

the good agreement of catalogues corrected for equator point, and the necessity of including such corrections in the published catalogue as a part of its fundamental system. Such agreement has been further shown in Cp₂₅ (p. xxxvi) and Gr₂₅ (p. A-xvi). Additional comparisons $\Delta\delta_s$ with Cape II 1900 and San Luis 1910 are given by the residuals in the last columns of the tables on pages 56 and 57.

Differences of Declinations, $\Delta\delta_s$

Decl.	W ₂₀ -A _v	W ₂₀ -(Ei)	W ₂₀ -(W ₀₀)	W ₂₀ -(W ₁₀)	W ₂₀ -Gr ₂₅	W ₂₀ -(Bs)	W ₂₀ -N	W ₂₀ -(Cp ₂₅)
° °	"	"	"	"	"	"	"	"
+90 to +85	-0.11	-0.01	0.00	-0.08	-0.09	-0.09		
+85 to +80	-.12	-.12	+.01	-.04	-.04	-.05		
+80 to +75	-.01	+.07	+.04	+.01	+.06	+.01		
+75 to +70	-.04	-.01	+.08	+.02	+.07	+.05	+0.15	
+70 to +65	-.01	+.06	+.08	-.05	+.16	+.02	+.15	
+65 to +60	.00	+.07	+.04	-.09	+.19	-.01	+.15	
+60 to +55	.00	-.02	+.09	-.03	+.23	+.08	+.02	
+55 to +50	+.07	+.04	+.16	+.06	+.24	+.19	-.12	
+50 to +45	+.11	+.09	+.16	+.12	+.13	+.25	+.01	
+45 to +40	+.05	-.01	+.11	+.11	+.09	+.21	+.14	
+40 to +35	+.13	+.07	+.19	+.19	+.24	+.26	+.17	
+35 to +30	+.15	+.07	+.27	+.27	+.19	+.34	+.20	
+30 to +25	+.07	+.01	+.18	+.19	+.24	+.26	+.21	+0.07
+25 to +20	+.12	+.06	+.19	+.26	+.35	+.31	+.22	+.09
+20 to +15	+.11	+.04	+.08	+.20	+.34	+.26	+.26	+.01
+15 to +10	+.09	.00	+.09	+.21	+.20	+.28	+.31	+.03
+10 to + 5	-.02	-.04	-.03	+.01	+.18	+.10	+.15	-.13
+ 5 to 0	+.02	-.05	+.11	+.15	+.20	+.21	-.01	.00
0 to - 5	-.03	+.01	-.02	+.01	+.18	+.04	-.05	-.15
- 5 to -10	-.02	-.06	+.10	+.12	+.09	+.10	-.09	-.08
-10 to -15	-.04	-.07	+.11	+.07	-.08	+.03	-.10	-.16
-15 to -20	-.01	+.01	+.19	+.11	-.16	+.05	-.12	-.13
-20 to -25	-.13	-.08	+.08	-.05	-.27	-.07	-.02	-.23
-25 to -30	-.15	-.21	+.21	.00	-.47	+.03	+.07	-.17
-30 to -35	-.23	-.23	+.12	-.15		-.07		-.37
+30 to -30	.00	.00	+.10	+.10	+.07	+.13	+.07	-.07

REVISION OF THE 1900 CATALOGUE

The present reductions have furnished information applicable to some revision of the reductions of the previous work on this instrument, 1903-1913, as given in Vol. IX, more particularly as to the day terms and the fundamental declination system.

The derivation of personal equation corrections and of the difference between night and day observations in right ascension in the present work shows that the corrections for personal equation for the Sun, as reduced with night clock corrections, given on page A-cxlvii, Vol. IX, virtually included the day terms and are very much the same as found at present, and they should be applied. The personal equations for Mercury and Venus are not known but are small, and for them the night minus day correction $+0^s.04$ found in the present work should be applied.

