,495	2,008	1,200	1,774		
11,500	1,167	1,796	1,622	2,161	1,290	1,890		
11,750	1,255	1,912	1,772	2,336	1,393	2,020		
12,000	1,357	2,041	1,949	2,540	1,512	2,167		
12,250	1,474	2,188	2,164	2,781	1,651	2,334		
12,500	1,611	2,356	2,427	3,071	1,817	2,529		
12,750	1,774	2,549	2,756	3,429	2,015	2,758		
13,000	1,969	2,777	3,181	3,882	2,257	3,031		

Distance.	Washington $\varphi=38° 54'$ $\lambda=77° 03'$ W.		Wien $\varphi=48° 15'$ $\lambda=16° 22'$ E.		Zi-ka-wei $\varphi=31° 12'$ $\lambda=121° 26'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*
1,000	482	97	384	90	568	104
1,250	484	121	386	113	571	130
1,500	486	146	388	136	574	157
1,750	489	171	390	159	578	184
2,000	493	196	392	182	582	210
2,250	497	221	395	205	587	237
2,500	501	247	399	229	593	265
2,750	506	273	403	253	600	294
3,000	512	299	407	277	607	322
3,250	519	326	411	302	615	351
3,500	526	353	417	327	624	381
3,750	533	381	422	352	634	412
4,000	542	409	428	378	645	443
4,250	551	438	435	404	656	475
4,500	560	468	442	431	669	508
4,750	571	498	450	459	683	542
5,000	583	530	458	487	698	577
5,250	595	562	467	515	715	614
5,500	609	595	477	545	733	651
5,750	624	630	488	575	752	691
6,000	640	665	499	606	774	732
6,250	657	703	512	639	797	774
6,500	676	741	525	672	822	819
6,750	697	781	539	707	850	867
7,000	719	823	555	742	880	917
7,250	743	868	572	780	913	969
7,500	770	914	590	818	950	1,026
7,750	799	963	610	859	990	1,086
8,000	831	1,015	631	901	1,034	1,150
8,250	865	1,070	654	946	1,084	1,219
8,500	903	1,129	680	993	1,137	1,294
8,750	945	1,192	708	1,042	1,200	1,375
9,000	992	1,259	738	1,094	1,268	1,465
9,250	1,044	1,332	771	1,150	1,346	1,563
9,500	1,101	1,411	808	1,209	1,434	1,671
9,750	1,166	1,497	848	1,272	1,535	1,793
10,000	1,239	1,592	893	1,340	1,651	1,930
10,250	1,322	1,697	942	1,414	1,787	2,087
10,500	1,416	1,814	997	1,493	1,946	2,268
10,750	1,524	1,945	1,059	1,580	2,136	2,480
11,000	1,650	2,094	1,129	1,675	2,365	2,732
11,250	1,798	2,266	1,209	1,780	2,649	3,037
11,500	1,973	2,464	1,299	1,897	3,006	3,416
11,750	2,182	2,699	1,403	2,028	3,469	3,903
12,000	2,439	2,982	1,523	2,176	4,093	4,551
12,250	2,762	3,328	1,665	2,346		
12,500	3,172	3,766	1,832	2,542		
12,750	3,718	4,339	2,034	2,774		
13,000	4,472	5,121	2,280	3,050		

FORMULAE.

Velocity of longitudinal waves in an isotropic medium $= V_P = \sqrt{\dfrac{\lambda + 2\mu}{\rho}}$

" transverse " " $= V_S = \sqrt{\dfrac{\mu}{\rho}}$

" surface " " $= V_L = \cdot 9194 \sqrt{\dfrac{\mu}{\rho}}$ (Galitzin)

E = Young's modulus, or the longitudinal elasticity of a body which is perfectly free to expand or contract laterally,

$$= \frac{\mu\,(3\lambda + 2\mu)}{\lambda + \mu} = \frac{9k\mu}{3k + \mu}$$

μ = Modulus of rigidity or resistance to shearing, $= \dfrac{E}{2(1 + \sigma)}$

k = Modulus of cubical compression, $= \lambda + \frac{2}{3}\mu = \dfrac{E}{3\,(1 - 2\sigma)}$.
$\lambda = k - \frac{2}{3}\mu$

σ = Poisson's ratio, or ratio of transverse contraction to longitudinal expansion, $= \cdot 25$ very nearly for rocks.

ρ = density.

Assuming $\sigma = \cdot 25$ for the above formulae we get the continued relation

$$V_P = \sqrt{\frac{6}{5} \cdot \frac{E}{\rho}} = \sqrt{3}\, V_S = 1 \cdot 732\, V_S = \frac{\sqrt{3}\, V_L}{\cdot 9194} = 1 \cdot 884\, V_L$$

To give a concrete example of known data of μ and ρ at the surface of the earth for deducing V_L, we have for granite, $\mu = 2 \cdot 373 \times 10^{11}$ in absolute C. G. S. units, and $\rho = 2 \cdot 8$,

hence $V_L = \cdot 9194 \sqrt{\dfrac{\mu}{\rho}} = 2 \cdot 68 \times 10^5$ cm., or $2 \cdot 68$ km. per second.

