APPENDIX I.

REFRACTION TABLES

ARRANGED FOR USE AT THE

ROYAL OBSERVATORY, GREENWICH,

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Refraction Tables arranged for Use at the Royal Observatory, Greenwich.

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The following tables are intended to represent the refractions of Bessel's Tabulæ Regiomontanæ down to 85° from the zenith, or those of Bessel's Fundamenta increased in the ratio 1·0033 : 1 for all zenith distances.

In the last two pages supplementary tables are given, so as to adapt the tables to represent the refractions of the Pulkowa Tables.

The formula for refraction is :—

$$\text{Refraction} = a \tan (\text{zenith distance}) (\mathrm{BT})^{\frac{A\lambda}{\gamma}}$$

when a, A, λ are slowly varying functions of the zenith distance and B, T, γ depend on the Barometer, Internal and External Thermometers respectively. λ is sensibly unity down to zenith distance 55°, A down to zenith distance 77°.

The principle of the tables is :—(i.) to tabulate $a \tan z$, or the mean refraction calculated for Barometer $30^{\text{in.}}00$, External and Internal Thermometers 50°·0 Fahr. (Table III.); (ii.) to facilitate the computation of $\mathrm{BT}\gamma$, which for small zenith distances is the ratio of the true to the mean refraction; (iii.) to make the proper correction for the difference between λ, A, and unity.

Table III. gives the mean refractions for every minute of zenith distance down to 88° 40′. The great extension of this table is with a view to diminishing the labour of interpolation. It may be remarked that the difference for one minute in units in the last place is smaller than for the corresponding five figure logarithms to below 82° zenith distance.

Table I. tabulates the natural logarithm of the factor B to four places of decimals for every hundredth of an inch of the barometer from $28^{\text{in.}}90$ to $30^{\text{in.}}60$, and for every tenth of an inch for a little distance beyond each of these limits.

Table II. tabulates the natural logarithm of $\gamma\mathrm{T}$ to four places of decimals to every tenth of a degree Fahrenheit of the thermometer from 25°·0 to 70°·0, and for greater intervals beyond these limits.

The sum of the above two quantities, with argument height of Barometer, height of External Thermometer, differs from log BTγ in as much as log T should be taken with argument height of Internal Thermometer instead of External Thermometer.

The necessary correction may be made by subtracting one unit in the fourth decimal place for every degree Fahrenheit that the Internal Thermometer is above the External Thermometer.

It is now necessary to find BTγ from its natural logarithm. To do this we add to log BTγ half its square, a quantity that seldom exceeds a few units in the fourth place. We thus obtain the excess of BTγ over unity, or for zenith distances less than 55°, the ratio of the excess of the true over the mean refraction to the mean refraction. Multiplying the mean refraction by this quantity, and adding the product to the mean refraction, the true refraction is obtained.

Example—Z. D. 44° 10′ 13″, Bar. 29^{in}·05, Ext. Therm. 48°·3 F., Int. Therm. 47°·2 F.

From Table I., arg. 29^{in}·05	−·0322	From Table III.	56″·58
From Table II., arg. 48°·3	+ 35	Product of 56″·58 by −·0282	−1·60
Difference of Thermometers	+ 1		
	−·0286	True Refraction =	54″·98
½ square	+ 4		
	−·0282		

For zenith distances greater than 55°, a correction for A, λ must be applied. It is convenient to find this correction in a different manner for zenith distances less and greater than 75° respectively. For zenith distances less than 75°, it is sufficient to note that the correction is proportional to the difference between the temperature and 50°·0 F. The rule, therefore, is to add to the quantity computed, as in the last example, a correction found by multiplying a factor depending on the zenith distance tabulated for each degree at the head of Table III., by the number of degrees Fahrenheit that the temperature is below 50°. Note that the correction is insensible between 45° and 55°, so that the simpler calculation is sufficient down to 55° from the zenith; also that the correction is negative for temperatures above 50°; and lastly, that the correction hardly ever exceeds three-tenths of a second.

For zenith distances greater than 75°, the logarithm of BTγ is to be corrected by the addition of $(A-1)\log B + (A-1)\log T + (\lambda-1)\log\gamma$. Observing that $\log T = \frac{1}{22}\log\gamma$, and that $A-1 = \frac{1}{10}(\lambda-1)$ nearly, the correction is sensibly equal to $(A-1)\log B + \frac{24}{25}(\lambda-1)\log\gamma T$.

Bessel's value of $(\lambda - 1)$ has therefore been diminished by four per cent., and tabulated in Table V. to three places of decimals only. Table IV. gives Bessel's values of $(A - 1)$ to three places of decimals. The quantities in Tables IV. and V. must be multiplied respectively by the quantities in Tables I. and II. Note that if a low star be followed by a high star without change of barometer or thermometer readings, these last two corrections must be removed, and their removal may affect the value of the half square of the sum of the quantities that remain.

Example—Z. D. 75° 0′, Bar. 30^{in}·62, Ext. Therm. 23°·4 F., Int. Therm. 26°·7 F.

(1) By the method applicable to zenith distances less than 75°.

Table I.	+·0204		
Table II.	+ 557	Correction for λ (50 − 23 =)27 × ·008	+0″·22
Diff. of Thermometers	− 3	Mean Refraction	214·10
	+·0758	Mean Refraction × + ·0787	+16 85
½ square	29	True Refraction	231″·17
	+·0787		

(2) By the method applicable to zenith distances greater than 75°.

Table I.	+·0204		
Table II.	+ 557		
Diff. of Thermometers	− 3		
Table I. × Table IV.	0	Mean Refraction	214″·10
Table II. × Table V.	+ 11	Mean Refraction × + ·0799	+17·11
	+·0769	True Refraction	232″·21
½ square	30		
	+·0799		

Pulkowa Refractions.—The refractions of Bessel's Tables for Bar. 30^{in}·00, Therm. 50°·0 F., are equivalent as far as 75° zenith distance to those of the Pulkowa Tables for Bar. 31^{in}·056, Therm. 65°·55. Tables I. and II. have been replaced by appropriate new tables, and it should be noted that between 55° and 75° zenith distances the correction for λ is found by multiplying the factor depending upon the zenith distance by the temperature in degrees Fahrenheit subtracted from 65°·6 the mean temperature. The calculation for greater zenith distances proceeds in the same way as in the case of Bessel's Refractions. Tables IV. and V. are also replaced by new tables adapted to the

Pulkowa Refractions, and there is an additional Table VI. giving the natural logarithm of the ratio of the Pulkowa Refractions to Bessel's Refractions at corresponding zenith distances. This quantity is a function of the zenith distance, and is zero for zenith distances less than 75°; it must be added to the other quantities in forming the ratio of the true to the mean refractions.

Example—Z. D. 80° 29′ 53″, Bar. 30^{in}·02, Ext. Therm. 50°·3 F., Int. Therm. 48°·0 F.

Table I.	−·0339		
Table II.	+ 311		
Diff. of Thermometers	+ 2	Mean Refraction	335″·03
Table I. × Table IV.	− 2	Mean Refraction × −·0018	−0″·60
Table II. × Table V.	+ 13		
Table VI.	− 3	True Refraction	334″·43
Sum	−·0018		
½ square	0		
	−·0018		

REFRACTION TABLES.

TABLE I.

Argument, Height of Barometer in English Inches.

The Quantity tabulated is expressed in Units of the Fourth Decimal Place.

