Astronomy and astro-physics

THE

SIDEREAL MESSENGER;

A

Monthly Review of Astronomy.

VOLUME V, 1886.

Conducted by WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

NORTHFIELD, MINN.
CARLETON COLLEGE OBSERVATORY,
1886.

QB1
A82
V.5

134448

LIBRARY
LELAND STANFORD JUNIOR
UNIVERSITY

VOLUME V, 1886.

CONTENTS:

By faith we understand that the worlds have been framed by the word of God, so that which is seen hath not been made out of things which do appear.

JANUARY.

CONTENTS.

FEBRUARY.

MARCH.

APRIL.

CONTENTS.

CONTENTS.

JULY.

Articles:—

OCTOBER.

Articles:—

NOVEMBER.

Articles:—

CONTENTS.

DECEMBER.

The Sidereal Messenger

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

VOL. 5. No. 1. JANUARY, 1886. WHOLE No. 41.

SMALL TELESCOPES VS. LARGE.

PROFESSOR C. A. YOUNG.

[For the Messenger.]

Although the subject has been pretty thoroughly canvassed of late, it may, perhaps, be permitted to add a few words more to the discussion.

The first thing to be said, and always borne in mind, is that the excellence of an observer's eye and his power of *perceiving* what he sees (i. e. of getting an idea from the impression on his retina) have quite as much to do with the discovery and delineation of planetary features as the excellence and power of the telescope used. The writer certainly would not expect to be able to make out with the instruments of such eagle-eyed observers as DAWES and KAISER and SCHIAPARELLI all that they detected. Mr. DENNING has quoted against the great telescope at Washington the small amount of detail shown upon certain drawings of *Mars* by Professor HARKNESS. But it is well known to many that other drawings, made about the same time, by a junior observer, and since then communicated to TERBY at Louvain, exhibit everything that appears upon the best maps of SCHIAPARELLI. It is altogether probable that an observer blest with exceptionally perfect vision could see on *Jupiter*, with a power of 300 on an 8-inch telescope, all that most of the rest of us could make out with a power of 800 on an 18-inch instrument:—but give him the larger instrument, and then!—the writer for one is very sure that even the perfect eyes would never again be contented with the smaller glass.

Another remark is that the discordance between the different maps of *Mars* indicates that the best and most keen-eyed of observers unconsciously supplement what they really see, with details which they only *think* they see; so that in the finished drawing fact and fancy are inextricably mingled. The later observer with larger telescope and higher power naturally fails to recognize many features, and some, he has to repudiate.

As regards atmospheric disturbance, there can be little doubt that the smaller beam of light incident upon a smaller object glass is less affected; and so, with a given magnifying power, the image formed by the smaller telescope is somewhat better defined and less veiled by stray light. But the mal-definition produced in this way, instead of increasing with the *cube* of the diameter of the object-glass, as has been asserted, probably varies much more nearly with its square root, or even with some still more slowly growing function. Under ordinary atmospheric conditions, if the writer's experience is worth anything, the patch of stray light around a star image, and its apparent 'dancing' is not nearly twice as great with our 23-inch object glass as with our 9½-inch; using, not the same eye-piece of course, but the same magnifying power in both cases. Usually, in the writer's judgment, this slight gain in definition, only about balances the loss in definition due to the diffraction effect of the diminished aperture. And of course the loss of light is wholly unbalanced.

Probably however the best test would be an actual trial made by varying the aperture of a telescope without changing the magnifying power.

We tried the experiment here on the evening of Friday, the 20th. The night was rather a poor one for star definition: on a scale of *ten* the seeing would be recorded as about five or six. We pointed the telescope on *Saturn*, about 1*h* 30*m* sidereal time, using first the whole aperture of 23 inches, and a Steinheil mono-centric eye-piece, giving a power of 480: the object would not bear a power of 700, which was tried and rejected.

On the outer ring, A, ENCKE's division (?) was faintly perceptible at times, very near the middle of the ring: Y thought it a little nearer the outer edge, but MCNEILL on the contrary, thought it a little inside the middle. No markings were visible on the brighter ring B. The dusky ring C was fairly well seen: it was a little fainter and more transparent on the eastern ansa than on the western, so that the eastern limb of the planet could be traced through it nearly to the edge of ring B. On the planet, the bright equatorial belt was conspicuous, bounded on the southern edge by a narrow dark stripe. Another dark belt was visible near the poles, where the Arctic circle ought to be; and between this and the southern tropic were faintly visible two other narrow darkish stripes, best made out near the planet's central meridian.

On the western side of the planet its shadow was just perceptible on ring C, and on ring B was of course conspicuous. Y. could not perceive certainly anything abnormal in its outline, but McN. thought it *straighter* than it should have been if the ring were plane. It seemed to terminate exactly in the Cassinian division between B and A. *Enceladus* was easily seen, coming out towards eastern elongation, but we could not find *Mimas*.

We now (at 2.0*h*, sidereal time) cut down the aperture to 15 inches. The appearance was only slightly altered. The limb of the planet was perhaps a little sharper, but the inner edge of ring C was not so easily seen. The shadow of the planet seemed to Y. to show indications of a knot or lump where it touched CASSINI's division. ENCKE's stripe was still perceptible. On the whole it was impossible to say whether the smaller aperture, was, or was not, an improvement. *Enceladus* was a little fainter, but still easily seen, and the planet of course was not as bright as before.

About 2:15 or 2:20 we cut down the aperture again; this time to 9 inches: and it certainly made surprisingly little difference — at least that was our impression at the moment. ENCKE's stripe could no longer be made out by Y.; but everything else remained, though ring C was rather misty in outline and the eastern limb of the planet not clearly seen through it. The belts on the planet were all visible, and the 'knot' on the shadow, before alluded to, was very evident to Y., though McN. was not so sure about it. *Enceladus* even could still be seen, for the planet was fainter and the background darker. There did not seem to be any gain in sharpness over the 15-inch aperture, and the boiling and dancing was not perceptibly lessened. Still we were obliged to admit that we could see fairly with 9 inches about everything we had been able to make out with the whole aperture.

But now we removed the cap; and this time there was a change. At our first observation the planet was only 25° high, and not fairly out of the haze. Now, at 2:40, it was nearly 40° high, and although the air was still boiling, it had cleared the mists, and shone out splendidly. ENCKE's stripe was perhaps no better seen than at first, but everything else was improved immensely. A faint dark streak came out just on the equator, exactly in the middle of the bright equatorial belt; the tropical belt showed, though not very clearly, a pronounced filamentary structure like that of the belts of *Jupiter*, and the polar cap, inside the Arctic circle belt, showed faintly its peculiar greenish hue. It is to be noted by the way, however, that there was almost none of the bright pink color upon the planet's disc, which was so conspicuous two or three years ago.

On the *east* side of the planet the shadow was now visible as an exceedingly fine dark line, just dividing the planet's limb from ring B, and sharply defining it. On the *western* side the shadow was well seen on ring C, and its outline on ring B was perfectly normal and regular: the imagined knot had disappeared — a mere optical illusion, in this case at least. On ring B a faint, ill-defined, concentric structure was indicated, a sort of 'brush-marking', as if the ring were a painting made with a flat brush, not by radial strokes, but by a circular sweep. There were no distinct stripes that the eye could seize upon, and yet the general impression was quite decided. *Enceladus* shone out strong and clear like a star of 3rd or 4th magnitude; and in spite of the boiling and dancing, and without any previous knowledge of its position, we now detected *Mimas*, creeping out to conjunction with the western extremity of the ring. Both observers agreed that there was simply no comparison between the 9-inch and the 23-inch aperture. If the 'seeing' had been better, what we should rank as 8 or 9, instead of 5 or 6, the difference would probably have been still more striking.

PRINCETON, N. J., November 27th, 1885.

P. S. We estimated the conjunction (inferior) of *Mimas* with the western edge of the ring as occurring at 2*h* 51*m* Princeton sidereal time.

GALLE'S CATALOGUE OF COMETS FROM 1860 TO 1884.

(*Continued from page 273, vol. 4.*)

237. M. N. 26: 84. Observed in the southern hemisphere only. Seen with the naked eye January 17, by ABBOTT at Hobart Town; January 18, by MOESTA at Santiago and by ELLERY at Melbourne; observed at the Cape from January 22 to May 2 by MANN. The above corrected elements by TEBBUTT Jr. represent very well the Melbourne and Windsor observations.

(96) E. Mem. de l'acad. de St. Petersb. 26 (1878). Seen February 13 at Leipzig by BRUHNS and ENGELMANN, and probably, also, before that date, by D'ARREST at Copenhagen (January 25). It could not be observed, however, till after perihelion, when it was seen, June 24, by TEBBUTT at Windsor and MANN at the Cape: last observed at the Cape July 22, though seen again July 23.

238. A. N. 68: 249. Discovered 1865, December 19, by TEMPEL at Marseilles, and 1866, January 5, by TUTTLE at Cambridge, U. S.; last observed February 9 by v. OPPOLZER at Vienna. According to OPPOLZER's most probable orbit, deduced from all the observations, the period of revolution is 33.18 years. A computation made at the same time by PECHULE (A. N. 68: 270) leads to very nearly the same result. An agreement between the orbit of Comet 1866 I and the orbit of the meteors of November 13, as computed by SCHIAPARELLI and LE VERRIER was remarked by PETERS, and this comet in connection with Comet 1862 III furnished the data for SCHIAPARELLI'S discovery of 1866.

(163) F. Verhandl. d. Akad. in Stockholm 1872. FAYE's comet. Found 1865 August 22 at Copenhagen by THIELE; last observed 1866 January 12 at the same place by D'ARREST.

239. A. N. 69:111. Discovered at Marseilles by STEPHAN, January 25, and at the same place by TEMPEL January 28; last observed by WINLOCK, at Cambridge, U. S., April 3. The ellipse satisfies the observations as far as they go.

240 T_1. A. N. 74: 103. Discovered April 3 at Marseilles by TEMPEL; last observed August 21 by SCHMIDT at Athens, though seen till August 27. The elliptic form of the orbit was soon remarked, and it has been confirmed by the return of the comet in 1873 and 1879.

241. A. N. 73: 57. Discovered September 26 by BAEKER at Nauen and about four hours later by WINNECKE at Toennisstein near Brohl on the Rhine. Last observed October 31 at Helsingfors by KRUEGER. Elements from October 1, 14 and 27—in part normal places.

(171) Br. A. N. 93: 183. BRORSEN's comet. Found at Athens, April 11, by SCHMIDT, and about the same time by other astronomers also; last observed June 23 by SCHMIDT.

242. Manuscript; also Annuaire 1884: 214. Discovered June 13 by WINNECKE at Carlsruhe; last observed July 17 by SCHMIDT at Athens. The most probable parabola from the observations used, divided into seven normals; no ellipticity perceived.

(96) E. Mem. de St. Petersb. 26 (1878). Found July 17 by WINNECKE at Carlsruhe; last observed September 3 by VOGEL at Leipzig.

(131) W. A. N. 97: 338. WINNECKE's comet. Found by WINNECKE himself, April 9, at Carlsruhe; last observed October 12 by WEISS at Vienna. The first return of this periodic comet since its second discovery, 1858.

243. A. N. 81: 143. Discovered by TEMPEL at Marseilles, October 11; last observed November 12 by WEISS at Vienna. KOWALCZYK, SEYDLER (Wien Ak. S. B. 1871) and DOBERCK (A. N. 79: 384) have made accurate computations of the orbit from the few observations which were obtained. All three computations, although by different methods, give substantially the same result.

SUMMARY OF THE ORBIT-ELEMENTS OF COMETS WHICH HAVE APPEARED SINCE 1860.