This is less than observed values, but it must be remembered that our data are for the surface conditions, while the conditions at a considerable depth must be taken into account, but which can not be directly measured. However, the ratio between μ and ρ, or E and ρ can be found from observed velocities. As the velocity increases with depth, it is obvious that both μ and E must increase faster than does ρ, the density. Galitzin gives a numerical example* for the velocity of the longitudinal waves in steel, for which he takes $E = 21 \cdot 6 \times 10^{11}$ and $\rho = 7 \cdot 8$,

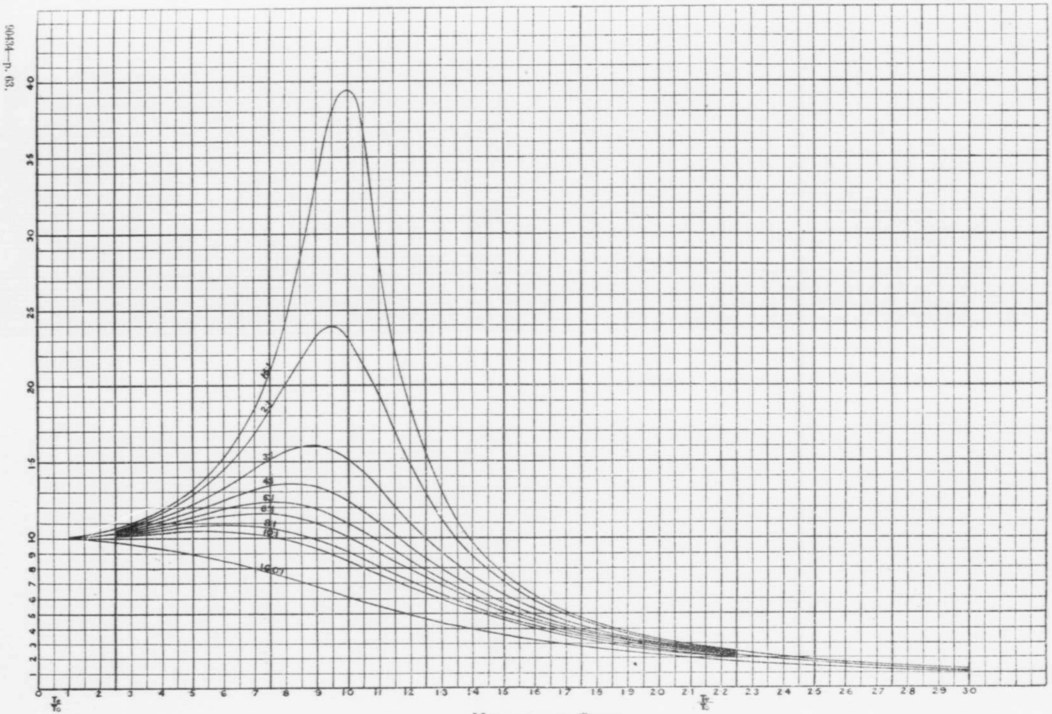
$$\text{hence } V_p = \sqrt{\frac{6}{5} \cdot \frac{216 \times 10^{10}}{7 \cdot 8}} = 5 \cdot 77 \text{ km. per second.}$$

This value too is less than the initial value of the velocity of the P waves. Theoretically the velocity of the L waves is constant, while for P and S waves the velocity increases with the depth of the path, that is, with the distance. But this increase does not continue up to 180° or for the path along a diameter. The constitution of the interior of the earth and its separation into various concentric shells is not as yet sufficiently well known to assign definite limits to abrupt changes in the velocities of P and S waves.

*Seismometrie, p. 61

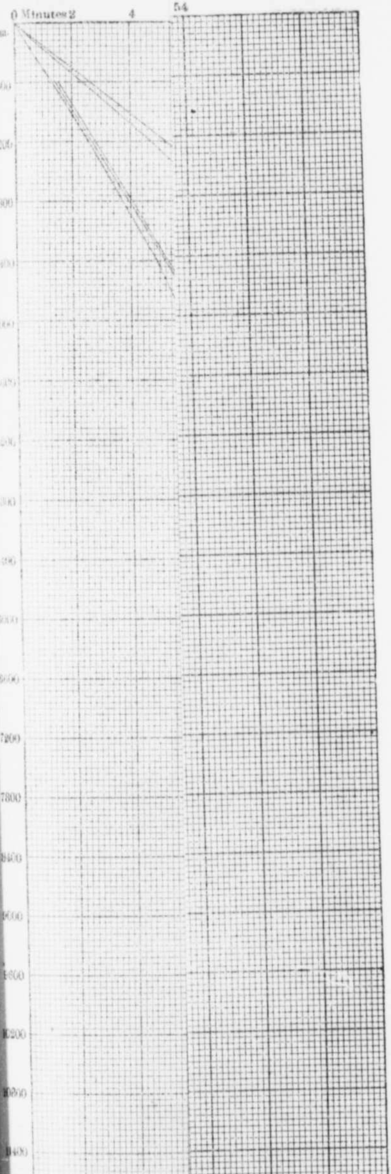
Dominion Observatory,
Ottawa,
December, 1915.