	0	1	2	3	4	5	6	7	8	9	
in.											in.
28·9	−374	−370	−367	−363	−360	−356	−353	−349	−346	−343	28·9
29·0	339	336	332	329	325	322	318	315	312	308	29·0
29·1	305	301	298	294	291	288	284	281	277	274	29·1
29·2	270	267	264	260	257	253	250	246	243	239	29·2
29·3	236	233	229	226	223	219	216	212	209	205	29·3
29·4	202	199	195	192	189	185	182	178	175	171	29·4
29·5	168	165	161	158	155	151	148	144	141	138	29·5
29·6	134	131	127	124	121	117	114	111	107	104	29·6
29·7	101	97	94	90	87	84	80	77	74	70	29·7
29·8	67	64	60	57	53	50	47	43	40	37	29·8
29·9	−33	−30	−27	−23	−20	−17	−13	−10	− 7	− 3	29·9
30·0	0	+ 3	+ 7	+10	+13	+17	+20	+23	+27	+30	30·0
30·1	+33	37	40	43	47	50	53	57	60	63	30·1
30·2	66	70	73	76	80	83	86	90	93	96	30·2
30·3	100	103	106	109	113	116	119	123	126	129	30·3
30·4	132	136	139	142	146	149	152	155	159	162	30·4
30·5	+165	+169	+172	+175	+178	+182	+185	+188	+192	+195	30·5
	0	1	2	3	4	5	6	7	8	9	

in.	
28·4	−548
28·5	−513
28·6	−478
28·7	−443
28·8	−408
28·9	−374

in.	
30·6	+198
30·7	+231
30·8	+263
30·9	+296

TABLE II.

Argument, Temperature of External Thermometer in Degrees Fahrenheit.

The Quantity tabulated is expressed in Units of the Fourth Decimal Place.

	0	1	2	3	4	5	6	7	8	9	
°											°
25	+523	+521	+518	+516	+514	+512	+510	+508	+506	+503	25
26	501	499	497	495	493	491	489	486	484	482	26
27	480	478	476	474	471	469	467	465	463	461	27
28	459	457	454	452	450	448	446	444	442	439	28
29	437	435	433	431	429	427	424	422	420	418	29
30	416	414	412	410	407	405	403	401	399	397	30
31	395	393	391	388	386	384	382	380	378	376	31
32	374	372	370	367	365	363	361	359	357	355	32
33	353	351	348	346	344	342	340	338	336	334	33
34	332	329	327	325	323	321	319	317	315	313	34
35	311	308	306	304	302	300	298	296	294	292	35
36	290	288	286	284	282	280	277	275	273	271	36
37	269	267	265	263	261	259	256	254	252	250	37
38	248	246	244	242	240	238	236	233	231	229	38
39	227	225	223	221	219	217	214	212	210	208	39
40	206	204	202	200	198	196	193	191	189	187	40
41	185	183	181	179	177	175	173	171	169	167	41
42	165	162	160	158	156	154	152	150	148	146	42
43	144	142	140	138	136	133	131	129	127	125	43
44	123	121	119	117	115	113	111	109	107	105	44
45	102	100	98	96	94	92	90	88	86	84	45
46	82	80	78	76	74	72	70	68	66	64	46
47	61	59	57	55	53	51	49	47	45	43	47
48	41	39	37	35	33	31	29	27	25	23	48
49	+20	+18	+16	+14	+12	+10	+ 8	+ 6	+ 4	+ 2	49
50	0	− 2	− 4	− 6	− 8	−10	−12	−14	−16	−18	50
51	−20	22	24	26	28	30	32	35	37	39	51
52	41	43	45	47	49	51	53	55	57	59	52
53	61	63	65	67	69	71	73	75	77	79	53
54	81	83	85	87	89	91	93	95	97	99	54
55	102	104	106	108	110	112	114	116	118	120	55
56	122	124	126	128	130	132	134	136	138	140	56
57	142	144	146	148	150	152	154	156	158	160	57
58	162	164	166	168	170	172	174	176	178	180	58
59	182	184	186	188	190	192	194	196	198	200	59
60	202	204	206	208	210	212	214	216	218	220	60
61	222	224	226	228	230	232	234	236	238	240	61
62	242	244	246	248	250	252	254	256	258	260	62
63	262	264	266	268	270	272	274	276	278	280	63
64	282	284	286	288	290	292	294	296	298	300	64
65	302	304	306	308	310	312	314	316	318	320	65
66	322	324	326	328	330	332	334	336	338	340	66
67	342	344	346	348	350	352	354	356	358	360	67
68	361	363	365	367	369	371	373	375	377	379	68
69	−381	−383	−385	−387	−389	−391	−393	−395	−397	−399	69
	0	1	2	3	4	5	6	7	8	9	

°	
5	+960
6	+938
7	+916
8	+894
9	+871
10	+849
11	+827
12	+805
13	+783
14	+761
15	+739
16	+718
17	+696
18	+674
19	+652
20	+630
21	+609
22	+587
23	+566
24	+544
25	+523

°	
70	−401
71	−421
72	−440
73	−460
74	−479
75	−499
76	−518
77	−538
78	−557
79	−577
80	−596
81	−615
82	−635
83	−654
84	−674
85	−693
90	−788
95	−883

TABLE III.

Mean Refractions—Barometer 30^{in}·00, Thermometers 50°·0 F.