No.	Year	T [Paris M. T.]		π		☊		i		log. q	e	Mot.	Computer.
		h	m	°	'	°	'	°	'				
216	1860 I A	Feb. 16, 15	9	173	50	324	4	79	40	0.0788		D	Pechule
216	1860 I B	Feb. 16, 16	14	173	45	324	3	79	36	0.0785		D	Pechule
217	1860 II	Mar. 5, 13	44	50	5	8	53	48	13	0.1162		D	Gylden
218	1860 III	June 16, 1	18	161	32	84	41	79	19	9.4667		D	Auwers
219	1860 IV	Sept. 22, 7	38	356	48	44	51	32	12	9.8342		D	Kowalczyk
220	1861 I	June 3, 9	31	243	22	29	56	79	46	9.9641	0.98346	D	v. Oppolzer
221	1861 II	June 11, 12	19	249	5	278	59	85	26	9.9151	0.98508	D	Kreutz
222	1861 III	Dec. 7, 4	21	173	31	145	6	41	59	9.9238		R	Noether
(96) E	1862 I	Feb. 6, 5	59	158	1	334	31	13	5	9.5314	0.84670	D	v. Asten
223	1862 II	June 22, 0	53	299	20	326	33	7	54	9.9918		R	Seeling
224	1862 III	Aug. 22, 22	3	344	42	137	27	66	26	9.983[illegible]		R	v. Oppolzer
225	1862 IV	Dec. 28, 4	20	125	11	355	46	42	29	9.9048		R	Krahl
226	1863 I	Feb. 3, 11	55	191	23	116	56	85	22	9.9002		D	Engelmann
227	1863 II	Apr. 4, 21	52	247	16	251	16	67	22	0.0286		R	Frischauf
228	1863 III	Apr. 20, 20	49	3[illegible]5	47	250	11	85	29	9.7985		D	Frischauf
229	1863 IV	Nov. 9, 11	50	94	43	97	29	78	5	9.8492		D	v. Oppolzer
230	1863 V	Dec. 27, 18	28	60	24	304	43	64	29	9.8873		D	Valentiner
231	1863 VI	Dec. 29, 4	17	183	8	105	2	83	19	0.1183		D	Rosen
232	1864 I	July 27, 19	38	188	53	174	59	45	0	9.7966		R	Kowalczyk
233	1864 II	Aug. 15, 14	0	304	12	95	15	1	52	9.9587	0.99635	R	Kowalczyk
234	1864 III	Oct. 11, 10	37	159	18	31	45	70	18	9.9690		R	v. Asten
235	1864 IV	Dec. 22, 10	59	321	41	203	13	48	53	9.8869		D	Kowalczyk
236	1864 V	Dec. 27, 17	26	162	24	340	54	17	7	0.0471		R	Valentiner
237	1865 I	Jan. 14, 7	58	141	16	253	3	87	32	8.4148		R	Tebbutt
(96) E	1865 II	May 27, 22	21	158	4	334	33	13	4	9.5327	0.84630	D	v. Asten
228	1866 I	Jan. 11, 3	22	60	28	231	26	17	18	9.9897	0.90542	R	v. Oppolzer
(163) F	1866 II	Feb. 13, 23	32	49	56	209	42	11	22	9.2259	0.55754	D	Moeller
239	1867 I	Jan. 19, 20	49	75	52	78	36	18	13	0.1966	0.84906	D	Searle
240 T_1	1867 II	May 23, 22	15	236	9	101	10	6	25	0.1941	0.50971	D	Sandberg
241	1867 III	Nov. 6, 23	15	276	22	64	59	83	26	9.5191		R	v. Oppolzer
(171) Br	1868 I	Apr. 17, 10	17	116	2	101	14	29	22	9.7760	0.80797	D	Schulze
242	1868 II	June 26, 11	35	285	38	52	15	48	27	9.7624		R	Karlinski
(96) E	1868 III	Sept. 14, 14	53	158	11	334	32	13	7	9.5233	0.84913	D	v. Asten
(131) W	1869 I	June 29, 22	44	275	55	113	33	10	48	9.8929	0.75190	D	v. Oppolzer
243	1869 II	Oct. 9, 20	39	123	17	311	30	68	20	0.0902		R	Kowalczyk
244 T_3	1869 III	Nov. 18, 19	25	42	58	296	44	5	24	0.0266	0.65813	D	Schulhof and Bossert
245	1870 I	July 14, 2	8	303	32	141	45	58	12	0.0038		R	Seydler
246	1870 II	Sept. 2, 4	53	17	53	12	56	80	39	0.2593		R	Gerst
(189) D'A	1870 III	Sept. 22, 16	46	318	41	146	25	15	39	0.1073	0.63487	D	Leveau
247	1870 IV	Dec. 19, 21	11	4	9	94	45	32	44	9.5902		R	Schulhof
248	1871 I	June 10, 14	33	141	50	279	19	87	36	9.8158	0.99781	D	Holetschek
249	1871 II	July 27, 0	59	115	34	211	54	78	1	0.0348		R	Cramer
(102) Tu	1871 III	Nov. 30, 11	18	116	5	269	18	54	17	0 0129	0.82105	D	Tischler
250	1871 IV	Dec. 20, 9	18	264	13	147	6	81	40	9.8397	0.99643	R	A. Lindhagen
(96) E	1871 V	Dec. 28, 19	33	158	13	334	34	13	7	9.5224	0.84935	D	v. Asten
(240) T_1	1873 I	May 9, 15	21	237	58	78	43	9	46	0.2484	0.46308	D	R. Gautier
251 T_2	1873 II	June 25, 5	9	306	6	120	57	12	45	0.1284	0.55260	D	Schulhof
(163) F	1873 III	July 18, 11	50	50	5	209	41	11	22	0.2260	0.55738	D	Moeller
252	1873 IV	Sept. 10, 18	58	36	48	230	35	84	1	9.8999	0.99647	R	R. Gautier
253	1873 V	Oct. 1, 18	28	302	58	176	43	58	31	9.5853		R	Weiss
(171) Br	1873 VI	Oct. 10, 11	49	116	5	101	15	29	25	9.7736	0.80883	D	Schulze
254	1873 VII	Dec. 3, 2	53	85	30	248	37	26	29	9.8895	0.77062	D	Weiss

No.	Year	T [Paris M. T.]	π	☊	i	log. q	e	Mot.	Computer
		h m	° ′	° ′	° ′				
255	1874 I	Mar. 9, 22 35	299 48	30 18	58 53	8.6490		D	Wittstein
256	1874 II	Mar. 13, 22 37	302 22	274 7	31 35	9.9473		R	Wenzel
257	1874 III	July 8, 20 45	271 6	118 44	66 21	9.8298	0.99882	D	v. Hepperger
258	1874 IV	July 17, 16 57	5 27	215 51	34 8	0.2274	0.96283	D	Holetschek
259	1874 V	Aug. 26, 20 24	344 8	251 30	41 50	9.9924	0.99883	D	Gruss
260	1874 VI	Oct. 18, 22 47	265 41	281 58	80 47	9.7061		R	Holetschek
[131] W	1875 I	Mar. 12, 2 34	276 38	111 29	11 17	9.9185	0.74101	D	v. Oppolzer
[96] E	1875 II	Apr. 12, 23 58	158 17	334 37	13 7	9.5223	0.84942	D	v. Asten
261	1877 I	Jan. 19, 4 27	200 5	187 15	27 5	9.9071		R	Thraen
262	1877 II	Apr. 17, 15 54	253 29	316 37	58 51	9.9777	0.99870	R	Plath
263	1877 III	Apr. 26, 20 0	102 52	346 4	77 10	0.0040		D	Zelbr
[189] D'A	1877 IV	May 10, 8 9	319 7	146 7	15 43	0.1199	0.62780	D	Leveau
264	1877 V	June 27, 1 51	81 2	184 17	64 15	0.0296		R	Gruss
265	1877 VI	Sept. 11, 9 57	107 38	250 59	77 42	0.1977		R	Plummer
266	1878 I	July 20, 16 44	279 50	102 16	78 11	0.1436		D	Buettner
[96] E	1878 II	July 26, 2 56	158 20	334 39	13 7	9.5230	0.84917	D	v. Asten
[251] T_2	1878 III	Sept. 7, 6 25	306 8	121 1	12 46	0.1270	0.55869	D	Schulhof
[171] Br	1879 I	Mar. 30, 2 0	116 14	101 18	29 23	9.7708	0.80980	D	Schulze
267	1879 II	Apr. 27, 10 18	42 1	45 46	72 58	9.9526		R	Kremser
240 T_1	1879 III	May 10, 21 52	238 12	78 46	9 47	0.2483	0.46304	D	R. Gautier
268	1879 IV	Aug. 24, 5 58	308 12	32 22	72 15	9.9962		R	Hartwig
269	1879 V	Oct. 4, 15 16	202 38	87 11	77 8	9.9955		D	A. Palisa
270	1880 I	Jan. 27, 10 48	278 23	356 17	36 52	7.7714	0.99947	R	W. Meyer
271	1880 II	July 1, 17 54	112 3	257 15	56 56	0.2587		R	J. Mayer
272	1880 III	Sept. 6, 22 36	82 12	45 19	38 6	9.5498		R	Molien
[244] T_3	1880 IV	Nov. 8, 0 4	43 5	296 51	5 23	0.0282	0.65530	D	Schulhof and Bossert
243	1880 V	Nov. 9, 10 7	261 4	249 23	60 42	9.8193		D	Bigourdan
[163] F	1881 I	Jan. 22, 16 7	50 50	209 36	11 20	0.2401	0.54902	D	Moeller
274	1881 II	May 20, 10 38	300 12	126 24	77 58	9.7717		D	Gruss
275	1881 III	June 16, 10 46	265 18	270 58	63 26	9.8660	0.99643	D	Bossert
276	1881 IV	Aug. 22, 7 30	334 55	97 3	39 46	9.8018		R	Stechert
277	1881 V	Sept. 13, 10 36	18 36	65 52	6 50	9.8609	0.83041	D	Plummer
278	1881 VI	Sept. 14, 8 55	267 52	274 10	67 11	9.6524		R	Millosevich
[96] E	1881 VII	Nov. 15, 1 43	158 30	334 34	12 53	9.5358	0.84550	D	Backlund
279	1881 VIII	Nov. 19, 13 30	63 31	181 18	35 10	0.2847		R	Bigourdan
280	1882 I	June 10, 12 52	53 56	204 56	73 49	8.7836	0.99999	D	Parsons
281	1882 II	Sept. 17, 5 32	276 25	346 1	38 0	7.8895	0.99991	R	Kreutz
282	1882 III	Nov. 12, 23 51	354 48	249 7	83 51	9.9802	0.99923	R	Wolyncewicz
283	1883 I	Feb. 18, 23 1	29 2	278 6	78 6	9.8809		D	Bryant
284	1883 II	Dec. 25, 7 25	125 46	264 25	65 1	9.4909		R	H. Oppenheim
[124] P	1884 I	Jan. 25, 17 22	93 21	254 9	74 3	9.8897	0.95500	D	{ Schulhof
285	1884 II	Aug. 16, 10 54	306 11	5 11	5 27	0.1070	0.58246	D	} and Bossert
286	1884 III	Nov. 17, 18 16	19 3	206 22	25 15	0.1964	0.55996	D	Berberich Krueger

244 T_3. A. N. 99: 13. Discovered November 27 by TEMPEL at Marseilles; observed till December 31 by BRUHNS at Leipzig, and by STRASSER at Kremsmuenster. A deviation from a parabola was suggested at this first short appearance, but it was not fully established till 1880, when after two revolutions, it was discovered for the second time by SWIFT. The elements com-

puted by CHANDLER, Jr. (A. N. 99: 46) in 1880 agree closely with these by SCHULHOF and BOSSERT above.

245. Wien. Ak. S. B. 64 (1871). Discovered May 29 almost simultaneously by TEMPEL at Marseilles and by WINNECKE at Carlsruhe; last observed July 9, at Athens, by SCHMIDT. The orbit by SEYDLER computed from seven normal places agrees very closely with one by DREYER (A. N. 80: 221) from six normal places. DREYER suspects a connection with certain Perseid radiants (A. N. 82: 289).

246. A. N. 80: 237. Discovered by COGGIA at Marseilles, August 28; last observed at Hamburg by PECHULE, December 23. An orbit designated by the computer as provisional—from five normal places.

(189) d'A. Annales de l'Observ. de Paris 14 p. B. 25. D'ARREST's periodic comet. Found August 31 by WINNECKE at Carlsruhe; last observed December 20, by SCHMIDT at Athens.

247. A. N. 85: 323. Discovered November 23 by WINNECKE at Carlsruhe, and observed for only a week; last, by RUMKER at Hamburg November 30. The fourteen observations available were brought together by SCHULHOF into four normals.

248. A. N. 84: 330. Discovered April 7 by WINNECKE at Carlsruhe, April 13 by BORELLY at Marseilles, April 15 by SWIFT at Marathon (New York). Last observed May 16 by SCHMIDT at Athens, and once after perihelion, August 5, at the Cape. In the above system of elements, the third computed by HOLETSCHEK, the Cape observations, are included, and the result is an ellipse with a period of 5188 years, to whlch, however, considerable uncertainty is attached.

