

THE ASTRONOMICAL JOURNAL

FOUNDED BY B. A. GOULD.

No. 876

VOL. XXXVII

ALBANY, N. Y., 1927, JANUARY 21

No. 12

FIFTY SEVEN ADDITIONAL CHANDLER-POND STARS,

BY SETH C. CHANDLER

(COMPILED BY H. RAYMOND.)

The following paper presents the declinations of 57 stars observed by POND with two mural circles and reduced by SETH C. CHANDLER, but never published. They form a continuation of his work on 36 principal stars, undertaken during his study of the variation of latitude in 1894-95 and published in five papers in this Journal.^{1, 2, 3, 4, 5} To these papers the reader is referred, but enough will be repeated here to render the tables intelligible.

The observations were made by POND in 1825-35 with two mural circles, observing the star directly with one instrument and its reflection in mercury with the other. Stars near the zenith or horizon were observed directly with both instruments, and gave the relation between the two zero-points. The difference between the two observations, direct and reflected, corrected for the difference of zero-points, gives twice the altitude of the star, from which its declination can be found. It was intended that the direct and reflected observations should be equally divided between the two instruments.

THE STAR LIST

CHANDLER'S manuscripts contain a list of 597 stars with 10,702 double-altitude observations, divided into several classes. One of these contains the 36 principal stars with 7,176 observations — more than two-thirds of the whole number. Another contains the 57 stars here presented, with 979 observations completely reduced. The reduction of the other groups was never begun.

The principle upon which these 57 stars rather than others were selected is not obvious. Probably it was intended to include the stars common to BOSS' *Northern Boundary Catalogue* and AUWERS' *Fundamentalkatalog* that were well observed by POND, but no rigid criterion was adopted. δ Aquilae with 105 observations is unreduced, probably by inadvertence.

The 36 principal stars are included here for completeness, although the declinations of 34 of them have

been published.⁴ The observations of γ Draconis direct, made during 1825-29, were reduced by CHANDLER, as also were those of several deep *sub-polo* stars used in his investigation of the temperature term in the refraction. The corrections for variation of latitude have been applied to these by the compiler, from CHANDLER'S tables, and the results here given. As they are all observed direct with both circles, however, they are put in a separate list at the end of the catalogue. Both internal evidence and oral tradition attest that CHANDLER regarded the halt at this point as only temporary. Unfortunately the pressure of other duties postponed and finally prevented the resumption of the work. NEWCOMB in his *Fundamental Catalogue*⁶ says: "In the case of many of the stars the declinations of the (POND) catalogue were replaced by manuscript results communicated by MR. CHANDLER." These stars are probably those of this list. NEWCOMB tabulates⁷ $\Delta\delta_s$ for CHANDLER-POND down to declination -30° , whereas the most southerly star here given is *Sirius*; but as POND appears not to have observed double altitudes south of this the table must in any case have been extrapolated. These stars may therefore be regarded as constituting the whole of the remainder of CHANDLER-POND.

REDUCTIONS

CHANDLER adopted the zero-points of the two circles derived and used by POND. Only the half-difference is used in reducing the double altitudes. As CHANDLER points out, a revision of the zero-points would make some improvement in detail but would scarcely affect the work systematically, since the direct and reflected observations are nearly evenly divided between the two instruments.

The latitude adopted by CHANDLER was $+51^\circ 28' 38'' .42$, derived from stars observed both above and below pole, including four of the eight refraction stars. Most of the weight of the determination is contributed by *Polaris*. The variation of latitude was

(93)

derived by a series of approximations. Finally a formula ⁸ was adopted, from which a table for application was computed. The correction $+.''046 \tan N. Z. D.$ was applied for difference of level of the mercury basin.