	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	
′	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	′
0	0·00	1·02	2·04	3·06	4·08	5·10	6·13	7·16	8·20	9·23	10·28	11·33	12·39	13·46	14·54	0
1	02	04	06	08	10	12	15	18	22	25	30	35	41	48	56	1
2	03	05	07	09	11	13	16	19	23	27	32	37	43	50	58	2
3	05	07	09	11	13	15	18	21	25	28	33	38	44	51	59	3
4	07	09	11	13	15	17	20	23	27	30	35	40	46	53	61	4
5	0·09	1·11	2·13	3·15	4·17	5·19	6·22	7·25	8·29	9·32	10·37	11·42	12·48	13·55	14·63	5
6	10	12	14	16	18	20	23	26	30	34	39	43	50	57	65	6
7	12	14	16	18	20	22	25	28	32	35	40	45	51	59	67	7
8	14	16	18	20	22	24	27	30	34	37	42	47	53	60	68	8
9	15	17	19	21	23	25	28	32	35	39	44	49	55	62	70	9
10	0·17	1·19	2·21	3·23	4·25	5·27	6·30	7·33	8·37	9·41	10·46	11·50	12·57	13·64	14·72	10
11	19	21	23	25	27	29	32	35	39	42	47	52	59	66	74	11
12	20	22	24	26	28	31	34	37	41	44	49	54	60	68	76	12
13	22	24	26	28	30	32	35	39	42	46	51	56	62	69	77	13
14	24	26	28	30	32	34	37	40	44	48	53	58	64	71	79	14
15	0·26	1·28	2·30	3·32	4·34	5·36	6·39	7·42	8·46	9·49	10·54	11·60	12·66	13·73	14·81	15
16	27	29	31	33	35	37	40	44	47	51	56	61	68	75	83	16
17	29	31	33	35	37	39	42	45	49	53	58	63	69	77	85	17
18	31	33	35	37	39	41	44	47	51	55	60	65	71	78	86	18
19	32	34	36	38	40	43	46	49	53	56	61	67	73	80	88	19
20	0·34	1·36	2·38	3·40	4·42	5·44	6·47	7·51	8·54	9·58	10·63	11·68	12·75	13·82	14·90	20
21	36	38	40	42	44	46	49	52	56	60	65	70	76	84	92	21
22	37	39	41	43	45	48	51	54	58	62	67	72	78	86	94	22
23	39	41	43	45	47	49	52	56	59	63	68	74	80	87	95	23
24	41	43	45	47	49	51	54	58	61	65	70	75	82	89	97	24
25	0·43	1·45	2·47	3·49	4·51	5·53	6·56	7·59	8·63	9·67	10·72	11·77	12·84	13·91	14·99	25
26	44	46	48	50	52	55	58	61	65	69	74	79	85	93	15·01	26
27	46	48	50	52	54	56	59	63	66	70	75	81	87	95	03	27
28	48	50	52	54	56	58	61	65	68	72	77	82	89	96	04	28
29	49	51	53	55	57	60	63	66	70	74	79	84	91	98	06	29
30	0·51	1·53	2·55	3·57	4·59	5·62	6·65	7·68	8·72	9·76	10·81	11·86	12·93	14·00	15·08	30
31	53	55	57	59	61	63	66	70	73	77	82	88	94	02	10	31
32	54	56	58	60	62	65	68	71	75	79	84	90	96	04	12	32
33	56	58	60	62	64	67	70	73	77	81	86	91	98	05	13	33
34	58	60	62	64	66	68	71	75	78	83	88	93	13·00	07	15	34
35	0·60	1·62	2·64	3·66	4·68	5·70	6·73	7·77	8·80	9·84	10·89	11·95	13·01	14·09	15·17	35
36	61	63	65	67	69	72	75	78	82	86	91	97	03	11	19	36
37	63	65	67	69	71	74	77	80	84	88	93	98	05	13	21	37
38	65	67	69	71	73	75	78	82	85	90	95	12·00	07	14	22	38
39	66	68	70	72	74	77	80	84	87	91	96	02	09	16	24	39
40	0·68	1·70	2·72	3·74	4·76	5·79	6·82	7·85	8·89	9·93	10·98	12·04	13·10	14·18	15·26	40
41	70	72	74	76	78	80	83	87	90	95	11·00	05	12	20	28	41
42	71	73	75	77	79	82	85	89	92	97	02	07	14	22	30	42
43	73	75	77	79	81	84	87	91	94	98	03	09	16	23	31	43
44	75	77	79	81	83	86	89	92	96	10 00	05	11	17	25	33	44
45	0·77	1·79	2·81	3·83	4·85	5·87	6·90	7·94	8·97	10·02	11·07	12·13	13·19	14·27	15·35	45
46	78	80	82	84	86	89	92	96	99	04	09	14	21	29	37	46
47	80	82	84	86	88	91	94	97	9·01	05	10	16	23	31	39	47
48	82	84	86	88	90	92	95	99	02	07	12	18	25	32	40	48
49	83	85	87	89	91	94	97	8·01	04	09	14	20	26	34	42	49
50	0·85	1·87	2·89	3·91	4·93	5·96	6·99	8·03	9·06	10·11	11·16	12·21	13·28	14·36	15·44	50
51	87	89	91	93	95	98	7·01	04	08	12	17	23	30	38	46	51
52	88	90	92	94	96	99	02	06	09	14	19	25	32	40	48	52
53	90	92	94	96	98	6·01	04	08	11	16	21	27	34	41	49	53
54	92	94	96	98	5·00	03	06	10	13	18	23	28	35	43	51	54
55	0·94	1·96	2·98	4·00	5·02	6·04	7·07	8·11	9·14	10·19	11·24	12·30	13·37	14·45	15·53	55
56	95	97	99	01	03	06	09	13	16	21	26	32	39	47	55	56
57	97	99	3·01	03	05	08	11	15	18	23	28	34	41	49	57	57
58	99	2·01	03	05	07	10	13	17	20	25	30	35	42	50	58	58
59	1·00	02	04	06	08	11	14	18	21	26	31	37	44	52	60	59
60	1·02	2·04	3·06	4·08	5·10	6·13	7·16	8·20	9·23	10·28	11·33	12·39	13·46	14·54	15·62	60
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	

TABLE III.—*continued.*

Mean Refractions—Barometer 30^{in}·00, Thermometers 50°·0 F.

′	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	′
0	15″·62	16″·72	17″·83	18″·94	20″·07	21″·22	22″·38	23″·55	24″·74	25″·95	27″·18	28″·43	29″·70	30″·99	32″·31	0
1	64	74	85	96	09	24	40	57	76	97	20	45	72	31·01	33	1
2	66	76	87	98	11	26	42	59	78	99	22	47	74	03	35	2
3	67	78	89	19·00	13	28	44	61	80	26·01	24	49	76	06	38	3
4	69	79	90	02	15	30	46	63	82	03	26	51	79	08	40	4
5	15·71	16·81	17·92	19·03	20·17	21·32	22·48	23·65	24·84	26·05	27·28	28·54	29·81	31·10	32·42	5
6	73	83	94	05	18	34	50	67	86	07	30	56	83	12	44	6
7	75	85	96	07	20	36	52	69	88	09	33	58	85	14	47	7
8	77	87	98	09	22	37	54	71	90	11	35	60	87	17	49	8
9	78	89	18·00	11	24	39	56	73	92	13	37	62	89	19	51	9
10	15·80	16·90	18·01	19·13	20·26	21·41	22·57	23·75	24·94	26·15	27·39	28·64	29·91	31·21	32·53	10
11	82	92	03	15	28	43	59	77	96	18	41	66	94	23	56	11
12	84	94	05	17	30	45	61	79	98	20	43	68	96	25	58	12
13	86	96	07	18	32	47	63	81	25·00	22	45	71	98	28	60	13
14	88	98	09	20	34	49	65	83	02	24	47	73	30·00	30	62	14
15	15·89	17·00	18·11	19·22	20·36	21·51	22·67	23·85	25·04	26·26	27·49	28·75	30·02	31·32	32·64	15
16	91	02	13	24	38	53	69	87	06	28	51	77	04	34	67	16
17	93	03	14	26	40	55	71	89	08	30	53	79	07	36	69	17
18	95	05	16	28	41	57	73	91	10	32	55	81	09	39	71	18
19	97	07	18	30	43	59	75	93	12	34	58	83	11	41	73	19
20	15·99	17·09	18·20	19·32	20·45	21·61	22·77	23·95	25·14	26·36	27·60	28·85	30·13	31·43	32·76	20
21	16·00	11	22	34	47	63	79	97	16	38	62	87	15	45	78	21
22	02	13	24	35	49	65	81	99	18	40	64	90	17	47	80	22
23	04	15	26	37	51	66	83	24·01	20	42	66	92	19	50	82	23
24	06	16	27	39	53	68	85	03	22	44	68	94	22	52	85	24
25	16·08	17·18	18·29	19·41	20·55	21·70	22·87	24·05	25·24	26·46	27·70	28·96	30·24	31·54	32·87	25
26	10	20	31	43	57	72	89	07	26	48	72	98	26	56	89	26
27	11	22	33	45	59	74	91	09	28	50	74	29·00	28	58	91	27
28	13	24	35	47	61	76	93	11	30	52	76	02	30	61	94	28
29	15	26	37	49	63	78	95	13	32	54	78	04	32	63	96	29
30	16·17	17·27	18·38	19·50	20·64	21·80	22·96	24·14	25·34	26·56	27·80	29·06	30·34	31·65	32·98	30
31	19	29	40	52	66	82	98	16	37	59	83	09	37	67	33·00	31
32	21	31	42	54	68	84	23·00	18	39	61	85	11	39	69	02	32
33	22	33	44	56	70	86	02	20	41	63	87	13	41	72	05	33
34	24	35	46	58	72	88	04	22	43	65	89	15	43	74	07	34
35	16·26	17·37	18·48	19·60	20·74	21·90	23·06	24·24	25·45	26·67	27·91	29·17	30·45	31·76	33·09	35
36	28	39	50	62	76	92	08	26	47	69	93	19	47	78	11	36
37	30	40	51	64	78	94	10	28	49	71	95	21	50	80	14	37
38	32	42	53	66	80	95	12	30	51	73	97	23	52	83	16	38
39	33	44	55	67	82	97	14	32	53	75	99	26	54	85	18	39
40	16·35	17·46	18·57	19·69	20·84	21·99	23·16	24·34	25·55	26·77	28·01	29·28	30·56	31·87	33·20	40
41	37	48	59	71	86	22·01	18	36	57	79	03	30	58	89	23	41
42	39	50	61	73	87	03	20	38	59	81	05	32	60	91	25	42
43	41	52	63	75	89	05	22	40	61	83	08	34	62	94	27	43
44	43	53	64	77	91	07	24	42	63	85	10	36	65	96	29	44
45	16·44	17·55	18·66	19·79	20·93	22·09	23·26	24·44	25·65	26·87	28·12	29·38	30·67	31·98	33·31	45
46	46	57	68	81	95	11	28	46	67	89	14	40	69	32·00	34	46
47	48	59	70	83	97	13	30	48	69	91	16	42	71	02	36	47
48	50	61	72	84	99	15	32	50	71	93	18	45	73	05	38	48
49	52	63	74	86	21·01	17	34	52	73	95	20	47	75	07	40	49
50	16·54	17·64	18·75	19·88	21·03	22·19	23·35	24·54	25·75	26·97	28·22	29·49	30·77	32·09	33·43	50
51	55	66	77	90	05	21	37	56	77	27·00	24	51	80	11	45	51
52	57	68	79	92	07	23	39	58	79	02	26	53	82	13	47	52
53	59	70	81	94	09	24	41	60	81	04	28	55	84	16	49	53
54	61	72	83	96	10	26	43	62	83	06	30	57	86	18	52	54
55	16·63	17·74	18·85	19·98	21·12	22·28	23·45	24·64	25·85	27·08	28·33	29·59	30·88	32·20	33·54	55
56	65	76	87	99	14	30	47	66	87	10	35	62	90	22	56	56
57	66	77	88	20·01	16	32	49	68	89	12	37	64	93	24	58	57
58	68	79	90	03	18	34	51	70	91	14	39	66	95	27	61	58
59	70	81	92	05	20	36	53	72	93	16	41	68	97	29	63	59
60	16·72	17·83	18·94	20·07	21·22	22·38	23·55	24·74	25·95	27·18	28·43	29·70	30·99	32·31	33·65	60
	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	