249. Diss. inaug. Leiden 1875. "Berekening van de loopbaan der Komet 1871 II." Discovered by TEMPEL at Milan June 14; last observed by RUMKER at Hamburg September 20. Most probable orbit, computed very carefully from all the observations.

(102) Tu. A. N. 77: 255. Found October 12 by BORRELLY at Marseilles, October 15 by WINNECKE at Carlsruhe, October

22 by TUTTLE at Washington. Last observed, at Washington December 10, and also in the southern hemisphere, at the Cape, December 15, 1871 to January 30, 1872. First predicted return of comet 1790 II, re-discovered in 1858 by TUTTLE and BRUHNS.

250. A. N. 111: 112. Discovered November 3 by TEMPEL at Milan. The last European observation, November 18, was made at Hamburg by RUMKER, but the comet was observed, January 19 to February 17, 1872, at the Cape, and January 17 to February 20, at Cordoba (Argentina). In the above orbit by LINDHAGEN these observations after perihelion are included, but it seems impossible to satisfy all the observations by a parabola.

(96) E. Mem. de St. Petersb. 26 No. 2: 121. Found September 19 by WINNECKE at Carlsruhe, September 22 by HIND at Twickenham; picked up also by STEPHAN at Marseilles on September 18. Observed up to December 10 at Hamburg by PECHULE, and at Lund by WIJKANDER.

For a nebula found by TEMPEL at Milan on December 29, and taken for a comet, see A. N. 78: 383, 80: 27 and A. V. S.7: 98.

A comet was discovered by POGSON at Madras on December 2, and was observed by him on December 2 and 3, but it was only two evenings not seen elsewhere. Accounts and investigations in regard to it are to be found in A. N. vols. 80, 81, 84; in M. N. vol. 33, and in A. V. S. vol. 10. The comet was found through a telegram from KLINKERFUES, who had pointed out the probable visibility of BIELA's comet in that particular part of the heavens, since the radiant of the great meteor shower of November 27 in the northern hemisphere had shown a close agreement with the comet's place. Discussions, both in favor of and against the connection of this comet with the meteor shower and BIELA's comet have been published; those by v. OPPOLZER (A. N. 81: 281) and by BRUHNS (A. V. S. 10, 2) being of especial value.

(To be Continued.)

THE BIELA METEORS.

WM. W. PAYNE.

Most of our readers will remember that the meteoric shower of November 27, 1872, was predicted some time beforehand, as part of the remains of the Biela comet, which was not found in 1866, though most diligent search was made for it. At that time, two instances of the relation of comets and meteors had been established. In January, 1867, Dr. OPPOLZER, of Vienna, published an orbit of TEMPEL'S comet, and within a few days, LEVERRIER published an orbit of the November meteors. The elements of these two orbits agreed so nearly that the comet and the meteors were believed to move in the same path. A re-discussion of this interesting problem by Professor DANIEL KIRKWOOD, published in MESSENGER No. 38 brings out very clearly the striking fact that the meteors in this path are moving in three distinct groups, designated by the letters A, B and C; and that the next return of the several bodies may be expected at the times indicated below:

TEMPEL'S Comet I (1866)	1899
The A group of meteors	1899 to 1901
The B " " "	1886 to 1889
The C " " "	1912 to 1915

As soon as it was known that the November meteors and TEMPEL'S comet were moving in the same orbit it was also learned that SCHIAPARELLI, an Italian astronomer, had come to a similar conclusion respecting the August meteors and the second comet of 1862. In view of the difficulty of observing accurately the radiant point of a stream of meteors, and also the uncertainity of the period of the last named comet because of the ellipticity of its orbit, it is surprising that the computed orbits of the comets and meteors of these two cases agree as nearly as they do.

In the meteors of November 27 and BIELA'S comet we have a third instance of these apparently dissimilar bodies moving in the same path. The history of this system is brief, but intensely interesting. This comet was first seen by BIELA in Bohemia, February 27, 1826; then thought to be identical with the comet of 1805, for which GAUSS had computed an elliptic orbit, the more correct elements of which showed a periodic time of six years and nine months. By tracing back its orbit observations were found as early as 1772, showing a fair agreement of place. Its ninth return was then predicted for November 26, 1832, and "it* passed its perihelion in exact accordance with the prediction". Though faint, it was seen for three months and finally disappeared January 3, 1833. In 1839 its return was not observed because, in position, it was unfavorably near the *Sun*. On its eleventh appearance, the comet was first seen by DE VICO, at Rome, November 26, 1845. It was visible until April following, passing its perihelion on the 11th of February, 1846. About the middle of December preceding, the comet gave strong indication of a violent change in form; a few days later an attendant nebulous patch was seen at a small distance from the comet, and on January 15 two distinct comets were observed traveling side by side. The gradual increase in the companion comet and the fading of the parent nucleus, the arched and swaying bridge of light between them, the frequent reverse of brilliancy in the two comets, and in March of that year, the apparent re-union of them were some of the astonishing phenomena that met the observer's gaze. This battle of comets at a distance from 100,000 to 200,000 miles apart continued for three months, and until both disappeared from sight.

In 1852, the comets were again seen traveling one and one-half millions of miles apart, and although separated so widely, it was impossible to tell which was the original comet of 1846. They were observed from August 26 to September 28. The companion comets were in unfavorable position for observation in 1859, and so were not seen. In consequence of this the next return in 1866 was anxiously waited for, and though diligently sought, under most favoring circumstances, the BIELA comets were not then found, nor have they since certainly been seen.

At the time of next return on November 27, 1872, an unus-

* Watson on Comets,

ually brilliant star shower appeared, with radiant point in the constellation of *Andromeda*, and hence the meteors have been generally called *Andromedes.* It was then noted that shooting stars in considerable numbers were seen from the same radiant point on December 7, 1798, and December 8, 1838. Immediately after the shower of 1872 POGSON discovered a small comet in the opposite part of the heavens from the radiant of these meteors, which was moving, in nearly the same orbit, and which could be neither of the lost twin comets.

It is probable that the *Andromedes* are older than the disruption of BIELA's comet, and very probable that the POGSON comet was much older, if ever a part of the parent mass. The next return of the shower was looked for in 1879 and 1880, but so far as we know there was no display.

The latest shower of the BIELA meteors occurred November 26 to 29, 1885, which was unusually brilliant and very generally observed. We have given large space to the reports from different parts of this country.

THE COMETS 1812 I, AND 1846 IV.

DANIEL KIRKWOOD.

Attention has been more than once called to the striking resemblances between the orbits of these bodies* — a resemblance too close to be regarded as accidental. "According to the theory now generally accepted, comets enter the solar syetem *ab-extra*, move in parabolas or hyperbolas around the *Sun*, and, if undisturbed by the planets, pass off beyond the limits of the *Sun's* attraction to be seen no more. If in their motion, however, they approach very near any of the larger planets, their direction is changed by planetary perturbation,— their orbits being sometimes transformed into ellipses. The new orbits of such bodies would pass very nearly through the points at which their greatest perturbation occurred; and accordingly we find that the aphelia of a large proportion of the periodic comets are near the orbits of the major planets." Those of the com-

Comets and Meteors, Chap. III, and Pop. Sci. Monthly, Feb., 1884, p. 48.

ets 1812 I, and 1846 IV, are near the path of *Neptune.* These comets, therefore, in all probability, owe the present form of their orbit to that planet's disturbing influence. At what epoch was this transformation effected?

The aphelion longitude of the Pons-Brooks comet (1812) is about 256°. *Neptune* had this mean longitude A. D. 1814.5, 1649.88, 1485·26, 1320.64, 1156.02, 991.4, etc. The comet of 1812 was in aphelion about 1777.1. But $1777.1-991.4=785.7=11\times71.4+$. That is, *Neptune* and the comet of 1812 were in the same longitude in A. D. 991. The elliptic form of the cometary orbit probably dates from that epoch.

The fourth comet of 1846 was in aphelion in 1809. The interval between 991 and this date was 818 years, or eleven periods of about seventy-four years. This differs by less than a year from PEIRCE'S value.

Opinions of NORMAN R. POGSON, *C. I. E., F. R. A. S. Government Astronomer at Madras, on American Astronomical Instruments; Extracted from his recently published volume on Telegraphic Longitude Determinations in India.*

[Communicated by Professor C. PIAZZI SMYTH, Astronomer Royal of Scotland.]

On page 2 occurs the following:—

"The need of a good cylinder chronograph for other (than longitude) purposes, especially for investigation of the solar parallax by means of observations of the planet *Mars* in opposition, for which Madras Observatory is above all others the most favorably situated in the world, was often urged, but to this day nothing of the kind has been supplied, except a French tape recorder, sent out in November, 1874, for the transit of *Venus*, due in the following month;—a mere toy which no astronomer would care to possess and which has never been of the slightest use since its arrival.

"The chronographs now constructed by leading American and British makers are as near perfect as can be desired, and enable inexperienced observers to make records, equal, if not superior to those obtainable by long practiced observatory assistants without such aid; while in cases in which numerous times have to be noted, in more rapid succession than any one could possibly accomplish by the old eye and ear method, they are simply indispensable. American chronographs seem to me preferable for their greater simplicity, having only pen or pencil for both clock seconds and observer's records, instead of two, separately marking side by side; and also in their being worked by a portable chronometer, just as readily as by a fixed astronomical clock.

Also on page 12:—

Speaking of longitude observations at Singapore, by Lieut. Commodore H. DAVIS and Lieut. J. A. MORRIS of U. S. Navy, in January, 1882, Mr. POGSON writes:—

"The exquisite instruments I had the pleasure of seeing employed here by my esteemed American friends, Messrs. DAVIS and LEENLEY, as well as the skilled way in which they were handled, were the realization of what I had hoped for when I first made my own proposals to Government for latitude determinations upon my arrival in India. Perfection of accuraate simplicity, eschewing all affectation of needless refinement, seems to be the distinguishing characteristic of American scientific instruments, and researches in general, and of such nature were the appliances and methods used upon this occasion."

MEASURES OF THE VELOCITY OF LIGHT.*

When it became clearly understood that vision was not an immediate perception of objects by the eye, but was produced by the passage of an entity called light from the object to the eye, the question of the time which might possibly be required for this passage became one of interest to physical investigators. The first proposal for an experimental investigation of this question is due to GALILEO.† He suggested that two observers,

*Introduction to Parts III and IV of Vol. II of Astronomical papers, by Professor Simon Newcomb.

†Poggendorff Geschichte der Physik p. 402, where reference is made to the Saggi of the Florentine Academy.

each holding a lantern, should be stationed at a distance apart, in sight of each other. Each should be supplied with a screen, by which he could, in a moment, cover or uncover his lantern. One observer should then uncover his lantern and the other uncover the other the moment he perceived the light from the first lantern. The interval which elasped after the first uncovered his light, until he perceived the light of the second, would be the interval required for the light to go and come, plus the time required for the second observer to perceive the light and make the required movement. This experiment was tried by the Florentine Academy, and of course resulted in a conclusion that the time required was insensible, since we now know that it was far below any interval that could have been detected by so rude a method.

It is, however, interesting to notice that, rude though this experiment was, the principle on which it was based is the same which underlies one of the most celebrated methods used in recent times for the attainment of the same object. Two very simple improvements which we might have imagined the academicians to make in their experiments are these:

Firstly, to dispense with the second observer, and in his place to erect a mirror, in which the first observer could see the image of his own lantern by reflection. The time required for the second observer to perceive the light and uncover his lantern would then have been eliminated from the problem. The interval sought would have been that between the moment at which the observer uncovered his lamp and the moment at which he perceived the reflection.

Secondly, to use the same screen with which he uncovered his own lamp to cut off the returning ray from the distant mirror, and thus obviate the necessity of an uncertain estimate of the interval between his muscular effort in removing the screen and his perception of the return flash of light. If the image was perceived before he could cover his own eye with the screen removed from the lamp, it would show that the interval of passage was less than the time required to make a motion with the screen. This interval might have been reduced almost indefinitely by having both lines of sight as near together as possible.