The corrections to the Ephemeris declination of the Sun, 1903-1913, have the same clamp difference as found in the present observations; moreover, the amount and the variations with declination are similar. Day stars were not observed,

except a few hundred near the ends of the day, but such observations an hour out in daylight show the same day terms as found in the present work. The day observations in 1903–1913 require, therefore, the same day corrections in declination as found in the present work and as given on page 64 above. Conforming to more recent discussions, small additional corrections to the tabular positions of the Moon have been used.

Various solutions were made of the circumpolar observations for correction to the refraction, with the conclusion that, as in the present work, the Pulkowa refractions, reduced to this latitude ($\Delta R = -0''.104$) have been adopted as best representing the Washington observations. See page 53 above.

Having corrected the declinations of the Sun, Moon, Mercury, and Venus as just indicated, the corrections to the Ephemeris declinations for these four objects for the 12 years were meaned in three declination groups, at the equator, and at about 20° each side of the equator, and one group mean was formed for the outer planets. The equator points so determined were combined with the circumpolar equations in a fundamental solution for the declination system. The form of the solution was suggested by the investigations in the present work, and also by preliminary comparisons with fundamental catalogues as follows: The declinations of the 1900 catalogue from 75° north to 75° south of the zenith, corrected for the small change in refraction ($0''.104$ – $0''.134$), were compared with NEWCOMB and with the recent revision of BOSS (*Astr. Jour.* No. 884), giving the following results; where the initial latitude is $+38^\circ 55' 14''.37$.

Provisional Comparisons (W_{00} , 1903–13) with Newcomb and Boss

Decl.	$N - W_{00}$	v	$(Bs) - W_{00}$	v_1	v_2	v_3
"	"	"	"	"	"	"
+67 S.P.	-0.14	-0.07	-0.01	-0.04	+0.14	+0.06
+75 S.P.	- .11	- .06	- .01	- .07	- .09	- .01
+85 S.P.	+ .08	+ .10	+ .11	+ .03	- .07	+ .04
+85	+ .05	+ .07	+ .03	+ .09	+ .17	+ .11
+75	- .16	- .10	- .07	- .04	+ .02	+ .01
+65	- .15	- .04	- .03	+ .02	+ .03	+ .08
+55	- .02	+ .15	- .16	- .06	- .06	+ .03
+45	- .29	- .06	- .34	- .12	- .12	- .02
+35	- .27	+ .01	- .34	+ .01	+ .03	+ .10
+25	- .44	- .10	- .43	+ .03	+ .06	+ .11
+15	- .62	- .22	- .63	- .09	- .07	- .04
+ 5	- .46	- .01	- .60	- .03	- .06	- .03
- 5	- .43	+ .06	- .58	- .05	- .09	- .08
-15	- .36	+ .18	- .45	+ .07	.00	- .04
-25	- .61	- .04	- .44	+ .08	+ .07	- .11

The residuals are from the following solutions:

$$\begin{aligned}
 N - W_{00}, \text{ Latitude, } +38^\circ 55' 14''.11, \Delta\delta &= +0''.34 \sin Z. \\
 (Bs) - W_{00}, \text{ Latitude, } +38^\circ 55' 14''.08, \Delta\delta_1 &= +0''.35 \sin Z + 0''.10 \sin 4Z. \\
 (Bs) - W_{00}, \text{ Latitude, } +38^\circ 55' 14''.07, \Delta\delta_2 &= +0''.17 \tan Z + 0''.17 \sin 4Z. \\
 (Bs) - W_{00}, \text{ Latitude, } +38^\circ 55' 14''.35, \Delta\delta_3 &= -0''.46 \cos \delta + 0''.11 \sin 4Z.
 \end{aligned}$$

These results from comparisons with fundamental catalogues agree closely with the independent solutions from the observations themselves given below, where for the circumpolars,

$$2\Delta\varphi + b(\sin Z' + \sin Z) = \delta' - \delta$$

and for the Sun, Moon and planets

$$\Delta\varphi + b \sin Z = \text{Eph.} - \delta$$

The differences below minus above pole ($\delta' - \delta$) are those given in the last column page A-cxxvii to A-cxxix, Vol. IX, taken in groups of nearly equal weight, and with the small correction for refraction.