The sine flexure is completely eliminated from these results. The compiler, however, has elsewhere pointed out⁹ that the effective flexure of these circles probably takes place in the attachments of the telescope to the circle and that therefore its mathematical form is unknown, save that it must be periodic. These attachments remained unchanged throughout the period of observation, so that the sine part of the flexure could readily be determined for use with the stars observed direct only. Division errors were never determined. The positions depend upon 24 divisions, except those observed direct only or with but one observation, where the number of division is 12.

The reduction from *apparent* to *mean* place was made with the STRUVE-PETERS elements¹⁰, changing the Aberration Constant to $20''.50$. The refractions were computed with BESSEL's constant. BESSEL's coefficient of expansion was confirmed in (1).

The positions are corrected for proper-motion to 1830.0. CHANDLER used the data of the *Northern Boundary Catalogue* for this purpose, except for one or two stars, but the compiler has modified the positions to correspond to the annual variations of the *Preliminary General Catalogue*. The change never exceeds $0''.04$. Corrections for orbital motion have been applied to the declinations of four stars to reduce to the center of gravity. The quantities were taken from the *Preliminary General Catalogue*, Appendix II, correcting the error of sign in the table for *Castor*. CHANDLER had already applied different corrections to two of them. The four stars are:

P. G. C.	Corr.	CHANDLER	Added
	"	"	"
1732	+1.65	+1.55	+0.10
1979	-0.37		
2008	+1.25	+1.01	+0.24
4246	+0.11		

Slight errors of reduction in α *Persei*, *s. p.*, and α *Virginis* were corrected. The modifications described in this paragraph are the only changes made in CHANDLER's results.

CHANDLER omitted but six observations of these 57 stars. The omissions are:

P. G. C. Remarks

- 1339 One, Date lacking.
3117 Two, One, with $7''$ discrepancy, has the note that a change from T direct — J refl.

to J direct — T refl. will bring about agreement. The other has a discrepancy of $2''.5$.

5433-34 Two observations marked "mean" omitted.

5452 One, $10''$ discrepancy. Apparently $20''$ misread on T.

THE CATALOGUE

The catalogue gives first the *Preliminary General Catalogue* number of the star, starred if it is one of the 36 principals: second, its name: third, approximate right ascension: fourth, CHANDLER-POND declination for 1830.0: fifth, sixth, seventh and eighth, the seconds of declination, annual and secular variations and proper-motions for the same date from the *Preliminary General Catalogue*. The declinations and annual variations were taken from the final "expansion sheets" used in the preparation of that work and take note of an additional decimal place in the variations, suppressed in publication. Because of the large time interval, a computation based upon the printed data may differ by as much as $0''.05$ in declination or $0''.001$ in annual variation from the figures here given. The ninth and tenth columns give the mean epoch of the observations and their number. An "Observation" means the result of a pointing with both instruments at one culmination — a double-altitude.

A comparison with the *Preliminary General Catalogue* gives the systematic differences of Table I in the sense BOSS — CHANDLER-POND.

TABLE I

SYSTEMATIC CORRECTIONS AND WEIGHTS					
$\Delta\delta_\alpha = (+0''.061 \pm 0''.023) \sin \alpha - (0''.063 \pm 0''.028) \cos \alpha$					
δ °	$\Delta\delta_\delta$ "	δ °	$\Delta\delta_\delta$ "	δ °	$\Delta\delta_\delta$ "
+90	+0.05	+50	-0.14	+10	-0.17
85	.00	45	-.22	5	-.13
80	-.06	40	-.26	0	-.06
75	-.09	35	-.23	-5	.00
70	-.07	30	-.18	10	+.10
65	-.05	25	-.15	15	+.20
60	-.05	20	-.15	20	+.30
55	-.08	15	-.17		
No. Obs.		Wt.		No. Obs.	
1		0.3		20 - 25	
2		0.6		26 - 37	
3 - 5		1.0		38 - 56	
6 - 8		1.5		57 - 90	
9 - 10		2.0		91 - 200	
11 - 12		2.5		201 - 300	
13 - 15		3.0		300 -	
16 - 19		3.5			