Had these improvements been made the academicians would have had, in principle, FIZEAU's method of measuring the velocity of light by the toothed wheel, a tooth being represented by the screens. To realize the principle more fully, the two lines of sight should have been rendered absolutely coincident by reflection through a telescope. It does not, however, appear that any effort to put the question to a severer test was made until the subject was approached from a different point of view. It was probably considered that the passage was absolutely instantaneous, or, at least, that the velocity was above all powers of measurement.

The subject was next approached from the astronomical side. In 1676 ROEMER made his celebrated communication to the French Academy, claiming that observations of the eclipses of the first satellite of *Jupiter* did really prove that light required time to pass through celestial spaces.* He found $11m$ to be the time required for light to pass over a distance equal to the radius of the *Earth's* orbit. DOMINIQUE CASSINI while admitting that the hypothesis of ROEMER explained the observed inequality, contested its right to reception as an established theory, on the ground that the observed inequality might be a real one in the motion of the satellite itself.†

Continued observation showed that the time assigned by ROEMER for the passage of light between the *Earth* and *Sun*, or "the light equation" as it is briefly called, was somewhat too great. In 1809 it was fixed by DELAMBRE at $493.2s$ from an immense number of observations of eclipses of *Jupiter's* satellites during the previous 150 years. This number has been received as a definitive result with a degree of confidence not at all warranted. In 1875, GLASENAPP, then of Pulkowa, from a discussion of all available eclipses of *Jupiter's* first satellite between 1848 and 1870 showed that results between $496s$ and $501s$

* Paris Memoirs, tome i., page 212, and tome x., page 575.

† Ibid, tome viii., page 47. Poggendorff (Geschichte der Physik, page 656) quotes Maraldi as also contesting Roemer's explanation on the ground that a similar inequality should be found depending on the position of Jupiter in his orbit. The ground here taken was quite correct; the only fallacy being the assumption that such an inequality did not exist.

could be obtained from different classes of these observations by different hypotheses.*

As not a trace of DELAMBRE'S investigation remains in print, and probably, not in manuscript, it is impossible to subject it to any discussion.†

The discovery of aberration by BRADLEY afforded an independent and yet more accurate method of determining the light equation. We call to mind that the latter constant, and that of aberration, are not to be regarded as independent of each other, but only as two entirely distinct expressions of the same result. The constant of aberration gives a relation between the velocity of light and the velocity of the *Earth* in its orbit from which, by a very simple calculation, the time required for light to pass from the *Sun* to the *Earth* may be deduced.

It is remarkable that the early determination of the constant of aberration agreed with DELAMBRE'S determination of the light equation, although we now know they were both in error by an amount far exceeding what was, at the time, supposed probable. STRUVE'S value, 20.″445, determined in 1845 from observations with the prime vertical transit of Pulkowa, has been the standard up to the present time. The recent determinations by NYREN being founded on a much longer series of observations than those made by STRUVE, and including determinations with several instruments, must be regarded as a standard at present. ‡His result is:

Definitive value of the constant of aberration= 20.″492 ± 0.″006.

(*To be Continued.*)

---

* This paper of Glasenapp's was published only in the Russian language as an inaugural dissertation, and in consequence has never become generally known.

† The author could find no remains of this investigation among Delambre's papers at the Paris Observatory.

‡ Memoires de l'Academie Imperiale des Sciences de St. Petersbourg, vii serie, tome xxxi, No 9.

Observations of Comets at the U. S. Naval Observatory by Profs. Hall, Frisby and Winlock. The Observations of Prof. Hall were made on the 26-inch Equatorial, the Others on the 9.6-inch Equatorial.

(Communicated by Commodore Geo. E. Belknap, U. S. N. Supt.)

COMET III., 1884.—(Wolf.)

Date 1885	Mean Time	Δα	Δδ	Comp.	App. α	log. Δp	App. δ	log. Δp	Star	Obs.
Jan. 10	7h 32m 15s	+1m 15.05s	—1′ 57.1″	20.4	1h 5m 5.94s	9.329s	— 5° 40′ 39.8″	0.786″	1	F
12	6 56 39	+1 22.33	+7 17.2	19.4	1 10 4.27	9.189	— 5 31 53.1	0.787	2	F
13	6 37 1	+0 41.27	—2 30.5	15.3	1 12 31.12	9.070	— 5 27 33.5	0.788	3	F
22	7 52 21	+1 7.52	—0 58.2	20.4	1 32 32.68	9.438	— 4 44 55.1	0.776	4	F
22	7 17 7	+3 32.10	+4 38.2	20.4	34 57.24	9.396	— 4 39 18.7	0.778	4	F
26	7 26 20	+0 5.80	+1 32.4	20.4	1 44 47.18	9.386	— 4 14 29.9	0.776	5	F
Feb. 3	9 4 17	—0 39.15	+0 27.0	20.4	2 6 23.25	9.596	— 3 21 24.5	0.760	6	F
11	8 33 29	—0 57 95	+3 11.7	20.4	2 23 28.67	9.575	— 2 44 46.9	0.755	7	F
16	8 22 43	—0 8.58	—4 39.6	15.3	2 35 18.01	9.571	— 1 49 3.2	0.752	8	F

COMET ENCKE.

Jan. 21	7h 29m 58s	—1m 49.24s	+1′ 15.7″	5.1	23h 17m 40.84s	9.622s	+ 5° 25′ 52.4″	0.718″	9	F
22	7 45 23	—0 32.43	+7 22.4	19.4	23 18 57.64	9.635	+ 5 31 59.0	0.721	9	F
29	6 50 9	—1 31.66	+1 22.1	10.2	23 28 51.51	9.601	+ 6 14 35.5	0.709	10	F
Feb. 3	7 8 6	+0 19.95	+9 19.6	15.3	23 36 24.77	9.630	+ 6 46 11.5	0.714	11	F
10	7 2 5	—2 29.10	—12 33.2	15.3	23 47 15.29	9.639	+ 7 22 27.0	0.742	12	F
11	8 19 8	—1 0.13	—8 45.8	15.3	23 48 44.26	9.666	+ 7 26 14.3	0.739	12	F
12	7 25 42	+0 25.91	—5 35.1	20.4	23 50 10.30	9.655	+ 7 29 25.0	0.724	12	F
16	7 1 9	+5 57.75	—0 45.5	10.2	23 55 42.10	9.648	+ 7 34 14.2	0.718	12	F
17	6 42 42	+7 11.08	—2 24.6	10.2	23 56 55.43	9.645	+ 7 32 35.0	0.716	12	F

COMET 1885.—Barnard.

July 30	9h 39m 46s	+0m 3.37s	—1′ 35.4″	15.3	16h 45m 8.76s	9.268s	—17° 17′ 27.5″	0.855″	13	F
31	8 58 37	—0 45.33	—1 12.1	20.5	16 44 0.74	9.052	—17 45 28.3	0.864	14	H
31	9 56 21	—0 47.82	—2 24.8	17.4	16 43 58.25	9.344	—17 46 41.0	0.857	14	F
Aug. 5	9 13 15	—1 26.56	—12 57.0	10.2	16 38 46.83	9.289	—20 6 10.5	0.867	15	F
6	9 7 13	+0 58.66	—4 17.7	15.3	16 37 51.51	9.285	—20 32 53.3	0.859	16	H
10	9 16 26	+3 15.65	....	10.	16 34 32.33	9.410	....	.....	17	H
12	8 28 1	—1 12.59	—0 37.1	16.4	16 33 8.48	9.241	—23 6 30.6	0.882	18	H

COMET 1885.—Brooks.

Sep. 6	8h 9m 29s	—1m 6.30s	—4′ 39.9″	19.3	14h 4m 33.70s	9.758s	+38° 28′ 0.5″	0.531″	19	W
12	9 16 37	+2 19.18	—8 40.7	10.2	14 41 36.20	9.783	+40 48 13.9	0.630	20	F

ADOPTED POSITIONS OF COMPARISON STARS.

Star.	R. A. 1885.0.	δ 1885.0.	Reduction.	Authority.
1	1h 3m 50.74s	— 5° 38′ 37.1″	+0.15s — 5.7″	Weisse, 1h, 12.
2	1 8 41.78	— 5 39 4.4	+0.16 — 6.0	Schj., 396.
3	1 11 49.68	— 5 24 56.9	+0.17 — 6.1	Schj., 409.
4	1 31 24.98	— 4 43 49.6	+0.18 — 7.2	Weisse. 1h, 5:4.
5	1 44 41.18	— 4 15 54.4	+0.20 — 7.9	Weisse, 1h, 768.
6	2 7 2.17	— 3 21 42.7	+0.23 — 8.9	Schj., 636.
7	2 24 26.40	— 2 27 49.0	+0.22 — 9.7	Schj., 701.
8	2 35 26.39	— 1 44 13.5	+0.20 —10.1	Weisse, 2h, 588.
9	23 19 30.49	+ 5 24 35.4	—0.41 + 1.3	Schj., 9650.
10	23 30 23.56	+ 6 13 12.7	—0.39 + 0.7	Schj., 9738.
11	23 36 5.24	+ 6 36 51.9	—0.42 0.0	Yarnall, 10456.
12	23 49 44.78	+ 7 35 0.9	—0.39 — 0.8	Schj., 9920.
13	16 45 2.45	—17 15 57.2	+2.94 + 5.1	Wash., T. C.
14	16 44 43.16	—17 44 21.2	+2.91 + 5.0	O. A. S., 16034.
15	16 40 10.51	—19 53 17.5	+2.88 + 4.0	Yarnall, 6923.
16	16 36 49.98	—20 28 39.3	+2.87 + 3.7	Yarnall, 6902.
17	16 31 13.83	....	+2.85	O. A. S., 15779.
18	16 34 18.22	—23 5 56.0	+2.85 + 2.5	O. A. S., 15827-8.
19	14 5 39.77	+38 32 32.4	+0.23 + 8.0	M. [2] 14h, 77-78.
20	14 39 16.73	+40 48 13.9	+0.29 +10.6	M. [2] 14h, 811-813.

EDITORIAL NOTES.

Volume V begins with full reports of topics of present general interest. Many subscribers have anticipated its first issue by encouraging words and a renewal of subscription. This number is sent to the list of 1885.

The two new comets and the Biela meteors have been observed and talked about in all parts of the world. Some exceedingly interesting matter concerning the computation of the orbits of meteor streams is deferred until our next number.

So much interest has been manifested, at home and abroad, in the English translation of Dr. GALLE'S Catalogue of recent comets, by W. C. WINLOCK of the Naval Observatory, Washington, D.C., that we have decided to reprint a small edition of the catalogue during the present month, for the benefit of all interested in cometary astronomy. So far as we know, more information concerning recent comets is contained within the limits of 25 pages than is elsewhere found in English. At sight it is evident that the translation has been in very competent hands.

This Catalogue, in pamphlet form, will be mailed to any address on receipt of fifty cents.

On the Titles of Contributions to Astronomical Periodicals. Reply to X. Y. Z. in No. 38.

Your esteemed correspondent is right, when he declares it desirable that the titles of articles be precise and so stated that the reader can from the titles judge of the contents of the articles.

So far as the *Astronomische Nachrichten* is concerned, I have taken pains in the index of the volumes to remedy this defect. In the index the reader is fully informed concerning the contents of the articles, even when over the original article only a heading which may be termed general is found. Nevertheless I will gladly yield to the wishes of your contributor, and in future remember, in regard to such articles as are communicated in the form of a letter, to indicate, at once, in the heading the subject matter. A. KRUEGER.

ROYAL OBSERVATORY, KIEL.

A new comet was discovered in Paris December 1.3924, Gr. M. T., in R. A. 0*h* 39*m* 8.5*s*: Decl. +21° 2′ 25″. Daily motion in R. A. −2*m* 28*s*; in Decl. −3′.

Science Observer Circular No. 61 gives the following observations, and elements:

Gr. M. T.	App. α	App. δ	Observer
d h m s	*h m s*	° ′ ″	
Dec. 1 9 25 4	0 39 8.5	+21 2 25	Paris.
2 11 52 45	36 26.42	21 0 30.4	Wendell, H. C. O.
2 13 42 9	36 15.68	21 0 25.6	Egbert, Albany.
2 14 28 11	36 11.10	21 0 20	Frisby, Washington
2 16 34 35	35 57.70	21 0 13.	Wendell, H. C. O.
3 12 54 48	33 56.28	20 58 51.8	Wendell, H. C. O.
3 16 20 17	33 35.73	20 58 36.3	Wendell, H. C. O.
5 18 18 57	28 44.51	20 55 8.2	Chandler, H. C. O.
6 3 14 53	26 57.43	20 53 56.1	Wendell, H. C. O.
7 12 51 54	24 46.01	+20 52 34.9	Schæberle, Ann Arbor.