Solution of Pole and Equator Points (W_{00} , 1903-13)

Decl.	$\Delta\delta$	O-C	Decl.	$\Delta\delta$	O-C
<i>Pole Stars</i>			<i>Pole Stars</i>		
"	"	" "	"	"	" "
+65.2	-0.17	-0.12	+86.7	-0.19	-0.19 -0.01
+66.3	+ .09	+ .14	+87.2	+ .14	+ .14
+67.4	- .10	- .06	+87.7	- .04	- .04
+68.6	+ .12	+ .16	+88.2	- .05	- .05
+69.7	+ .16	+ .19	+88.7	+ .23	+ .23
+70.5	- .07	- .04 +0.04	+88.8	+ .12	+ .12
+72.1	- .07	- .05	+89.0	- .17	- .17 + .04
+72.7	- .10	- .08			
+73.8	- .14	- .12	<i>Sun</i>		
+74.7	- .08	- .06	+20.0	- .54	- .11
+76.1	+ .07	+ .08	0.0	- .59	- .05
+77.1	- .03	- .02 - .04	-20.0	- .66	- .03
+77.6	.00	+ .01			
+78.3	+ .10	+ .11	<i>Moon</i>		
+79.5	+ .10	+ .11	+20.0	- .04	+ .39
+81.7	- .09	- .09	0.0	- .35	+ .19
+82.1	- .10	- .10	-20.0	- .72	- .09
+82.5	+ .06	+ .06 + .02			
+84.4	- .06	- .06	<i>Planets</i>		
+85.3	+ .19	+ .19	+20.0	- .81	- .38 - .03
+85.7	- .12	- .12	0.0	- .72	- .18 - .01
+86.4	+ .13	+ .13	-20.0	- .42	+ .21 + .03
+86.6	- .01	- .01			

The solution gives:

$$\text{Latitude, } +38^{\circ}55'14''.07, \Delta\delta = +0''.39 \sin Z$$

with the residuals in the last columns.

The coefficient ($\sin Z + \sin Z'$) for the circumpolars is so nearly a constant that the residuals are practically unchanged from the refraction solution, but the actual variations with zenith distance, as shown in the Boss comparison are materially improved, and the latitude is more in accord with other determinations. The declinations were reduced with flexure from the collimators, to which the reflection observations indicate a correction of $0''.13$. The observations therefore give an additional term $+0''.2 \sin Z$, the same as found on page 53 for the present work. Such a term may be due to errors in collimator measures, to flexure, or to refraction effects.

Solutions of the above residuals were also made using $\tan Z$ and $\cos \delta$ instead of $\sin Z$ with the following results:

$$\text{Latitude, } +38^\circ 55' 14''.06, \Delta\delta = +0''.25 \tan Z + 0''.09 \sin 4Z$$

$$\text{Latitude, } +38^\circ 55' 14''.36, \Delta\delta = -0''.55 \cos \delta$$

The large coefficient in $\tan Z$ gives inadmissible residuals in the circumpolars. The cosine form is not symmetrical with the zenith, as flexure or refraction effects should be, and the corresponding latitude stands out from accepted determinations.

The fundamental solution has been adopted giving the following correction to the declinations of the 1903–1913 work, as derived from the work itself, and so keeping it independent.

$$\Delta\delta = -0''.34 + 0''.03 \tan Z + 0''.39 \sin Z$$

Corrections to the Declinations of the Catalogue (W_{00} , 1903–13)

Decl.	$\Delta\delta$	Decl.	$\Delta\delta$	Decl.	$\Delta\delta$	Decl.	$\Delta\delta$
°	"	°	"	°	"	°	"
+66 S.P.	−0.15	+85	−0.03	+35	−0.37	−15	−0.69
+67 S.P.	−.13	+80	−.05	+30	−.40	−20	−.72
+68 S.P.	−.13	+75	−.09	+25	−.44	−25	−.75
+69 S.P.	−.12	+70	−.12	+20	−.47	−30	−.78
+70 S.P.	−.12	+65	−.16	+15	−.51	−31	−.79
+75 S.P.	−.09	+60	−.19	+10	−.55	−32	−.80
+80 S.P.	−.05	+55	−.22	+ 5	−.58	−33	−.80
+85 S.P.	−.02	+50	−.26	0	−.60	−34	−.81
+90 S.P.	.00	+45	−.30	− 5	−.64	−35	−.81
+90	.00	+40	−.34	−10	−.66	−36	−.83

In forming his Standard Catalogue from the Washington and Cape observations, EICHELBERGER corrected W_{00} by $-0''.48 \cos \delta$.