TABLE III.—*continued.*

Mean Refractions—Barometer 30^{in}·00, Thermometers 50°·0 F.

′	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°	42°	43°	44°	′
0	33″·65	35″·02	36″·41	37″·84	39″·30	40″·80	42″·33	43″·90	45″·52	47″·17	48″·88	50″·63	52″·44	54″·31	56″·24	0
1	67	04	43	86	32	83	36	93	55	20	91	66	47	34	27	1
2	70	07	46	89	35	85	38	95	57	23	94	69	50	37	31	2
3	72	09	48	91	37	88	41	98	60	25	97	72	53	40	34	3
4	74	11	50	94	40	90	43	44′·01	63	28	49′·00	75	56	44	37	4
5	33′·76	35′·13	36′·53	37′·96	39′·42	40′·93	42′·46	44′·03	45′·66	47′·31	49′·02	50′·78	52′·59	54′·47	56′·40	5
6	79	16	55	98	45	95	49	06	68	34	05	81	63	50	44	6
7	81	18	58	38′·01	47	98	51	09	71	37	08	84	66	53	47	7
8	83	20	60	03	50	41′·00	54	11	74	40	11	87	69	56	50	8
9	85	23	62	06	52	03	56	14	77	42	14	90	72	59	54	9
10	33′·88	35′·25	36′·65	38′·08	39′·55	41′·05	42′·59	44′·17	45′·79	47′·45	49′·17	50′·93	52′·75	54′·63	56′·57	10
11	90	27	67	10	57	08	62	19	82	48	20	96	78	66	60	11
12	92	30	69	13	60	10	64	22	85	51	23	99	81	69	64	12
13	94	32	72	15	62	13	67	25	88	54	26	51′·02	84	72	67	13
14	97	34	74	18	65	15	69	27	90	57	29	05	87	75	70	14
15	33′·99	35′·36	36′·76	38′·20	39′·67	41′·18	42′·72	44′·30	45′·93	47′·59	49′·31	51′·08	52′·90	54′·78	56′·73	15
16	34′·01	39	79	22	69	21	75	33	96	62	34	11	94	82	77	16
17	04	41	81	25	72	23	77	35	98	65	37	14	97	85	80	17
18	06	43	84	27	74	26	80	38	46′·01	68	40	17	53′·00	88	83	18
19	08	46	86	30	77	28	82	41	04	71	43	20	03	91	87	19
20	34′·10	35′·48	36′·88	38′·32	39′·79	41′·31	42′·85	44′·43	46′·07	47′·74	49′·46	51′·23	53′·06	54′·94	56′·90	20
21	13	50	91	34	82	33	88	46	09	76	49	26	09	97	93	21
22	15	53	93	37	84	36	90	49	12	79	52	29	12	55′·01	97	22
23	17	55	95	39	87	38	93	51	15	82	55	32	15	04	57′·00	23
24	19	57	98	42	89	41	95	54	18	85	58	35	18	07	03	24
25	34′·22	35′·59	37′·00	38′·44	39′·92	41′·43	42′·98	44′·57	46′·20	47′·88	49′·60	51′·38	53′·21	55′·10	57′·06	25
26	24	62	03	46	94	46	43′·01	59	23	91	63	41	25	13	10	26
27	26	64	05	49	97	48	03	62	26	93	66	44	28	16	13	27
28	28	66	07	51	99	51	06	65	29	96	69	47	31	20	16	28
29	31	69	10	54	40′·02	53	08	67	31	99	72	50	34	23	20	29
30	34′·33	35′·71	37′·12	38′·56	40′·04	41′·56	43′·11	44′·70	46′·34	48′·02	49′·75	51′·53	53′·37	55′·26	57′·23	30
31	35	73	14	58	07	59	14	73	37	05	78	56	40	29	26	31
32	38	76	17	61	09	61	16	75	40	08	81	59	43	33	30	32
33	40	78	19	63	12	64	19	78	42	11	84	62	46	36	33	33
34	42	80	22	66	14	66	22	81	45	13	87	65	50	39	36	34
35	34′·44	35′·83	37′·24	38′·68	40′·17	41′·69	43′·24	44′·84	46′·48	48′·16	49′·90	51′·68	53′·53	55′·42	57′·40	35
36	47	85	26	71	19	71	27	86	51	19	93	71	56	46	43	36
37	49	87	29	73	22	74	29	89	53	22	96	74	59	49	46	37
38	51	90	31	76	24	77	32	92	56	25	98	77	62	52	50	38
39	54	92	34	78	27	79	35	95	59	28	50′·01	80	65	55	53	39
40	34′·56	35′·94	37′·36	38′·81	40′·29	41′·82	43′·37	44′·97	46′·62	48′·31	50′·04	51′·83	53′·68	55′·59	57′·56	40
41	58	97	38	83	32	84	40	45′·00	64	34	07	86	71	62	60	41
42	61	99	41	86	34	87	43	03	67	36	10	89	75	65	63	42
43	63	36′·01	43	88	37	89	45	06	70	39	13	92	78	68	66	43
44	65	04	46	91	39	92	48	08	73	42	16	95	81	72	70	44
45	34′·67	36′·06	37′·48	38′·93	40′·42	41′·94	43′·50	45′·11	46′·75	48′·45	50′·19	51′·98	53′·84	55′·75	57′·73	45
46	70	08	50	95	45	97	53	14	78	48	22	52′·02	87	78	76	46
47	72	11	53	98	47	42′·00	56	16	81	51	25	05	90	82	80	47
48	74	13	55	39′·00	50	02	58	19	84	54	28	08	93	85	83	48
49	77	15	58	03	52	05	61	22	87	56	31	11	97	88	86	49
50	34′·79	36′·18	37′·60	39′·05	40′·55	42′·07	43′·64	45′·25	46′·89	48′·59	50′·34	52′·14	54′·00	55′·91	57′·90	50
51	81	20	62	08	57	10	66	27	92	62	37	17	03	95	93	51
52	84	22	65	10	60	12	69	30	95	65	40	20	06	98	96	52
53	86	25	67	13	62	15	72	33	98	68	42	23	09	56′·01	58′·00	53
54	88	27	70	15	65	18	74	36	47′·00	71	45	26	12	04	03	54
55	34′·90	36′·29	37′·72	39′·18	40′·67	42′·20	43′·77	45′·38	47′·03	48′·74	50′·48	52′·29	54′·15	56′·08	58′·06	55
56	93	32	74	20	70	23	79	41	06	77	51	32	18	11	10	56
57	95	34	77	23	72	25	82	44	09	79	54	35	22	14	13	57
58	97	36	79	25	75	28	85	47	11	82	57	38	25	17	16	58
59	35′·00	39	82	28	78	30	87	49	14	85	60	41	28	21	20	59
60	35′·02	36′·41	37′·84	39′·30	40′·80	42′·33	43′·90	45′·52	47′·17	48′·88	50′·63	52′·44	54′·31	56′·24	58′·23	60
	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°	42°	43°	44°	