From the above observations the following orbit has been computed, by Messrs. CHANDLER and WENDELL:

ELEMENTS.

T=1886, March 15.494, Gr. M. T

$\Omega = 33° 36.'6$ $\qquad \delta\lambda \cos.\beta = -1''$

$\pi - \Omega = 133\ 17.$ $\qquad \delta\beta = -17''$

$i = 56\ 49.\ 6$

log. q=9.69050

On account of the large distance of the comet and its considerable anomaly (v=120°) the orbit is somewhat indeterminate, several attempts failing to reduce the residual below the figures given, and there is some suspicion that the orbit is elliptical.

Light December 1 = unity.

The comet is faint, 2′ in diameter, with central condensation; 12 magnitude.

COMET BARNARD (II) 1885 D.

December 3 9*h* 37*m*, Wash. M. T., E. E. BARNARD, Vanderbilt University, Nashville, discovered a faint telescopic comet, whose R. A. was 4*h* 21*m* 57*s*; Decl. +4° 45′, having daily motion northwest 35′, as reported from H. C. Observatory.

Respecting the discovery, Mr. BARNDRD says:

"On the night of December 3, while searching near *Orion* with the 6-inch refractor, I came across what I instantly recognized as a comet, being perfectly familiar with all the nebulæ in that region. A half hour's time confirmed the cometary character of the object. Ring micrometer comparisons with an unknown ninth magnitude star were made. The following night being cloudy, on the evening of the 5th comparison with the same star was made, the comet's declination having changed so little. At this time an exceedingly small and faint star-like nucleus was seen in the preceding part of the nebulosity. On account of cloudy skies no positions could be secured until the 9th. The motion of the comet is nearly due west, and only slightly to the north. On the night of discovery this comet passed almost centrally over a small star, which shone through the nebulosity, without probably any diminution of luster." E. E. B.

VANDERBILT UNIVERSITY OBSERVATORY, December 10th, 1885.

The following positions of the above comet have been secured, and from those between December 5 and 10, the orbit given below has been computed by Messrs. CHANDLER and WENDELL as published in *Science Observer* Circular 62:

Gr. M. T.					App. α			App. δ			Observer
	d	h	m	s	h	m	s	°	′	″	
Dec.	3	14	45		4	21	57.0	+4	45		Barnard, Nashville.
	5	16	37	56		16	58.30		54	14.6	Barnard, Nashville.
	5	16	13	58		16	38.80		54	47.8	Chandler, Harvard.
	6	12	57	25		14	52.40	4	58	30.6	Wendell, Harvard.
	7	12	58	21		12	25.93	5	4	2.6	Wendell, Harvard.
	10	20	9	30		4	17.15		23	15.0	Wendell, Harvard.
	11	11	9	52	4	2	43.67	+5	27	11.4	Wendell, Harvard.

ELEMENTS.

T=1886, June 4.066, Greenwich M. T.

$$\left.\begin{aligned}\pi - \Omega &= 108^\circ\ 24.'8 \\ \Omega &= 63\ \ 13.\ 8 \\ i &= 108\ \ 30.\ 8\end{aligned}\right\}1885.0 \qquad \begin{aligned}&C - O \\ \delta\lambda \cos\beta &= +5'' \\ \delta\beta &= +9''\end{aligned}$$

log. q=9.86877

Light on December 3=unity

The comet is faint, with a 12th mag. nucleus, eccentrically placed near the preceding part of the coma.

On December 31 the comet was about 8° almost directly south of a third magnitude star known as Gamma in the *Hyades* of *Taurus*.

Professor SWIFT, of Warner Observatory, recently published in A. N. No. 2693 a catalogue of one hundred new nebulæ. He is now re-observing another list of new nebulæ, numbering one hundred and twenty

Observations of the Biela Meteors at Princeton, N. J. on November 27th. By PROF. C. A. YOUNG.

Between 7:15 and 8:00 (Eastern Standard time) about one hundred meteors were recorded by one observer.

The number fell off rapidly from the beginning: I counted thirty-six in the first ten minutes, although I was then walking under trees and among buildings, which hid a large part of the sky; while during the last ten minutes, under an open sky, I saw only four. Probably, therefore, the maximum must be set as early as 7:30, if not before 7:15. I regret that I did not look out for the meteors earlier in the evening: but other matter, during the day had quite driven them out of my mind.

The radiant was well marked, an oval space about 4° long (north and south) and about 2° wide. I estimated its center to be about 2° northwest of Gamma *Andromedæ*; A. R. $1h$ $50m$, Decl. 43.°5, with a probable error of $\pm \frac{1}{2}°$.

The determination rests upon three nearly stationary meteors observed actually within the limits of the oval, confirmed by the projection of about twenty other meteor paths in the immediate neighborhood.

Very few of the meteors seen were seriously unconformable, though a few (perhaps five or six) had paths strongly curved or irregularly crooked.

About half-a-dozen of the whole hundred were of the first magnitude, about fifty, of the second or third. A large proportion of the remainder were very small — of the fifth or sixth: and there were numerous glimpses of minute meteors, caught only by averted vision; not fairly seen, and so not counted.

Most of the paths were short — less than 10° or 15°, and the motion was generally rather slow. Many of the brighter ones showed evanescent trains, never lasting more than two or three seconds. Whenever any color was visible in the meteor or its train, it was always reddish — never greenish or bluish as in the case of the Leonids.

Professor G. W. HOUGH'S report of Dearborn Observatory, Chicago, is received. His studies of the physical features of the planet *Jupiter* are continued, and in connection with the six years of work preceding, on the same theme, furnishes probably, the most definite knowledge respecting the markings of *Jupiter*, which has been given to astronomy. His article in MESSENGER No. 40 contains results of late work.

Though the red spot was fainter at the two oppositions preceding the last, it has never disappeared entirely from view.

Mr. BARNARD recognizes the nebula in *p*. end of *Andromeda* nebula as G. C. 106; not new as stated in October MESSENGER.

Volume XLVIII, of the Memoirs of the Royal Astronomical Society, in parts I and II, 1884, contains a series of papers of interest to astronomy. The first part is devoted to the study of parallax of nine stars in the southern hemisphere by Messrs. GILL and ELKIN. The following table gives final results:—

Star	Observer	Parallax	Probable Error	Mag. of Comp. Star
α Centauri	Gill & Elkin	+0."75	±0."01	7.6
Sirius	" " "	+ .38	.01	7.5
Epsilon Indi	" " "	+ .22	.03	7¼
Lacaille 9352	Gill	+ .28	.02	7.6
Omicron$_2$ Eridani	"	+ .166	.018	6.4
Beta Centauri	"	− .018	.019	7.
Zeta Tucanæ	Elkin	+ .06	.019	7½
ε Eridani	"	+ .14	.020	6.4
Canopus	"	+ .03	.030	8.

Following the discussion of the observation of these stars is a series of pertinent precautions, suggested by these experienced observers, to eliminate systematic errors in future investigations of the same kind. In the conclusion of this paper, the authors remark that "the great cosmical questions to be answered are not so much what is the precise parallax of this or that particular star, but:

1. What are the average parallaxes of those of the first, second, third, and fourth magnitude, respectively, as compared with those of lesser magnitudes?

2. What connection exists between the parallax of a star and the amount and direction of its proper motion? Can it be proved that there is no such relation?

Part II contains the fourth catalogue of micrometrical measures of double-stars made at the Temple Observatory, Rugby, by G. M. SEABROKE; a paper on the relative proper motion of forty stars in the *Pleiades*, determined from micrometrical and meridional observations by Professor C. PRITCHARD; observations of *Mars* at opposition in 1884, by E. B. KNOBEL; on the corrections required by HANSEN'S Tables de la Lune, by EDMUND NEISON and two others.

We are sure that this publication, of the Royal Astronomical Society, will be desired generally by American astronomers.

Messrs. WARNER and SWASEY, of Cleveland, Ohio, have lately completed a new 6-inch equatorial of the "Lick" pattern for Professor H. S. PRITCHETT, of Washington University, St. Louis. Full description will appear in our next.

NEW NEBULÆ.

I have found the following nebulæ with the 6-inch Cook equatorial of this observatory:

R. A.=3*h* 13*m* 21*s*
Decl.=−28° 2.′4 } 1886.0

Rather faint, moderate size, elongated nearly north and south, just south and slightly *p.* a small wide double-star.

R. A.=4*h* 54*m* 7*s*
Decl=−11° 18.′3 } 1886.0

Three small novæ close together, difficult; rather faint, all three prabably elongated north and south. The place is that of the preceding of the three nebulæ. A good many stars in field. It requires considerable power to make these nebulæ out distinctly, a power of 120 on the 6-inch is about the lowest with which they can be seen. Mean of three equatorial pointings.

R. A.=4*h* 54*m* 37*s*
Decl.= −11° 9′ } 1886.0

The R. A. might be 1*m* too great. The position is from one equatorial pointing. This lies between two small stars and is in field with the three nebulæ mentioned above. The two stars form the preceding side of a beautiful small triangle, the three stars nearly equal. This nebula is not large. Round v g b M. I have since been informed by PROF. SWIFT that this nebula was discovered by TEMPEL, probably in 1882.

R. A.=5*h* 3*m* 4*s*
Decl.=+47° 31′ } 1885.0

Small hazy spot, with high power (120) seems to be some faint stars mixed up in nebulosity, a small star involved *f.* It is followed some little distance by a 9th magnitude star. E. E. BARNARD.

VANDERBILT UNIVERSITY OBSERVATORY, NASHVILLE, TENN, NOV. 30, '85

THE ALMUCANTAR.

Mr. ROCKWELL has reason to esteem his new instrument highly. In a recent letter he says:—

"I give below the results of *one* evening's work for latitude, August 8th, 1885. Corrections to 41° 04′ 12.″5 (assumed).

Lambda *Acquilæ*	east	+0.″509
" "	west	+0. 462
Eta *Aquarii*	east	−0. 297
Gamma "	east	+0. 277
Beta "	east	−0. 204
Eta *Serpentis*	west	+0. 371

CHAS. H. ROCKWELL.

THE BIELA METEORS.

On Friday evening, 27th inst, a very considerable meteoric shower was noticed. Between the hours of 6 and 9 p. m. observations were made at intervals of a few moments each, other duties preventing continuous watching. At these times the meteors were seen falling in all parts of the sky, sometimes singly and sometimes several nearly simultaneously They were mostly small, with short paths, but occasionally some brilliant ones were noticed which left bright trails behind them, lasting a few seconds. The radiant point was evidently in *Andromeda* and one which appeared to glow out near the centre of the constellation, showed by the direction of the extremely short distance it appeared to move that this point was located near the feet of the constellation. Judging by the numbers seen during the brief observations, many hundreds must have entered our atmosphere during the continuance of the shower.

BAYONNE, N. J., November 30, 1885. JOHN H. EADIE.

Observations of 23 B. A. C. Stars Employed by the U. S. Coast and Geodetic Survey in 1873 to determine the latitude of Madison, Wisconsin.

[The observations were made by Mr. Comstock and Mr. Updegraff at the Washburn Observatory in June and July, 1885.]

B. A. C. number of star.	Approximate R. A.			Observed Decl. 1885.0			Prob. error mean	Prob. error 1 obs.	No. of Obs.
5950 *pr*	17*h*	29*m*	54*s*	+55°	15′	47.″72	0.″09	0.″26	9
5962		32	14	+30	51	23. 37	0. 16	0. 48	9
5990		36	14	+46	4	4. 46	0. 11	0. 34	11
6062		48	21	+40	0	27. 23	0. 17	0. 51	10
6079		51	32	+56	53	27. 52	0. 13	0. 40	11
6084	17	53	17	+29	15	38. 27	0. 07	0. 22	10
6224	18	13	12	+64	21	30. 42	0. 08	0. 27	11
6251		18	47	+21	43	4. 93	0. 11	0. 40	12
6476	18	54	48	+57	39	45. 54	0. 11	0. 34	10
6547	19	2	4	+28	26	53. 99	0. 12	0. 37	12
6651		19	58	+36	13	*			
6659		20	23	+50	2	48. 60	0. 12	0. 36	9
6687		24	37	+52	5	11. 70	0. 11	0. 36	11
6698		27	30	+34	12	31. 58	0. 09	0. 26	10
6741		34	45	+49	1	6. 51	0. 09	0. 28	11
6771		40	8	+37	4	36. 58	0. 09	0. 28	10
6784		42	4	+33	27	37. 27	0. 09	0. 26	10
6824		47	45	+52	41	47. 45	0. 07	0. 22	11
6895	19	58	6	+49	47	5. 71	0. 14	0. 46	11
6937	20	5	10	+36	30	4. 98	0. 04	0. 14	10
6983		11	55	+47	21	41. 07	0. 12	0. 39	10
7008		16	5	+39	2	26. 96	0. 09	0. 30	11
7067		24	42	+29	59	6. 71	0. 11	0. 34	10
7105	20	28	58	+56	23	21. 75	0. 08	0. 23	10
						Mean	±0.10	±0.32	10.4

* Will be observed at Harvard College Observatory.