The corrected declinations give the following comparisons with other catalogues. The comparisons were made through Boss; and (Bs), and A_v , are the recent revisions of Bs and A.

Differences in Declinations (W_{00} , 1903–13), minus Catalogue

Decl.	(Bs)	A_v	N	Ei	W_{20}	(W_{10})
°	"	"	"	"	"	"
+67 S.P.	−0.06	−0.05	+0.07	−0.04		
+75 S.P.	−.05	.00	+ .05	−.03		
+85 S.P.	−.13	−.14	−.10	−.12		
+85	−.06	−.07	−.08	−.05	−0.01	−0.07
+75	−.01	+ .04	+ .08	+ .01	−.06	−.04
+65	−.10	−.09	+ .02	−.06	−.06	−.13
+55	−.03	−.02	−.17	−.13	−.12	−.10
+45	+ .08	+ .08	+ .03	−.03	−.14	−.02
+35	+ .01	+ .01	−.06	−.03	−.23	.00
+25	+ .04	−.02	+ .05	−.06	−.18	+ .04
+15	+ .17	+ .15	+ .16	−.02	−.08	+ .12
+ 5	+ .08	+ .01	−.06	−.10	−.04	+ .04
− 5	+ .01	+ .07	−.14	−.14	−.04	+ .02
−15	−.16	−.10	−.25	−.25	−.15	−.06
−27	−.22	−.17	−.05	−.34	−.14	−.07

The observations of the Sun, Moon, Mercury, and Venus from 1903 to 1913 corrected as above outlined were then solved for equinox, equator point, and obliquity by the same methods as used in preceding pages, with the following results:

Corrections for Equinox, Equator, and Obliquity (W_{00} , 1903-13)

Object	No. Obs.	$\Delta\alpha_0$	$\Delta\delta_0$	$\Delta\epsilon$	$\Delta\lambda$	Δe	$\Delta\pi$
		^s	'	"	"	"	"
Sun.....	1, 400	-0. 054	-0. 08	+0. 06	+0. 25	-0. 13	-2. 45
Moon.....	1, 000	- . 037	+ . 14	- . 09	+1. 00		
Mercury.....	500	- . 083	- . 20	+ . 16			
Venus.....	600	- . 060	- . 08	+ . 15			
Planets.....	400		- . 08				
Mean.....		- . 054	- . 04	+ . 05			

The equinox correction $-0^s.054$ to the provisional clock system, or $-0^s.024$ to NEWCOMB, for the 277 clock stars, -16° to $+30^\circ$, is the same as that determined and applied in the 1900 catalogue. This discussion therefore gives no further correction to the right ascensions of that catalogue. This equinox is the same as that found on page 73 for the present work. Had no correction for personal equation been applied it would have been about the same as NEWCOMB's.

The right ascensions of the Sun, Moon, and planets, as published in Volume IX, were referred to the provisional equinox of the clock stars; they require, therefore, the correction $-0^s.053$ to reduce them to the equinox of the catalogue, or $-0^s.024$ to reduce them to NEWCOMB's equinox. The right ascensions of the Sun require the further correction for personal equation including day terms as given on page A-cxlvii, Volume IX, and the right ascensions of Mercury and Venus require the day correction $+0^s.04$.

The equator point correction, $-0''.04$, gives little further correction to the fundamental system just established. The declinations in the 1900 catalogue and of the Sun, Moon, and planet observations in Volume IX require, therefore, the correction

$$\Delta\delta = -0''.34 + 0''.03 \tan Z + 0''.39 \sin Z$$

as given in the table on page 99. The declinations of the Sun, Mercury, and Venus require the further correction, night minus day, given on page 64 of this volume.