TABLE II — CATALOGUE

No.	Star	R. A.	Decl. Ch.-P.	Boss	A. V.	S. V.	μ'	Epoch 1800+	Obs.
		^h ^m	[°] ' "	"	"	"	"		
10*	α Andromedæ	23 59.6	+28 9 5.90	5.71	+19.892	-.008	-.161	29.6	195
27*	γ Pegasi	0 4.5	+14 14 17.22	17.16	+20.036	-.017	-.013	29.6	99
123	π Andromedæ	27.8	+32 46 56.38	56.55	+19.896	-.064	-.009	30.3	6
132	δ Andromedæ	30.2	+29 55 45.39	45.84	+19.793	-.069	-.086	30.5	6
135*	α Cassiopeiae	30.9	+55 36 13.20	13.21	+19.840	-.074	-.031	27.8	91
164	ζ Andromedæ	0 38.4	+23 20 26.96	26.98	+19.093	-.086	-.080	31.1	5
199	γ Cassiopeiae	46.5	+59 47 38.76	39.10	+19.640	-.112	-.002	27.6	12
203	μ Andromedæ	47.4	+37 34 31.64	31.80	+19.654	-.108	+.027	30.4	5
259	β Andromedæ	1 0.2	+34 45 2.03	1.35	+19.249	-.135	-.114	30.9	4
314	δ Cassiopeiae	14.8	+59 20 53.85	54.23	+18.950	-.189	-.045	27.0	11
325*	Polaris	0 59.5	+88 24 8.48	8.50	+19.385	-.592	+.005	28.2	317
325*	s.p.	59.5	8.47	8.50	+19.385	-.592	+.005	27.7	257
477*	α Arietis	1 57.6	+22 39 16.14	16.03	+17.325	-.249	-.145	28.9	186
643	41 Arietis	2 40.0	+26 33 15.11	15.00	+15.248	-.336	-.113	28.8	13
691	α Ceti	53.4	+ 3 25 3.64	3.44	+14.504	-.319	-.077	27.2	28
698	ρ Persei	54.3	+38 10 31.34	30.44	+14.419	-.390	-.107	31.0	2
772	α Persei	3 12.2	+49 14 55.08	54.35	+13.375	-.465	-.028	26.0	27
838	δ Persei	30.9	+47 14 8.74	8.58	+12.115	-.496	-.033	26.6	9
913	ξ Persei	48.0	+35 17 40.27	40.52	+10.913	-.477	-.012	31.8	5
1000	γ Tauri	4 10.1	+15 12 35.80	35.55	+ 9.223	-.445	-.026	28.1	12
1077*	Aldebaran	26.2	+16 9 35.90	35.70	+ 7.792	-.463	-.190	28.8	181
1187	ϵ Aurigæ	4 49.8	+43 33 43.14	43.64	+ 6.035	-.599	-.013	31.1	1
1246*	Capella	5 4.1	+45 48 53.87	53.61	+ 4.412	-.629	-.428	28.4	141
1304*	β Tauri	15.5	+28 27 18.44	18.05	+ 3.688	-.544	-.177	29.3	135
1339	δ Orionis	23.3	- 0 25 56.25	55.95	+ 3.193	-.442	-.003	27.2	36
1370	ϵ Orionis	27.6	- 1 19 3.71	3.68	+ 2.824	-.440	-.002	27.3	34
1468*	α Orionis	5 46.0	+ 7 22 3.65	3.50	+ 1.236	-.474	+.008	28.6	114
1478	β Aurigæ	47.1	+44 55 11.96	11.37	+ 1.126	-.641	-.006	29.2	24
1482	θ Aurigæ	48.1	+37 11 28.26	28.37	+ 0.949	-.597	-.089	31.7	3
1732	Sirius	6 37.7	-16 29 20.90	20.19	- 4.491	-.373	-1.210	25.7	5
1898	δ Geminorum	7 10.0	+22 17 14.38	14.57	- 6.044	-.497	-.017	30.0	7
1979*	Castor	7 23.7	+32 15 8.85	8.73	- 7.276	-.518	-.111	29.1	209
2008*	Procyon	30.4	+20 41 15.24	15.37	- 8.742	-.412	-1.034	26.9	124
2031*	Pollux	34.9	+28 25 44.95	44.89	- 8.130	-.483	-.062	29.3	216
2507	α Lyncis	9 10.7	+35 6 21.63	21.29	-14.816	-.353	+.009	30.2	5
2533	α Hydrae	17.2	- 7 55 33.69	33.66	-15.288	-.271	+.031	27.3	10
2602	α Leonis	9 32.1	+10 39 41.06	41.03	-16.059	-.274	-.040	29.5	7
2618	ϵ Leonis	36.2	+24 33 9.63	9.85	-16.257	-.286	-.024	27.6	32
2648	μ Leonis	43.1	+26 48 12.68	12.27	-16.644	-.273	-.064	29.9	12
2698*	Regulus	59.3	+12 47 41.06	40.79	-17.340	-.226	-.004	28.0	141
2729	λ Ursæ Minoris	10 6.8	+43 45 34.46	34.77	-17.702	-.245	-.046	32.2	3