AN EXCESSIVELY FAINT NEBULA.

On the night of November 3, I found an excessively faint, but rather large nebulosity that is not in G. C. or supplement. This nebula lies a short distance following and south of a 9th magnitude star. It seems to be extended somewhat. It is probably about ½° long. An equatorial pointing gave its place

$$\left.\begin{matrix} \text{R. A.} = 3h\ 56m\ 1s. \\ \text{Decl.} = +36^\circ\ 6' \end{matrix}\right\} 1886.0$$

This requires the lowest power and cannot be seen by direct vision. It is only by directing the vision slightly to one side of its place that it is possible to see it, it then flashes out feebly.

E. E. BARNARD.

Professor C. PIAZZI SMYTH, Astronomer Royal of Scotland, kindly sends us a few paragraphs which appear on another page, showing how a distinguished foreign astronomer, N. R. POGSON, Madras Observatory India, looks upon American observers and American astronomical instruments. Mr. POGSON is one of Nature's gifted observers, and now holds the honorable place of Government astronomer. His opinion American astronomers will highly esteem.

But Professor SMYTH's own genial words in an accompanying private note are scarcely less complimentary and are amusingly to the point. Speaking of American progress in astronomy he says:—

"For even I can remember when American officers seemed to think, all the needs of ambition served, when they had obtained a London-made sextant and artificial horizon. But now the very directors of British observatories are sighing in vain and in despair for the new style of American instruments with their beautiful Quaker-like simplicity and rapid effectiveness for obtaining their point."

METEORS.

On the night of November 27, 1885, my mother, my brother Percival, and I saw two hundred and thirteen (213) meteors during the time from 6:30 p. m. to 7:50 p. m. Of this number my mother counted only about twenty, as she watched but a short time. Many of the meteors were much smaller than those usually seen. Some, however, were quite large and bright, and as they shot along left a little streak of light behind them. Most of the meteors appeared a little north-east of the zenith, in the region of the Milky-way. Their paths were from four to ten degrees in length, six or seven degrees being the usual length. In falling most slanted off towards the east. During the last of our watch they were not so numerous as at the first. [Good for young HALL.—ED.]

GEORGETOWN, D. C., 1885, November 28. ANGELO HALL.

Occultations in the Hyades.

Sept. 28th 1885: Early in the evening cloudiness prevented observation of the immersion of Theta[1] and Theta[2], *Tauri* but later on the sky became clear and the emersion of each star was beautifully seen.
The occultation of B A C 1391 was observed, though the brightness of the *Moon's* limb rendered doubtful the instant of disappearance.

Next in order came Alpha *Tauri*, whose immersion was observed with power of 165 on 4 1-10-inch refractor: For the other observations a power of 35 was used.

The times given in the Nautical Almanac for most phenomena suit us approximately, as we are so near, though occultations show very clearly the difference, both of latitude and longitude. Quite a neat illustration of this was noted on the present occasion.

The time given for the immersion of B A C 1391 was the same as that for the emersion of Theta[1], but as the time drew near, it became evident that both would not occur at the same moment. The star Theta[1] *Tauri* flashed out on the dark sky, while B A C 1391 was yet 40″ from the *Moon's* limb. The times given below are 75° time:

	Immersion	Emersion
Theta[2] *Tauri*	not seen	10*h* 45*m* 45*s*
Theta[1] "	" "	10 54 0
B A C 1391	10*h* 55*m* 20*s*	not seen
Alpha *Tauri*	13 14 20	14 58 50

Meteors of November 26–29 1885.

The shower of meteors (evidently the debris of Biela's comet) was well observed at Cambridgeport.

The first indication of the display was observed on the evening of the 26 (22, 23, 24, 25 being overcast) as during a partially clear interval, from 7*h* to 8*h*, forty-two meteors were recorded, thirty-seven being from the Biela radiant point.

The evening of the 27 was very clear, and a watch of two hours from 6*h* to 7*h*, and from 7:15*h* to 8:15*h*, revealed two hundred and sixty-one meteors of which number two hundred and fifty were Biela's. The radiant point was very accurately determined from several very short paths near the center of radiation to be at R. A. 22½°;+42½° between Chi and *u Andromadæ*. Traces of the shower were also noted on the 28 and 29.

Canrridgeport, Mass. EDWIN F. SAWYER.

Minor planet (252) was discovered in Nice by Perotin. R. A. 1*h* 8*m* 53.2*s*; Decl. +7° 8′ 19″ on October 27.2999, Gr. M. T.

THE BIELA METEORS.

In a short watch at Bloomington on the evening of November 26, I counted meteors of the Biela group at the rate of sixty per hour, and at one time I saw five in three minutes. The night of the 27th was cloudy

BLOOMINGTON, INDIANA, 1885, Nov. 28. DANIEL KIRKWOOD.

GEORGETOWN, D. C., November 27, 1885.

This evening at seven o'clock, having incidentally seen a few meteors shoot from the northern sky, I thought it worth while to count them, and perhaps determine their radiant point. With the assistance of G. HANEKAE, J. DENTZ, W. LEE and T. HORIGAN, stationed in different position s we began to count at the time above stated with the following results:

No. from 7h to 7h 30m	100
" " 7 30m to 7 55	100
" " 7 55 to 8 38	100
" " 8 38 to 9	28
Total	328

The radiant point was as near as I could fix it,a 2nd magnitude star in foot of *Andromeda*. Some were quite bright, of about the 3rd magnitude, leaving short trains, color mostly white, and violet, the greater number were faint, and some scarcely visible. At 9 o'clock it became hazy and then clouded over. D. HORIGAN.

Communicated by Prof. HALL.

"A STAR SHOWER."

In the evening of November 27 for about three hours we witnessed an unusual "star shower." The meteors were seen in all parts of the sky. A single observer could count from two to six per minute, and if the whole sky had been watched, from fifteen to forty could have been seen every minute. One observer saw three at the same instant.

The radiant point was in, or near, *Andromeda*, and as that constellation was in the zenith at that time, the paths of the meteors were mostly perpendicular to the horizon, though occasionally, one was seen to move nearly parallel to it.

The majority of them were small and yellow, but some were large, reddish and very brilliant and left a luminous train. Some of these trains were ten, and some were even thirty degrees in length, and were visible some seconds.

It is probable that the shower continued through the night and through the next day, for on the evening of the 28th, a few meteors were seen to come from the same radiant point. E. M. BARDWELL.

SOUTH HADLEY, MASS., December 1st, 1885.

Minor planet (251) was discovered by PALISA, of Vienna, October 4.453 Gr. M. T., its place was R. A. 0h 0m 20s; Decl. $-7° 5'$.

DOUBLE STAR B. A. C. 6814.

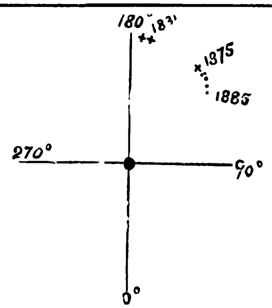
The double-star *h* 2904 (B. A. C. 6814) promises to be an interesting binary. The position of the star for 1885.0 is

R. A.=19*h* 47.4*m*;

Decl.=−24° 13′.

The components are of the 6th and 10th magnitudes. The first measures were made by Sir JOHN HERSCHEL in 1831 when the position angle was 173°.5 and the distance 20″. ±. In 1875 BURNHAM found that the position angle had changed nearly 30°. Later measures show that the change is becoming more rapid both in angle and distance and is due to orbital motion. The following are all the measures I have been able to find:

Date	Position Angle	Distance	No. of nights	Observer
1831.	173.°5	20 ″ ±	1	Herschel
1834.6	170. 6	20 ±	1	Herschel
1875.1	144. 7	....	1	Burnham
1877.73	141. 4	18. 30	2	Stone and Howe
1878.71	140. 8	18. 39	1	Burnham
1879.48	138. 9	18. 04	1	Egbert
1882.62	135. 8	17. 26	2	Wilson
1885.63	133. 0	16. 29	1	Wilson



The accompanying diagram shows graphically the change which has taken place since 1831. The approximate distances for the first three dates are indicated by crosses. H. C. WILSON.

BRILLIANT METEOR.

On the evening of Saturday, October 31, a very brilliant meteor was observed near Newark, Delaware. It dazzled the eyes of those who saw it, and lighted up the sky for several seconds like a grent flash of lightning. Information at hand is not more definite. F. G. U.

BALTIMORE.

LARGE NEBULA IN FIELD WITH GENERAL CATALOGUE 4510.

In SIDEREAL MESSENGER for October, 1884 (No 28) p. 254, I called attention to a new nebula that I had discovered; the place given being

$$\left.\begin{array}{l}\text{R. A.}=19h\ 38m\ 25s \\ \text{Decl.}=-15^{\circ}\ 2'\ 50''\end{array}\right\}1884.0$$

This object is in a lower power field with (and a little south, and a little *f.*) the small bright planetary nebula G. C. 4510. When I first saw this nebula on the night of August 17, 1884, it was very faint, and when some time later I determined its place with the 6-inch equatorial it was seen with difficulty. Since then I have frequently seen it, and it appears larger and brighter. I have on several occasions while not thinking of it swept it up and have been astonished at its distinctness.

I have lately examined it with the 6-inch and comet eye-piece, and find it fairly conspicuous, it certainly seems to be much larger and much denser than last year and I certainly think it has increased in density and size since that time.

This object is worthy of attention and I trust it may be examined by some one else. If it has always been as large and bright as now, I can not conceive how it could have been missed by observers when examining 4510 (G. C.). I have seen the small planetary nebula many times previously and swept over the region in search of comets, and cannot see why I failed to see the large nebula before August 17, 1884, unless it was fainter then With 6-inch this nebula is large and round and rather dense and even in its light. It is probably about 10′ or 15′ in diameter. There are several small stars involved in the preceding edge. Probably this is a variable nebula.
E. E. BARNARD.

METEORS NOVEMBER 27.

I sent a hurried notice to "*Science*" of the meteoric shower observed here on the evening of November 27. Since then I notice reports from Prof. YOUNG of Princeton, the Messrs. HALL and others, who fix the radiant point near Gamma *Andromadæ.* I located the same in *Perseus*, a few degrees north and west of Gamma *Andromadæ*, but cannot persist that I located it very sharply, for strange to say, no meteor appeared within fifteen to twenty degrees of this point. I began my observation at 6:15 which seems to be as early as any reported, and this was probably the maximum of the shower. I counted 134 meteors from 6:15 to 6:45. The total number must have been much greater, as very many undoubtedly escaped my notice, sometimes three and four being visible simultaneously in different parts of the sky.

None reached the brightness of first magnitude stars, few reached the second, the greater number being faint, and many at the verge of visibility. They all left trains and they moved with medium speed.

ROBERT D. SCHIMPFF.

SCRANTON, PA.

An item which has appeared in *Science*, *Nature*, and various papers and periodicals, stating that Beloit College Observatory has been closed for lack of funds is entirely without foundation.

Immediately upon the resignation of Mr. JOHN TATLOCK the present director was appointed and regular work was resumed in August.

Especial attention is given to sun-spot and spectroscopic work: a complete meteorological department has been added to the equipment and daily reports are published.

The college course has been extended for the philosophical division and students have regular work in different lines assigned to them.

A number of minor improvements in instruments have been made and the outlook is encouraging for further additions. CHAS. A. BACON.