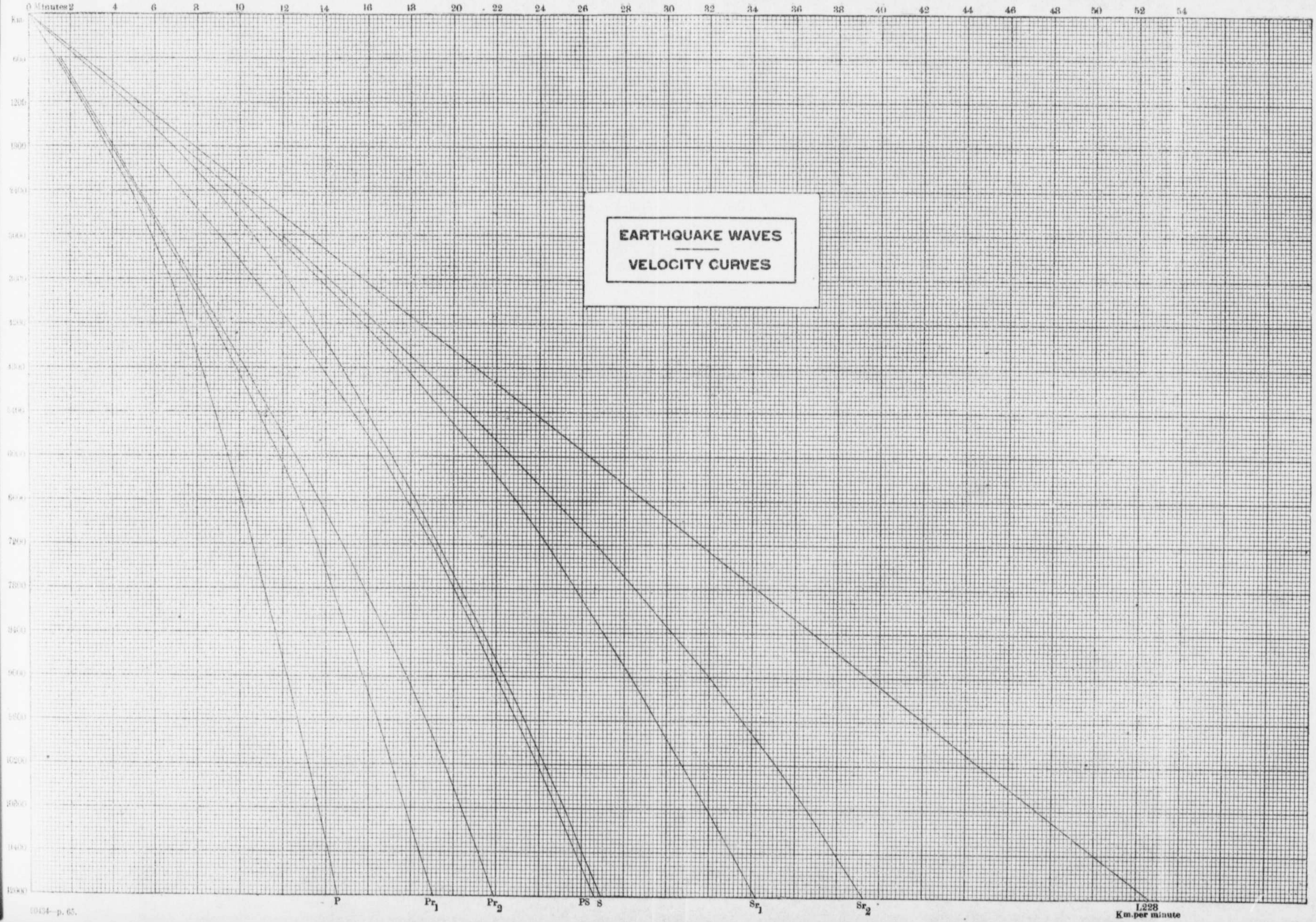
90434—p. 63.



Magnification Curves.


Km
600
1200
1800
7200
7800


0 Minutes 2
4
Km.
600
1200
1800
7200
7800
inute



EARTHQUAKE WAVES
VELOCITY CURVES
0 Minutes 2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
Km.
600
1200
1800
2400
3000
3600
4200
4800
5400
6000
6600
7200
7800
8400
9000
9600
10200
10800
11400
12000
P
Pr_1
Pr_2
PS
S
Sr_1
Sr_2
L228
Km. per minute