TABLE II — CATALOGUE

No.	Star	R. A.	Decl. Ch.-P.	Boss	A. V.	S. V.	μ'	Epoch 1800+	Obs.
		h m	° ' "	"	"	"	"		
2742*	γ Leonis	10 10.6	+20 41 53.36	53.24	-17.962	-.216	-.152	28.8	142
2933*	α Ursae Majoris	53.2	+62 40 0.18	0.35	-19.280	-.150	-.075	27.7	130
2972*	δ Leonis	11 5.1	+21 27 13.49	13.67	-19.624	-.102	-.145	27.9	116
3101	β Leonis	40.4	+15 31 19.42	19.45	-20.103	-.029	-.123	30.7	38
3117	γ Ursae Majoris	44.8	+54 38 23.98	23.65	-20.006	-.023	+.003	26.6	61
3155	α Virginis	11 56.5	+ 9 40 39.28	36.82	-20.013	+.002	+.038	28.9	12
3190*	δ Ursae Majoris	12 7.0	+57 58 39.76	39.87	-20.041	+.023	+.003	27.4	74
3474	ζ' Ursae Majoris	13 17.1	+55 48 55.39	55.16	-18.961	+.126	-.031	27.4	45
3476	Spica	16.2	-10 16 17.00	16.72	-18.989	+.158	-.036	27.4	24
3508	ζ Virginis	26.0	+ 0 16 34.60	34.15	-18.622	+.169	+.035	28.9	10
3596	η Bootis	13 46.6	+19 15 11.26	11.37	-18.289	+.194	-.367	29.1	11
3612	τ Virginis	53.0	+ 2 22 15.10	15.01	-17.690	+.218	-.025	29.0	6
3626*	α Draconis	59.8	+65 11 25.55	25.63	-17.360	+.124	+.016	28.4	134
3662*	Arcturus	14 7.9	+20 4 15.97	15.79	-19.008	+.212	-1.999	28.2	288
3771*	ϵ Bootis	37.6	+27 47 42.47	42.40	-15.490	+.248	+.008	28.7	148
3809*	β Ursae Minoris	14 51.3	+74 51 1.15	0.79	-14.701	-.023	+.006	29.0	194
3961*	α Coronae Bor.	15 27.5	+27 17 30.19	30.30	-12.484	+.297	-.103	28.3	214
4001*	α Serpentis	35.9	+ 6 57 58.57	58.43	-11.757	+.354	+.037	28.0	169
4134	δ Ophiuchi	16 5.4	- 3 14 60.09	59.89	- 9.764	+.405	-.153	25.5	2