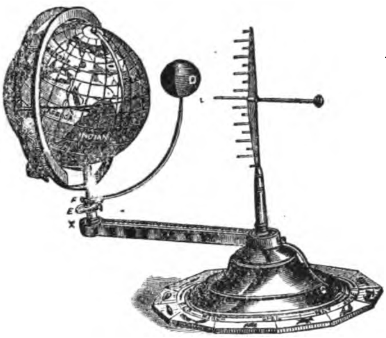
BELOIT, WIS., November 19, 1885.

The follwing orders and subscriptions have not been previously acknowledged:

George H. Peters, Chicago, Ill. Miss R. J. Thompson, Franklin, Johnson Co., Ind. Rev. Edward Brown, De Schmet, Dakota. D. A, Robinson, "Herald Office," Boston, Mass. William Higginson, Vankleek Hill, Ontario, Canada. Henry A. Pavey, Hillsborough, Ohio. William Dawson, Spiceland. Indiana. L. L. Gregg, No. 122 Front St., N. Y. City (Vols. 4 and 5). Library Company of Philadelphia,N. W. corner of Juniper and Locust Sts., Philadelphia, Pa. (Vols. 2, 3 and 4). Professor G. F. Chambers, Sussex, England (Vols. 2, 3 and 4). Professor C. H. Stewart, Warrensburg, Mo. (Vols. 2, 3 and 4). Robert Elliott, Hannibal, Mo. J. T. Clark, Topeka, Kansas. Oliver Gibbs, Jr., Lake City, Minn. C. Q. Newcombe, Great Bend, Barton Co., Kansas. Professor W. A. Grusinberg, Lenox College, Hopkinton, Iowa. Professor H. L. Smith Hobart College, Geneva, N. Y. C. M. Charroppin, S. J. St. Louis University, St. Louis, Mo. E. S. Hall, Hoopeston, Ills. Henry A. Pavey, Hillsboro, Ohio (Vol. 5). Mrs. W. R. Stiles, Warren, Ohio. Kaiserl Unniversitats, Sternwarte, Kassau, Russia. Henry A. Pavey, Hillsboro, Ohio (Vols. 2 and 3). W. E. Morgan, Spiceland, Ind. Charles G. Boerner, Vevay, Indiana. Washington and Jefferson College Library, Washington, Pa. E. M. Bardwell, Mt. Holyoke Seminary, South Hadley, Mass. C. H. F. Peters, Litchfield Observatory, Clinton, N. Y. R. Rother, 238 Randolph, Detroit, Mich. C. L. Clippenger, Fort Wayne, Indiana. Professor M. S. Snow, Washington University, St. Louis, Mo. Professor Frank H. Begelow, Racine College, Racine, Wis. President Wm. H. Baxton, National Bank, Cambridge, Maryland. W. H. Numsen, 18 Light St., Baltimore, Md. Professor Daniel Kirkwood, State University, Bloomington, Indiana. Professor H. S. Freeman, Adelbert College, Cleveland, Ohio. J. Hagan, S. J. College of the Sacred Heart, Prairie du Chien, Wisconsin.

This page next to reading matt—

ASTONISHING



That not one teacher in — either understands or can readily explain:

1. Change of Season and Causes.
2. Tropics and Signification.
3. Zones and Origin.
4. Phenomenon of Midnight Sun.
5. Phazes of Moon.
6. Twilight Belt.
7. Tides and Eclipses.

YET,

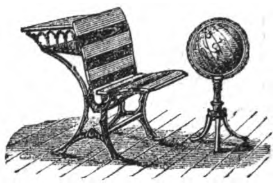
ANDREWS' TELLURIAN

(SEE CUT)

Shows all these points clearly by Object Teaching.

In fact, this apparatus is a revelation to Teachers.

The Triumph School Desk



Dovetailed and Doweled together, takes the Lead of all.

SIXTY KINDS OF GLOBES. ALL SIZES.

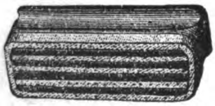
---

40 kinds of Blackboards, including Liquid Slating and the celebrated

Which is put on as a black mortar, better than Stone Slate, and costing say one-fifth as much.

THE DUSTLESS ERASER

Takes the lead by all odds, in durability, beauty and comfort. Ten sold to one of any other kind.



Crayons, Maps. Charts. Geometric Forms and Solids. Etc. Send for circulars to

A. H. ANDREWS & CO.,

195 Wabash Avenue, Chicago.

R. S. ALLEN,

MANUFACTURER OF REFRACTING

ASTRONOMI'L TELESCOPES,

of all sizes. Alt. Azimuth or Equatorial Mountings.
Objectives, Eye-pieces, Prisms and Accessories
Manufactured and Furnished at short notice.

NO. 136 WESTMINSTER STREET, PROVIDENCE, R. I.

Telescope for Sale. An Equatorial Telescope; 16-inch object-glass; made by Henry Fitz, N. Y.; for sale, very cheap, by the family of the late Dr. Wm. S. Van Duzee, of Buffalo, Address,

MRS. O. H. VANDUZEE,
Lancaster, Erie Co. N. Y.

ESTABLISHED 1846

Scientific American The most popular weekly newspaper devoted to science, mechanics, engineering discoveries, inventions and patents ever published. Every number illustrated with splendid engravings. This publication furnishes a most valuable encyclopedia of information which no person should be without. The popularity of the SCIENTIFIC AMERICAN is such that its circulation nearly equals that of all other papers of its class combined. Price, $3.20 a year. Discount to clubs. Sold by all newsdealers. MUNN & CO. publishers, 361 Broadway, N. Y.

CARLETON COLLEGE,

NORTHFIELD, MINN.

FULL PREPARATORY AND COLLEGIATE DEPARTMENTS.
ENGLISH, SCIENTIFIC, LITERARY and MUSICAL COURSES.
ALL DEPARTMENTS OPEN TO STUDENTS OF EITHER SEX.
EXPENSES VERY LOW.

The central office of the State Weather Service is located at Northfield and under the direction of Carleton College, affording special advantages for the study of Meteorology, and the Signal Service of the Government.

CALENDAR.

Term Examinations, December 21st and 22d, 1885.
Winter Term begins Wednesday, January 6, and ends March 18, 1886,
Term Examinations, March 17th and 18th, 1886.
Spring Term begins Wednesday, March 31. and ends June 17, 1886.
Examinations to enter College, June 12 and 14. and Sept. 7, 1886.
Term Examinations, June 15 and 16, 1886.
Anniversary Exercises, June 14–17, 1886.
Exhibition at Art Room of work of Pupils in Drawing and Painting, June 14–17, 1885.
Wednesday, September 9, 1886, Fall Term begins.
For further information address

JAMES W. STRONG, PRES. Northfield, Minn.

The Sidereal Messenger

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

VOL. 5. No. 2. FEBRUARY, 1886. WHOLE No. 42.

TO COMPUTE THE ELEMENTS OF METEORIC ORBITS

S. J. CORRIGAN. *

[For the Messenger.]

So far as the writer knows, no attention has been paid to the subject of the computation of the elements of meteoric orbits, in any work in the English language on Theoretical Astronomy; but the general equations of Celestial Mechanics, as given in any standard treatise such as WATSON'S in English, and OPPOLZER'S in German, enable one to deduce the formulæ necessary for the derivation of the elements from the observed position of the radiant.

The object of this article is to present, in the simplest manner, the process of deriving these formulæ and to so arrange the latter that one may readily apply them. This process is greatly simplified by the well-founded assumption that the orbit of a member of a well-defined meteoric stream is, approximately at least, a parabola, having its focus at the *Sun's* centre and one of the nodes at that longitude in which the *Earth* is at the time of apparition of the meteor.

Hence the radius-vector r of the meteor may be assumed equal to R, or the radius-vector of the *Earth*, and the co-ordinates of the *Sun* may be taken as the heliocentric co-ordinates of the meteor.

The elements of the orbit of any body moving around the *Sun* are known if we know the heliocentric rectangular co-ordinates of the body, and the velocities parallel to them; there-

* Nautical Almanac Office, Navy Dept. Washington, D. C.

fore since the co-ordinates of the meteor, at the time of its appearance, are known, only the component velocities remain to be found.

Let l represent the longitude and b the latitude of the observed radiant; x, y, z, the heliocentric rectangular co-ordinates of the meteor; ξ, η, ζ, its geocentric co-ordinates; and X, Y, Z, the co-ordinates of the *Sun*. The component velocities parallel to the respective axes will be,

$$\frac{dx}{dt},\ \frac{dy}{dt},\ \frac{dz}{dt};\ \frac{d\xi}{dt},\ \frac{d\eta}{dt},\ \frac{d\zeta}{dt};\ \frac{dX}{dt},\ \frac{dY}{dt},\ \frac{dZ}{dt}$$

Then

$$\left.\begin{aligned}\frac{dx}{dt}&=\frac{d\xi}{dt}+\frac{dX}{dt}\\ \frac{dy}{dt}&=\frac{d\eta}{dt}+\frac{dY}{dt}\\ \frac{dz}{dt}&=\frac{d\zeta}{dt}+\frac{dZ}{dt}\end{aligned}\right\}\qquad(1)$$

The velocities parallel to the geocentric co-ordinates may be obtained in the following manner: Expressing by g the ratio of the linear velocity of the meteor with respect to the *Earth*, to the velocity at unit distance, which velocity is known and is represented by the Gaussian constant k, we will have for the linear velocity of the meteor relative to the *Earth* the expression gk; hence the velocities parallel to the geocentric co-ordinates will be

$$\left.\begin{aligned}\frac{d\xi}{dt}&=-gk\cos l\cos b\\ \frac{d\eta}{dt}&=-gk\sin l\cos b\\ \frac{d\zeta}{dt}&=-gk\sin b\end{aligned}\right\}\qquad(2)$$

The negative sign is used because the orbital motion is in a direction opposite to the direction of the line of sight.

The linear velocity in any conic section is expressed by the equation

$$V^2=k^2(1+m)\left\{\frac{2}{r}-\frac{1}{a}\right\}\qquad(3)$$

m representing the mass, a the mean distance and r the radius-vector of the moving body. In the case of the parabola, in which we assume the meteor to move, $\frac{1}{a}$ will vanish, and the meteor being small, m may be neglected, and since r may be taken equal to R, equation (3) becomes

$$V^2=\frac{2k^2}{R_\circ}=\frac{dx^2+dy^2+dz^2}{dt^2} \tag{4}$$

Squaring and adding equations (1), reducing by means of equations (2) and (4), and taking the plane of the ecliptic as the fundamental plane, so that $\frac{dZ}{dt}=0$; we will have the equation

$$g^2-\frac{2g}{k}\cos b\left\{\cos l\frac{dX}{dt}+\sin l\frac{dY}{dt}\right\}=$$

$$\frac{2}{R}-\left\{\frac{2}{R}-1\right\}=1; \tag{5}$$

from which we can get the value of g. The velocities $\frac{dX}{dt}$ and $\frac{dY}{dt}$ are obtained in the following manner:

Let L=Longitude of *Sun*

π'= " " *Sun's* perigee=280°+1.'03(t−1850)

v=*Sun's* true anomaly

φ=Angle of *Earth's* eccentricity

Then since $L=\pi'+v$

$$\frac{dL}{dt}=\frac{dv}{dt}, \tag{6}$$

We have also

$$X=-R\cos L,\quad Y=-R\sin L \tag{7}$$

Differentiating equations (7) with respect to the time, we get:

$$\left.\begin{aligned}\frac{dX}{dt}&=-\cos L\frac{dR}{dt}+R\sin L\frac{dv}{dt}\\ \frac{dY}{dt}&=-\sin L\frac{dR}{dt}-R\cos L\frac{dv}{dt}\end{aligned}\right\} \tag{8}$$

to find $\frac{dv}{dt}$ and $\frac{dR}{dt}$ we take the well-known equation, expressing the double areal velocity, viz: $R^2\frac{dv}{dt}=2f=k(1+m)\sqrt{p}$ (8a)

neglecting the mass, substituting for p the semi-parameter, its value $a\cos^2\varphi$, and making a=1, we have

$$\frac{dv}{dt}=\frac{k\cos\varphi}{R^2} \tag{9}$$

Differentiating the equation, $R=\frac{a\cos^2\varphi}{1+\sin\varphi\cos v}$, with respect to the time as contained in v, we will get $\frac{dR}{dt}=\frac{R^2}{\cos\varphi}\tan\varphi\sin v\frac{dv}{dt}$, or by substituting the value of $\frac{dv}{dt}$, as given in equation (9);

$$\frac{dR}{dt}=k\tan\varphi\sin v \tag{10}$$

The equation $R=\frac{\cos^2\varphi}{1+\sin\varphi\cos v}$ gives $\frac{\cos^2\varphi}{R}=1+\sin\varphi\cos v$

Then equations (8) may be written

$$\left.\begin{aligned}\frac{dX}{kdt}&=\sin L+\sin\varphi\sin\pi'=s\sin L'\\ -\frac{dY}{kdt}&=\cos L+\sin\varphi\cos\pi'=s\cos L'\end{aligned}\right\} \tag{11}$$

Squaring and adding equations (11) and reducing by equation (3), we get $s^2=\frac{2}{R}-1$; (12)

and by neglecting the square of the eccentricity; $s=\frac{1}{R}$; (12 a)

Multiplying the first of equations (11) by cos L and the second by sin L and subtracting the latter from the former, we will have, after reduction, $\sin(L'-L)=\sin\varphi\sin(\pi'-L)$; or, since $(L'-L)$ is a small arc, we may take,

$$L'=L+\sin\varphi\sin(\pi'-L); \tag{13}$$

Equation (5) may then be written

$$g^2+2g\frac{\cos b\sin(l-L')}{R}=1; \tag{14}$$

The solution of equation (14) is facilitated by taking an auxiliary angle z, so that

$\frac{\cos b\sin(l-L')}{R}=\cot z$, we will then have,

$$g=\frac{\pm1-\cos z}{\sin z}=\tan\frac{1}{2}z \tag{15}$$

By restricting z to less than 180°, sin z will always be positive, and, since the ratio g must be positive, 1 will have the upper sign only. By substituting the value of g so found, in equations (2), we will have the velocities parallel to the geocentric axes, and we can now proceed to the determination of the elements.