TABLE III.—*continued.*

Mean Refractions—Barometer 30^{in}·00, Thermometers 50°·0 F.

Factor for λ correction, expressed in units of one thousandth of a second.

	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	58°	59°	
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
′	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	′
0	58·23	60·29	62·43	64·65	66·96	69·36	71·87	74·48	77·21	80·06	83·06	86·21	89·52	93·02	96·71	0
1	26	33	47	69	67·00	40	91	52	26	11	11	26	58	08	77	1
2	30	36	50	73	04	44	96	57	30	16	16	32	63	14	84	2
3	33	40	54	76	08	48	72·00	61	35	21	21	37	69	20	90	3
4	37	43	58	80	12	53	04	66	40	26	27	43	75	26	97	4
5	58·40	60·47	62·61	64·84	67·16	69·57	72·08	74·70	77·44	80·31	83·32	86·48	89·80	93·32	97·03	5
6	43	50	65	88	20	61	13	75	49	36	37	53	86	38	09	6
7	47	54	69	92	24	65	17	79	54	41	42	59	92	44	16	7
8	50	57	72	96	27	69	21	84	59	45	47	64	97	49	22	8
9	54	61	76	99	31	73	26	88	63	50	52	70	90·03	55	29	9
10	58·57	60·64	62·80	65·03	67·35	69·77	72·30	74·93	77·68	80·55	83·57	86·75	90·09	93·61	97·35	10
11	60	68	83	07	39	81	34	97	73	60	63	80	14	67	41	11
12	64	71	87	11	43	86	39	75·02	77	65	68	86	20	73	48	12
13	67	75	91	15	47	90	43	06	82	70	73	91	26	79	54	13
14	71	78	94	19	51	94	47	11	87	75	78	97	31	85	61	14
15	58·74	60·82	62·98	65·22	67·55	69·98	72·51	75·15	77·91	80·80	83·83	87·02	90·37	93·91	97·67	15
16	77	86	63·02	26	59	70·02	56	20	96	85	88	07	43	97	73	16
17	81	89	05	30	63	06	60	24	78·01	90	94	13	49	94·03	80	17
18	84	93	09	34	67	10	64	29	06	95	99	18	54	10	86	18
19	88	96	13	38	71	15	69	33	10	81·00	84·04	24	60	16	93	19
20	58·91	61·00	63·16	65·42	67·75	70·19	72·73	75·38	78·15	81·05	84·09	87·29	90·66	94·22	97·99	20
21	94	03	20	45	79	23	77	42	20	10	15	35	72	28	98·06	21
22	98	07	24	49	83	27	82	47	24	15	20	40	78	34	12	22
23	59·01	10	27	53	86	31	86	51	29	19	25	46	83	41	19	23
24	05	14	31	57	90	35	90	56	34	24	30	51	89	47	25	24
25	59·08	61·17	63·35	65·61	67·94	70·39	72·94	75·60	78·38	81·29	84·36	87·57	90·95	94·53	98·32	25
26	11	21	38	65	98	43	99	65	43	34	41	62	91·01	59	38	26
27	15	24	42	68	68·02	48	73·03	69	48	39	46	68	07	65	45	27
28	18	28	46	72	06	52	07	74	53	44	51	73	12	72	51	28
29	22	31	49	76	10	56	12	78	57	49	57	79	18	78	58	29
30	59·25	61·35	63·53	65·80	68·14	70·60	73·16	75·83	78·62	81·54	84·62	87·84	91·24	94·84	98·64	30
31	28	39	57	84	18	64	20	88	67	59	67	90	30	90	71	31
32	32	42	60	88	22	68	25	92	72	64	72	95	36	96	77	32
33	35	46	64	92	26	73	29	97	76	69	78	88·01	42	95·03	84	33
34	39	49	68	95	30	77	34	76·01	81	74	83	06	47	09	90	34
35	59·42	61·53	63·72	65·99	68·34	70·81	73·38	76·06	78·86	81·79	84·88	88·12	91·53	95·15	98·97	35
36	46	57	75	66·03	38	85	42	11	91	84	93	17	59	21	99·03	36
37	49	60	79	07	42	90	47	15	96	89	98	23	65	27	10	37
38	53	64	83	11	47	94	51	20	79·00	94	85·04	28	71	34	16	38
39	56	67	87	15	51	98	56	24	05	82·00	09	34	77	40	23	39
40	59·60	61·71	63·90	66·19	68·55	71·02	73·60	76·29	79·10	82·05	85·14	88·39	91·83	95·46	99·29	40
41	63	75	94	23	59	07	64	34	15	10	19	45	89	52	36	41
42	67	78	98	26	63	11	69	38	20	15	24	50	94	58	42	42
43	70	82	64·02	30	67	15	73	43	24	20	30	56	92·00	65	49	43
44	74	85	05	34	71	19	78	47	29	25	35	61	06	71	55	44
45	59·77	61·89	64·09	66·38	68·75	71·23	73·82	76·52	79·34	82·30	85·40	88·67	92·12	95·77	99·62	45
46	80	93	13	42	79	28	86	57	39	35	45	73	18	83	69	46
47	84	96	16	46	83	32	91	61	44	40	51	78	24	90	75	47
48	87	62·00	20	50	87	36	95	66	48	45	56	84	30	96	82	48
49	91	03	24	53	91	40	74·00	70	53	50	62	90	36	96·02	89	49
50	59·94	62·07	64·28	66·57	68·95	71·45	74·04	76·75	79·58	82·55	85·67	88·95	92·42	96·08	99·95	50
51	98	11	31	61	99	49	08	80	63	60	72	89·01	48	15	100·02	51
52	60·01	14	35	65	69·03	53	13	84	68	65	78	07	54	21	09	52
53	05	18	39	69	08	57	17	88	72	71	83	12	60	27	15	53
54	08	21	43	73	12	62	22	93	77	76	89	18	66	33	22	54
55	60·12	62·25	64·46	66·77	69·16	71·66	74·26	76·98	79·82	82·81	85·94	89·24	92·72	96·40	100·29	55
56	15	29	50	81	20	70	30	77·03	87	86	99	29	78	46	35	56
57	19	32	54	84	24	74	35	07	92	91	86·05	35	84	52	42	57
58	22	36	58	88	28	79	39	12	96	96	10	41	90	58	49	58
59	26	39	61	92	32	83	44	16	80·01	83·01	16	46	96	65	55	59
60	60·29	62·43	64·65	66·96	69·36	71·87	74·48	77·21	80·06	83·06	86·21	89·52	93·02	96·71	100·62	60
	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	58°	59°	

TABLE III.—*continued.*

Mean Refractions—Barometer 30^{in}·00, Thermometers 50°·0 F.