4220	σ Herculis	28.6	+42 47 32.18	31.23	- 7.750	+.263	+.035	29.7	5
4246	ζ Herculis	16 34.9	+31 54 56.37	55.99	- 6.890	+.305	+.388	29.0	16
4373*	α Herculis	17 6.9	+14 35 25.94	25.68	- 4.579	+.390	+.027	28.8	195
4381	π Herculis	9.1	+37 0 19.86	19.71	- 4.416	+.298	-.002	30.5	4
4419	ρ_2 Herculis	17.8	+37 18 26.21	25.48	- 3.673	+.297	-.004	29.0	9
4459*	α Ophiuchi	27.0	+12 41 25.61	25.14	- 3.109	+.404	-.236	28.9	219
4497	μ Herculis	17 39.8	+27 49 32.46	31.96	- 2.513	+.338	-.747	28.7	12
4535	θ Herculis	50.4	+37 16 40.29	39.86	- 0.833	+.300	+.004	29.0	12
4591	δ Ursae Minoris	18 27.1	+86 35 7.21	7.26	+ 2.414	-2.770	+.046	30.1	69
4591	s.p.	27.1	7.02	7.26	+ 2.414	-2.770	+.046	33.1	6
4638	η Serpentis	12.5	- 2 56 8.05	8.72	+ 0.399	+.446	-.696	25.7	2
4722*	Vega	31.2	+38 37 48.83	48.40	+ 2.997	+.294	+.278	28.3	292
4776*	β Lyrae	18 44.1	+33 10 13.30	13.09	+ 3.803	+.315	-.007	28.7	258
4824	γ Lyrae	52.6	+32 27 41.33	41.24	+ 4.554	+.317	-.007	28.8	18
4858*	ζ Aquilae	57.6	+13 37 1.34	1.16	+ 4.885	+.388	-.102	29.2	205
4909*	δ Draconis	19 12.5	+67 21 45.56	45.45	+ 6.324	+.005	+.088	29.5	180
5047*	γ Aquilae	38.2	+10 12 17.88	17.78	+ 8.326	+.375	-.004	30.6	162
5048	δ Cygni	19 39.7	+44 43 10.77	11.50	+ 8.485	+.245	+.036	29.7	2
5062*	α Aquilae	42.5	+ 8 25 32.19	31.78	+ 9.048	+.386	+.376	28.5	481
5093*	β Aquilae	47.0	+ 5 59 17.77	17.38	+ 8.540	+.380	-.483	30.5	164
5320*	α Cygni	20 35.6	+44 40 35.19	35.04	+12.594	+.226	-.001	27.3	435
5431	ξ Cygni	58.8	+43 15 11.60	11.03	+14.099	+.220	-.003	29.6	6

TABLE II — CATALOGUE

No.	Star	R. A.	Decl. Ch.-P.	Boss	A. V.	S. V.	μ'	Epoch 1800+	Obs.
		^h ^m	[°] ' "	"	"	"	"		
5433	61 ¹ <i>Cygni</i>	20 59.3	+37 55 4.90	4.52	+17.356	+ .302	+3.220	26.0	131
5434	61 ² <i>Cygni</i>	59.3	+37 55 5.09	4.20	+17.170	+ .328	+3.032	32.2	10
5452	ζ <i>Cygni</i>	21 5.7	+29 32 1.05	0.66	+14.469	+ .250	+ .059	27.3	25
5460	τ <i>Cygni</i>	8.0	+37 19 23.97	23.78	+15.093	+ .233	+ .426	32.7	10
5480*	α <i>Cephei</i>	14.5	+61 52 2.66	2.41	+15.097	+ .135	+ .048	29.6	206
5527	β <i>Aquarii</i>	21 22.6	- 6 18 52.38	52.35	+15.499	+ .286	- .007	25.8	2
5532*	β <i>Cephei</i>	26.4	+69 48 56.01	55.88	+15.722	+ .067	+ .005	29.5	203
5676	α <i>Aquarii</i>	57.0	- 1 8 32.09	32.24	+17.230	+ .222	- .006	26.5	85
5761	γ <i>Aquarii</i>	22 12.9	- 2 14 28.21	27.38	+17.911	+ .197	+ .009	28.7	1
5940	β <i>Pegasi</i>	55.5	+27 9 44.31	44.28	+19.398	+ .109	+ .132	29.8	11
5944*	α <i>Pegasi</i>	22 56.3	+14 17 32.26	32.09	+19.238	+ .111	- .045	29.1	161
6078	γ <i>Cephei</i>	23 32.3	+76 41 2.29	1.88	+20.067	+ .033	+ .158	27.8	6
6080	κ <i>Andromedæ</i>	32.1	+43 23 36.33	35.88	+19.880	+ .043	- .024	31.7	4
STARS OBSERVED DIRECT ONLY									
135	α <i>Cassiopeiæ</i> s.p.	0 30.9	+55 36 13.62	13.21	+19.840	- .074	- .031	26.3	36
772	α <i>Persei</i> s.p.	3 12.2	+49 14 55.60	54.35	+13.375	- .465	- .028	26.4	5
1246	<i>Capella</i> s.p.	5 4.1	+45 48 53.51	53.61	+ 4.412	- .629	- .428	27.4	10
3117	γ <i>Ursæ Majoris</i> s.p.	11 44.8	+54 38 23.68	23.65	-20.006	- .023	+ .003	26.4	43
3566	η <i>Ursæ Majoris</i> s.p.	13 4.0	+50 9 51.68	51.88	-18.163	+ .155	- .020	26.7	41
4443	β <i>Draconis</i> s.p.	17 2.5	+52 25 49.93	49.56	- 2.906	+ .195	+ .007	26.6	16
4541	γ <i>Draconis</i>	17 52.2	+51 30 43.02	43.53	- 0.668	+ .203	- .026	27.3	635
4541	s.p.		43.39	43.53	- 0.668	+ .203	- .026	26.7	50
5320	α <i>Cygni</i> s.p.	20 35.6	+44 40 35.90	35.04	+12.594	+ .226	- .001	27.2	11

REFERENCES.

1. S. C. CHANDLER, POND's double altitude observations 1823-25, A. J. **14**, 1, 1894.
2. S. C. CHANDLER, POND's double altitude observations 1823-25, A. J. **14**, 17, 1894.
3. S. C. CHANDLER, Variation of latitude from the Greenwich mural circle observations, A. J. **14**, 57, 1894.
4. S. C. CHANDLER, On a new determination of the constant of nutation, A. J. **16**, 1, 1895.
5. S. C. CHANDLER, On standard systems of declinations and proper-motions, A. J. **16**, 28, 1895.
6. SIMON NEWCOMB, Astronomical Papers, American Ephemeris **8**, 126.
7. SIMON NEWCOMB, Astronomical Papers, American Ephemeris **8**, 232.
8. S. C. CHANDLER, On the inequalities of the coefficients of the law of latitude variation, A. J. **14**, 73, 1894.
9. H. RAYMOND, Corrections to the declination system of Boss, etc., A. J. **36**, 132, 1926.
10. OTTO STRUVE, Tabulae quantitatuum Besselianarum pro annis 1750 ad 1840 computatae, Petropoli, 1869.

Department of Meridian Astrometry
Carnegie Institution of Washington
Dudley Observatory, Albany, N.Y.
December 2, 1926.

ON BINARY ORBITS OF THE TYPE OF 42 COMAE BERENICES,

By KURT LAVES.

In continuation of No. 865 of this Journal the special case is here considered when the plane of the orbit is perpendicular to the tangential plane of projection.

By a simple geometric consideration the equations for e , a and ω are derived and it is shown that these equations are in agreement with MOULTON's results,