	1	1	1	2	2	2	2	2	3	3	4	5	6	7	8	
	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°	71°	72°	73°	74°	
0′	100″62	104″77	109″19	113″90	118″94	124″35	130″17	136″45	143″26	150″67	158″76	167″65	177″44	188″33	200″46	0′
1	69	84	27	98	119·03	44	27	56	38	80	90	81	61	52	67	1
2	76	91	34	114·06	12	54	37	67	50	93	159·05	96	79	72	89	2
3	82	99	42	15	20	63	47	78	62	151·06	19	168·12	96	91	201·10	3
4	89	105·06	50	23	29	73	57	89	74	19	33	27	178·14	189·10	32	4
5	100·96	105·13	109·57	114·31	119·38	124·82	130·68	137·00	143·85	151·32	159·47	168·43	178·31	189·29	201·53	5
6	101·03	20	65	39	47	92	78	11	97	45	62	59	48	49	75	6
7	10	27	73	47	56	125·01	88	22	144·09	58	76	74	66	68	96	7
8	16	35	80	56	64	11	98	33	21	71	90	90	83	87	202·18	8
9	23	42	88	64	73	20	131·08	44	33	84	160·05	169·05	179·01	190·07	39	9
10	101·30	105·49	109·96	114·72	119·82	125·30	131·18	137·55	144·45	151·97	160·19	169·21	179·18	190·26	202·61	10
11	37	56	110·03	80	91	39	28	66	57	152·10	33	37	36	46	83	11
12	44	63	11	88	120·00	49	38	77	69	23	48	53	53	65	203·05	12
13	50	71	19	97	08	58	49	88	81	36	62	69	71	85	27	13
14	57	78	26	115·05	17	68	59	99	93	49	77	85	89	191·04	49	14
15	101·64	105·85	110·34	115·13	120·26	125·77	131·69	138·10	145·06	152·63	160·91	170·00	180·06	191·24	203·71	15
16	71	92	42	21	35	87	79	22	18	76	161·05	16	24	44	94	16
17	78	106·00	49	30	44	96	89	33	30	89	20	32	42	63	204·16	17
18	85	07	57	38	53	126·06	132·00	44	42	153·02	34	48	60	83	38	18
19	91	15	65	46	61	15	10	55	54	15	49	64	77	192·02	60	19
20	101·98	106·22	110·73	115·55	120·70	126·25	132·20	138·66	145·66	153·28	161·63	170·80	180·95	192·22	204·82	20
21	102·05	29	80	63	79	34	30	77	78	41	78	96	181·13	42	205·04	21
22	12	37	88	71	88	44	41	89	90	55	92	171·12	31	62	27	22
23	19	44	96	80	97	53	51	139·00	146·03	68	162·07	29	49	82	49	23
24	26	51	111·04	88	121·06	63	62	11	15	82	22	45	67	193·02	72	24
25	102·33	106·59	111·11	115·96	121·15	126·72	132·72	139·23	146·27	153·95	162·36	171·61	181·85	193·22	205·94	25
26	40	66	19	116·05	23	82	82	34	39	154·08	51	77	182·04	42	206·17	26
27	46	73	27	13	32	91	93	45	51	22	66	93	22	62	39	27
28	53	81	35	21	41	127·01	133·03	56	64	35	81	172·10	40	82	62	28
29	60	88	42	30	50	10	14	68	76	49	95	26	58	194·02	84	29
30	102·67	106·95	111·50	116·38	121·59	127·20	133·24	139·79	146·88	154·62	163·10	172·42	182·76	194·22	207·07	30
31	74	107·02	58	46	68	30	35	90	147·00	76	25	58	94	42	30	31
32	81	10	66	55	77	39	45	140·02	13	89	40	75	183·13	63	53	32
33	88	17	74	63	86	49	56	13	25	155·03	54	91	31	83	76	33
34	95	25	82	72	95	59	66	25	38	16	69	173·08	50	195·04	99	34
35	103·02	107·32	111·90	116·80	122·04	127·69	133·77	140·36	147·50	155·30	163·84	173·24	183·68	195·24	208·21	35
36	09	39	98	88	13	78	88	47	62	44	99	40	86	44	44	36
37	16	47	112·06	97	22	88	98	59	75	57	164·14	57	184·05	65	67	37
38	22	54	13	117·05	32	98	134·09	70	87	71	28	73	23	85	90	38
39	29	62	21	14	41	128·07	19	82	148·00	84	43	90	42	196·06	209·13	39
40	103·36	107·69	112·29	117·22	122·50	128·17	134·30	140·93	148·12	155·98	164·58	174·06	184·60	196·26	209·36	40
41	43	76	37	30	59	27	41	141·05	25	156·12	73	23	78	47	59	41
42	50	83	45	39	68	37	51	16	37	26	88	40	97	68	83	42
43	57	91	53	47	77	47	62	28	50	39	165·04	56	185·15	88	210·06	43
44	64	99	61	56	86	57	73	39	62	53	19	73	34	197·09	30	44
45	103·71	108·06	112·69	117·64	122·95	128·66	134·84	141·51	148·75	156·67	165·34	174·90	185·52	197·30	210·53	45
46	78	14	77	73	123·04	76	94	63	88	81	49	175·07	71	51	76	46
47	85	21	85	81	14	86	135·05	74	149·00	95	64	24	89	72	211·00	47
48	92	29	93	90	23	96	16	86	13	157·08	80	40	186·08	92	23	48
49	99	36	113·01	99	32	129·06	26	97	25	22	95	57	26	198·13	47	49
50	104·06	108·44	113·09	118·07	123·42	129·16	135·37	142·09	149·38	157·36	166·10	175·74	186·45	198·34	211·70	50
51	13	51	17	16	51	26	48	21	51	50	25	91	64	55	94	51
52	20	59	25	25	60	36	59	32	64	64	41	176·08	83	76	212·18	52
53	28	66	34	33	70	46	69	44	77	78	56	25	187·01	98	42	53
54	35	74	42	42	79	56	80	56	90	92	72	42	20	199·19	66	54
55	104·42	108·81	113·50	118·51	123·88	129·67	135·91	142·67	150·02	158·06	166·87	176·59	187·39	199·40	212·90	55
56	49	89	58	59	98	77	136·02	79	15	20	167·03	76	58	61	213·14	56
57	56	96	66	68	124·07	87	13	91	28	34	18	93	77	82	38	57
58	63	109·04	74	77	16	97	23	143·03	41	48	34	177·10	95	200·04	62	58
59	70	11	82	85	26	130·07	34	14	54	62	49	27	188·14	25	86	59
60	104·77	109·19	113·90	118·94	124·35	130·17	136·45	143·26	150·67	158·76	167·65	177·44	188·37	200·46	214·10	60
	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°	71°	72°	73°	74°	

Table III.—*continued.*

Mean Refraction—Barometer 30^{in}·00, Thermometers 50°·0 F.

	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	85°	86°	87°	88°		
′	″	″	″	″	″	″	″	″	″	″	″	″	″	″		′
0	214·10	229·55	247·20	267·52	291·20	319·16	352·60	393·33	443·86	508·07	591·99	705·80	866·78	1107·74		0
1	34	83	52	89	63	66	353·21	394·09	444·80	509·28	593·60	708·03	870·02	1112·74		1
2	58	230·10	83	268·25	292·06	320·17	82	85	445·74	510·49	595·22	710·28	873·29	1117·78		2
3	83	38	248·15	62	49	68	354·44	395·61	446·69	511·71	596·85	712·54	876·57	1122·87		3
4	215·07	65	46	98	92	321·19	355·06	396·37	447·65	512·94	598·49	714·81	879·87	1128·01		4
5	215·31	230·93	248·78	269·35	293·35	321·71	355·68	397·14	448·61	514·18	600·15	717·09	883·21	1133·19		5
6	55	231·21	249·10	72	79	322·22	356·30	91	449·58	515·42	601·81	719·39	886·57	1138·41		6
7	80	49	42	270·09	294·23	74	93	398·68	450·56	516·67	603·48	721·70	889·94	1143·66		7
8	216·04	77	74	47	67	323·26	357·56	399·45	451·54	517·93	605·16	724·02	893·32	1148·95		8
9	29	232·05	250·06	84	295·11	78	358·19	400·22	452·52	519·19	606·85	726·36	896·71	1154·27		9
10	216·53	232·33	250·38	271·21	295·55	324·30	358·82	400·99	453·50	520·46	608·56	728·72	900·13	1159·62		10
11	78	61	70	59	99	82	359·45	401·77	454·49	521·73	610·27	731·09	903·57	1165·02		11
12	217·03	89	251·03	97	296·43	325·34	360·09	402·55	455·48	523·01	611·99	733·48	907·04	1170·47		12
13	28	233·18	35	272·35	88	87	73	403·34	456·48	524·30	613·72	735·88	910·54	1175·97		13
14	53	46	68	73	297·32	326·40	361·37	404·13	457·48	525·59	615·45	738·29	914·08	1181·53		14
15	217·78	233·74	252·00	273·11	297·76	326·93	362·01	404·92	458·49	526·88	617·19	740·71	917·65	1187·15		15
16	218·03	234·02	33	49	298·21	327·46	66	405·71	459·50	528·18	618·94	743·15	921·24	1192·81		16
17	28	31	66	87	66	99	363·31	406·51	460·50	529·48	620·70	745·60	924·86	1198·52		17
18	54	59	98	274·26	299·10	328·52	96	407·31	461·50	530·79	622·46	748·07	928·50	1204·27		18
19	79	88	253·31	64	55	329·06	364·61	408·11	462·51	532·10	624·23	750·55	932·17	1210·05		19
20	219·04	235·16	253·64	275·02	300·00	329·60	365·26	408·91	463·52	533·41	626·01	753·04	935·87	1215·87		20
21	29	45	97	41	45	330·14	91	409·71	464·54	534·73	627·80	755·55	939·59	1221·75		21
22	54	74	254·30	79	91	68	366·57	410·52	465·56	536·06	629·60	758·08	943·34	1227·69		22
23	80	236·02	64	276·18	301·36	331·22	367·23	411·33	466·59	537·39	631·41	760·62	947·12	1233·68		23
24	220·05	31	97	56	82	77	89	412·15	467·63	538·74	633·23	763·17	950·93	1239·72		24
25	220·30	236·60	255·30	276·95	302·27	332·32	368·55	412·98	468·67	540·10	635·05	765·73	954·75	1245·81		25
26	56	89	64	277·34	73	87	369·22	413·81	469·72	541·46	636·89	768·31	958·60	1251·95		26
27	81	237·19	97	73	303·19	333·42	89	414·64	470·77	542·83	638·74	770·91	962·48	1258·14		27
28	221·07	48	256·31	278·12	66	98	370·56	415·47	471·83	544·21	640·60	773·53	966·38	1264·38		28
29	32	78	64	51	304·12	334·54	371·23	416·30	472·90	545·60	642·47	776·17	970·29	1270·68		29
30	221·58	238·07	256·98	278·90	304·58	335·10	371·90	417·15	473·97	546·99	644·36	778·82	974·22	1277·03		30
31	84	36	257·32	279·30	305·05	66	372·58	418·00	475·04	548·38	646·26	781·49	978·18	1283·44		31
32	222·10	66	66	69	52	336·22	373·26	84	476·12	549·78	648·17	784·18	982·17	1289·90		32
33	35	95	258·00	280·09	98	78	95	419·70	477·20	551·20	650·08	786·88	986·20	1296·42		33
34	61	239·25	34	48	306·45	337·34	374·64	420·56	478·28	552·62	652·00	789·60	990·28	1302·99		34
35	222·87	239·54	258·68	280·88	306·92	337·91	375·33	421·42	479·37	554·05	653·93	792·33	994·41	1309·61		35
36	223·13	84	259·03	281·28	307·40	338·48	376·02	422·28	480·46	555·47	655·87	795·08	998·56	1316·30		36
37	39	240·14	37	69	87	339·05	71	423·14	481·55	556·90	657·82	797·85	1002·74	1323·05		37
38	66	43	72	282·09	308·35	62	377·40	424·00	482·65	558·34	659·78	800·64	1006·94	1329·86		38
39	92	73	260·06	50	82	340·19	378·09	86	483·75	559·79	660·75	803·45	1011·17	1336·73		39
40	224·18	241·03	260·41	282·90	309·30	340·76	378·79	425·72	484·86	561·25	663·73	806·28	1015·43	1343·66		40
41	44	33	76	283·31	78	341·33	379·49	426·58	485·98	562·71	665·72	809·12	1019·73			41
42	71	63	261·11	72	310·26	91	380·20	427·44	487·09	564·18	667·73	811·98	1024·07			42
43	97	94	45	284·12	74	342·49	91	428·31	488·21	565·66	669·75	814·86	1028·44			43
44	225·24	242·24	80	53	311·22	343·07	381·62	429·18	489·34	567·14	671·77	817·76	1032·83			44
45	225·50	242·54	262·15	284·94	311·70	343·65	382·33	430·06	490·47	568·63	673·79	820·69	1037·25			45
46	77	85	50	285·35	312·19	344·23	383·05	95	491·60	570·13	675·83	823·63	1041·71			46
47	226·04	243·16	86	76	68	81	77	431·85	492·74	571·64	677·89	826·59	1046·20			47
48	30	46	263·21	286·18	313·17	345·40	384·49	432·76	493·89	573·16	679·97	829·56	1050·72			48
49	57	77	57	59	66	99	385·21	433·68	495·05	574·69	682·06	832·54	1055·26			49
50	226·84	244·08	263·92	287·00	314·15	346·58	385·93	434·61	496·21	576·23	684·16	835·53	1059·83			50
51	227·11	39	264·28	42	65	347·17	386·66	435·53	497·35	577·77	686·27	838·55	1064·44			51
52	38	70	63	84	315·15	76	387·39	436·45	498·50	579·32	688·40	841·60	1069·09			52
53	65	245·01	99	288·25	64	348·36	388·12	437·38	499·66	580·88	690·53	844·67	1073·78			53
54	92	32	265·34	67	316·14	96	86	438·30	500·83	582·45	692·67	847·76	1078·52			54
55	228·19	245·63	265·70	289·09	316·64	349·56	389·60	439·23	502·01	584·03	694·83	850·87	1083·29			55
56	46	94	266·06	51	317·14	350·16	390·34	440·15	503·21	585·61	697·00	854·00	1088·10			56
57	73	246·26	43	93	65	77	391·08	441·08	504·43	587·20	699·19	857·16	1092·95			57
58	229·01	57	79	290·36	318·15	351·38	83	442·00	505·64	588·79	701·39	860·34	1097·84			58
59	28	89	267·16	78	66	99	392·58	93	506·85	590·39	703·59	863·55	1102·77			59
60	229·55	247·20	267·52	291·20	319·16	352·60	393·33	443·86	508·07	591·99	705·80	866·78	1107·74			60
	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	85°	86°	87°	88°		

TABLE IV.

Factor for Correcting the Quantity in Table I

Argument, Zenith Distance. The Quantity is Positive, and is expressed in Units in the Third Decimal Place.

77°	3
78	3
79	4
80	4
81	5
82	6
83	8
84	10
85	13
86	17
87	24
88	37
88° 40′	50

TABLE V.

Factor for Correcting the Quantity in Table II.

Argument, Zenith Distance. The Quantity is Positive, and is expressed in Units in the Third Decimal Place.

	0′	10′	20′	30′	40′	50′	
75°	19	19	20	20	20	21	75°
76	21	22	22	23	23	24	76
77	24	25	25	26	27	28	77
78	29	30	30	31	32	33	78
79	34	35	36	37	38	39	79
80	40	41	42	44	45	46	80
81	47	49	50	52	54	56	81
82	58	60	62	65	67	70	82
83	72	75	78	81	84	88	83
84	91	95	100	104	109	114	84
85	118	123	129	135	142	149	85
86	156	164	172	181	191	202	86
87	213	225	238	252	268	284	87
88	302	321	342	365	390		88
	0′	10′	20′	30′	40′	50′	

TABLE I.

Argument, Height of the Barometer.

The Quantity tabulated is expressed in Units of the Fourth Decimal Place.

	0	1	2	3	4	5	6	7	8	9	
in.											in.
29·0	−685	−682	−678	−675	−671	−668	−664	−661	−658	−654	29·0
29·1	651	647	644	640	637	634	630	627	623	620	29·1
29·2	616	613	610	606	603	599	596	592	589	585	29·2
29·3	582	579	575	572	569	565	562	558	555	551	29·3
29·4	548	545	541	538	535	531	528	524	521	517	29·4
29·5	514	511	507	504	501	497	494	490	487	484	29·5
29·6	480	477	473	470	467	463	460	457	453	450	29·6
29·7	447	443	440	436	433	430	426	423	420	416	29·7
29·8	413	410	406	403	399	396	393	389	386	383	29·8
29·9	379	376	373	369	366	363	359	356	353	349	29·9
30·0	346	343	339	336	333	329	326	323	319	316	30·0
30·1	313	309	306	303	299	296	293	289	286	283	30·1
30·2	280	276	273	270	266	263	260	256	253	250	30·2
30·3	−246	−243	−240	−237	−233	−230	−227	−223	−220	−217	30·3

in.	
28·4	−894
28·5	−859
28·6	−824
28·7	−789
28·8	−754
28·9	−720
29·0	−685
30·4	−214
30·5	−181
30·6	−148
30·7	−115
30·8	− 83

TABLE II.

Argument, Height of the External Thermometer.

The Quantity tabulated is expressed in Units of the Fourth Decimal Place.

	0	1	2	3	4	5	6	7	8	9	
°											°
25	+846	+844	+842	+840	+838	+835	+833	+831	+829	+827	25
26	825	823	821	818	816	814	811	809	807	805	26
27	803	801	799	797	795	792	790	788	786	784	27
28	782	780	778	776	773	771	769	766	764	762	28
29	760	758	756	754	752	749	747	745	743	741	29
30	739	737	735	732	730	728	725	723	721	719	30
31	717	715	713	710	708	706	704	701	699	697	31
32	695	693	691	689	687	684	682	680	678	676	32
33	674	672	670	668	666	663	661	659	657	655	33
34	653	651	649	647	644	642	640	638	635	633	34
35	631	629	627	625	623	620	618	616	614	612	35
36	610	608	606	604	602	599	597	595	593	591	36
37	589	587	585	583	581	578	576	574	572	570	37
38	568	566	564	561	559	557	555	552	550	548	38
39	546	544	542	540	538	536	533	531	529	527	39
40	525	523	521	519	517	515	512	510	508	506	40
41	504	502	500	498	496	493	491	489	487	485	41
42	483	481	479	477	475	472	470	468	466	464	42
43	462	460	458	456	454	452	450	448	446	444	43
44	442	440	438	436	434	432	429	427	425	423	44
45	421	419	417	415	413	410	408	406	404	402	45
46	400	398	396	394	392	389	387	385	383	381	46
47	379	377	375	373	371	369	367	365	363	361	47
48	359	357	355	353	351	348	346	344	342	340	48
49	338	336	334	332	330	327	325	323	321	319	49
50	317	315	313	311	309	306	304	302	300	298	50
51	296	294	292	290	288	286	284	282	280	278	51
52	276	274	272	270	268	265	263	261	259	257	52
53	255	253	251	249	247	245	243	241	239	237	53
54	235	233	231	229	227	224	222	220	218	216	54
55	214	212	210	208	206	204	202	200	198	196	55
56	194	192	190	188	186	184	182	180	177	175	56
57	173	171	169	167	165	163	161	159	157	155	57
58	153	151	149	147	145	143	141	138	136	134	58
59	132	130	128	126	124	122	120	118	116	114	59
60	112	110	108	106	104	102	100	98	96	94	60
61	92	90	88	86	84	82	80	78	76	74	61
62	72	70	68	66	64	62	60	58	56	54	62
63	52	50	48	46	44	42	40	37	35	33	63
64	+31	+29	+27	+25	+23	+21	+19	+17	+15	+13	64

°	
5	+1288
10	+1176
15	+1064
20	+ 952
21	+ 931
22	+ 910
23	+ 889
24	+ 867
25	+ 846
65	+ 11
66	− 9
67	− 29
68	− 49
69	− 69
70	− 89
75	− 187
80	− 286
85	− 383

TABLE IV.

Argument, Zenith Distance.

The Quantity tabulated is Positive, and is expressed in Units of the Third Decimal Place.

77°	3
78	3
79	4
80	4
81	5

82°	6
83	8
84	10
85	13
86	17

86° 30′	20
87°	24
87° 30′	29
88°	36
88° 40′	47

TABLE V.

Argument, Zenith Distance.

The Quantity tabulated is Positive, and is expressed in Units of the Third Decimal Place.

	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	85°	86°	87°	88°	
0′	18	21	24	28	33	39	47	58	71	91	119	159	219	311	0′
10	18	21	25	29	34	40	49	60	74	95	124	167	231	331	10
20	19	22	25	29	35	42	50	62	77	99	130	176	245	352	20
30	19	23	26	30	36	43	52	65	81	104	137	186	260	375	30
40	20	23	27	31	37	44	54	67	86	108	144	196	276	400	40
50	20	24	27	32	38	46	56	69	87	113	151	207	293		50

TABLE VI.

Argument, Zenith Distance.

The Quantity tabulated is expressed in Units of the Fourth Decimal Place.

	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	85°	86°	87°	88°	
0′	0	−1	−1	−1	−2	−2	−4	−6	−10	−18	−29	−52	−95	−178	0′
10	0	1	1	1	2	2	4	6	11	20	32	57	105	199	10
20	0	1	1	1	2	2	4	7	12	21	36	63	117	223	20
30	0	1	1	1	2	3	5	7	14	22	40	70	129	250	30
40	0	1	1	1	2	3	5	8	15	23	44	77	144	−281	40
50	−1	−1	−1	−1	−2	−4	−6	−9	−17	−26	−48	−85	−160		50

from 12-hour Groups of the 1860, 1864, 1872, 1880, and 1890 Catalogues.

(*The Curves for* 1860 *and* 1864 *are derived from a Comparison with the* 12-*hour Groups of the* 1872 *Catalogue.*)