Taking the fundamental equations of planetary motion:

$$\frac{d^2x}{dt^2}+k^2\,(1+m)\frac{x}{r^3}=0$$

$$\frac{d^2y}{dt^2}+k^2\,(1+m)\,\frac{y}{r^3}=0$$

$$\frac{d^2z}{dt^2}+k^2\,(1+m)\frac{z}{r^3}=0$$

and multiplying the first of these equations by y and the second by x, and subtracting the latter result from the former, and treating the rest in like manner, so as to get rid of the second term of the first member of each equation, we will have after integrating:

$$\left.\begin{aligned}\frac{xdy-ydx}{dt}&=c\\ \frac{xdz-zdx}{dt}&=c'\\ \frac{ydz-zdy}{dt}&=c''\end{aligned}\right\}\qquad(16)$$

c, c' and c'' are the constants of integration, and they represent double the areal velocities, parallel to the axes x, y and z, respectively.

Let i represent the inclination of the plane of the meteoric orbit to the plane xy; and let Ω denote the angle between the axis x and the line of intersection of the orbital plane with the plane xy; then denoting the double areal velocity by $2f$, and having from equations (16,) c, c', and c'', as the components of this double velocity with respect to the axes x, y and z we will have, since $2f=k\sqrt{p}$:

$$\left.\begin{aligned}c&=2f\cos i &&=k\sqrt{p}\cos i &&=x\frac{dy}{dt}-y\frac{dx}{dt}\\ c'&=2f\cos\Omega\sin i &&=k\sqrt{p}\cos\Omega\sin i &&=x\frac{dz}{dt}-z\frac{dx}{dt}\\ c''&=2f\sin\Omega\sin i &&=k\sqrt{p}\sin\Omega\sin i &&=y\frac{dz}{dt}-z\frac{dy}{dt}\end{aligned}\right\}\qquad(17)$$

Substituting for the semi-parameter p its equivalent in the parabola, viz: $2q$, q representing the perihelion distance, and taking the *Sun's* rectangular co-ordinates for the heliocentric co-ordinates of the meteor, so that $X=-R\cos L$ and $Y=$

$-R\sin L$, we will have after reducing by the relations in equations (1) and (2):

$$\left.\begin{aligned} k\sqrt{(2q)}\cos i &= R\sin L\frac{dx}{dt} - R\cos L\frac{dy}{dt} \\ k\sqrt{(2q)}\cos\Omega\sin i &= -R\cos L\frac{dz}{dt} = gkR\cos L\sin b \\ k\sqrt{(2q)}\sin\Omega\sin i &= -R\sin L\frac{dz}{dt} = gkR\sin L\sin b \end{aligned}\right\} \quad (18)$$

Since in the two last of equations (18) $k\sqrt{(2q)}\sin i$ and gkR must be always positive, Ω will be equal to L when $\sin b$ is positive, but when $\sin b$ is negative, Ω will be equal to $L+180°$. From them also we get $\sqrt{(2q)}\sin i = \pm gR\sin b$; that sign to be taken that will make the first member positive.

From the first of equations (18) we get, after reducing by the relations in (1), (2), (12) and (12a)

$$\sqrt{(2q)}\cos i = \sin L\,(\sin L' - gR\cos b\cos l) + \cos L\,(\cos L' - gR\cos b\sin l).$$

Since $\cos(L-L')$ differs but little from unity, we may write this equation, $\sqrt{(2q)}\cos i = 1 + gR\cos b\sin(l-L)$.

Then we will have:

$$\left.\begin{aligned} \sqrt{(2q)}\sin i &= \pm gR\sin b \\ \sqrt{(2q)}\cos i &= 1 + gR\cos b\sin(l-L) \end{aligned}\right\} \quad (19)$$

from which to obtain the elements i and g. To derive the true anomaly v, from which we also get the perihelion longitude π; through the equation $\pi = L - v + 180°$, we differentiate the equation $r = \frac{q}{\cos^2 \frac{1}{2}v}$ with respect to the time, and get thereby $\frac{dr}{dt} = r\tan\frac{1}{2}v\,\frac{dv}{dt}$, or, substituting the value of $\frac{dv}{dt}$ from equation (8a) $\frac{dr}{dt} = \frac{k\sqrt{(2q)}}{r}\tan\frac{1}{2}v$; whence

$$\tan\tfrac{1}{2}v = \frac{r\frac{dr}{dt}}{k\sqrt{(2q)}};\ \text{but}$$

$\frac{rdr}{dt} = \frac{xdx+ydy}{dt}$, then through equations (1), (2), (12) and (12 a), and taking $r=R$, we will have $\frac{rdr}{kdt} = gR\cos b\cos(l-L) - \sin(L'-L)$, from which we get

$$\tan\tfrac{1}{2}v = \frac{gR\cos b\cos(l-L) - \sin(L'-L)}{\sqrt{(2q)}};$$

$\frac{1}{2}v$ is to be taken between the limits $-90°$ and $+90°$.

From the equation, $r=\frac{q}{\cos^2 \frac{1}{2}v}$, we get $q=R \cos \frac{1}{2}v$. This value of q should agree with that obtained from equations (19), if the computation is not in error; it may therefore be used as a check. We may express the value of $\sin \varphi = e =$ eccentricity of the *Earth's* orbit in minutes of arc; its logarithm is, therefore, 1.7609.

Then we will have the following formulæ for the computation of the parabolic elements of the orbit of a meteor stream, from the longitude and latitude of the radiant point:

$\log e' = 1.7609$

$\pi' = 280° \; 21' + 1.'03(t-1850)$

$L'-L = e' \sin (\pi'-L)$

The value $L'-L$ will be in minutes of arc;

$\cot z = \frac{\cos b \sin(l-L')}{R}$; z to be less than 180°

$g = \tan \frac{1}{2}z$

$f = Rg$

$\sqrt{(2q)} \sin i = \pm f \sin b$ { Upper sign when $\sin b$ is positive. Lower " " " " " negative.

$\sqrt{(2q)} \cos i = 1 + f \cos b \sin (l-L)$,

☊ $= L$ when $\sin b$ is positive,

☊ $= L + 180°$ when $\sin b$ is negative.

$\tan \frac{1}{2}v = \frac{f \cos b \cos (l-L) - \sin (L'-L)}{\sqrt{(2q)}}$.

$\frac{1}{2}v$ to be taken between the limits $-90°$ and $+90°$,

$\pi = L - v + 180°$,

Check: $q = R \cos^2 \frac{1}{2}v$.

Elements derived by means of the above formulæ will suffice to disclose the identity of the orbit of a meteoric stream with a cometary orbit, if such identity should exist. Then if periodicity can be well established, other assumptions as to the eccentricity may be made, and elliptic elements computed. It is hoped that this presentation of formulæ, derived from authentic sources may prove useful to those readers of the "MESSENGER" who are interested in this comparatively new branch of astronomy.

A computation of the parobolic elements of the orbits of the twenty meteoric showers whose radiants and dates of maximum are given by Mr. W. F. DENNING on page 300 of the December number of the MESSENGER, furnishes the following results which I tabulate in such a manner that they will correspond to the date given us by Mr. DENNING.

Night of max.	Radiant Point. R. A.	Decl.	π	☊	i	q	Direction of motion
1885			° ′	° ′	° ′		
July 8	245°	+52°	293 58	106 54	30 06	1.0127	Direct
" 13	271	+21	335 50	110 40	24 58	0.8727	"
" 12	329	+36	345 40	110 42	86 03	0.8000	Retrograde
" 9	280	−14	2 56	107 51	7 08	0.6392	Direct
Aug. 17	345	0	102 39	145 10	16 26	0.1330	"
" 17	345	+53	16 00	145 10	79 01	0.8255	"
" 20	5	+12	119 27	148 04	55 11	0.0618	Retrograde
Sept. 4	346	0	81 40	162 34	6 27	0.4241	Direct
" 3	354	+38	75 24	161 36	65 56	0.4706	"
" 3	253	+54	357 00	161 36	32 58	1.0057	"
" 8	62	+36	18 27	166 27	25 53	0.9302	Retrograde
" 9	335	+71	14 28	167 25	65 03	0.9514	Direct
" 15	76	+57	35	173 16	57 18	1.0007	Retrograde
" 8	335	+28	60 31	166 27	31 49	0.6416	Direct
" 15	5	+12	116 19	173 16	17 30	0.2284	"
" 15	13	+ 6	132 21	173 16	1 08	0.1228	"
Oct. 12	103	+33	50 23	199 50	17 37	0.9280	Retrograde
" 8	42	+55	106 08	195 52	83 26	0.4968	Direct
" 16	143	+49	59 21	203 48	57 16	0.9032	Retrograde
" 7	31	+18	149 57	194 53	13 04	0.1459	Direct

In the above table π represents the longitude of the perihelion of the meteoric orbit, ☊ its ascending node, *i* its inclination to the ecliptic and *q* its perihelion distance, the *Earth's* mean distance from the *Sun* being taken as the unit.

I also append the following table of comparison between the apparent velocities noted by Mr. Denning and the true linear velocities relative to the Earth, as derived from my computation on the hypothesis of parabolic motion.

Date	Appearance noted by Mr. Denning	Linear Velocity	Date	Appearance noted by Mr. Denning	Linear Velocity
1885			1885		
July 8	Meteors very slow	14 miles per s.	Sept. 8	Very swift, streaks	48 miles per s.
" 13	Slow, faint	14 " " "	" 9	Medium speed	25 " " "
" 12	Swift, streaks	32 " " "	" 15	Very swift, streaks	39 " " "
" 9	Slow, long paths	16 " " "	" 8	Slow, faint	19 " " "
Aug 17	Medium speed	26 " " "	" 15	Slow	24 " " "
" 17	Very swift	29 " " "	" 15	Swift	26 " " "
" 20	Medium speed	33 " " "	Oct. 12	Very swift, streaks	44 " " "
Sept. 4	Slow, bright	20 " " "	" 8	Slow	30 " " "
" 3	Very swift	27 " " "	" 16	Swift, streaks	39 " " "
" 3	Slow, yellow	15 " " "	" 7	Slow, bright	25 " " "

I think that the correspondence between the above named quantities is somewhat remarkable, and tends to strengthen the hypothesis of motion in a conic section whose eccentricity differs but little from unity. It also shows the accuracy with which a skilled observer can estimate a quantity so difficult to obtain.

Washington, D. C. December 10, 1885.

GALLE'S CATALOGUE OF COMETS FROM 1860 TO 1884.

(*Continued from page 10.*)

(240) T_1, A. N. 93: 319, 94: 157. Found with the help of SEELIGER's ephemeris April 3, by STEPHAN at Marseilles; last observed August 1 by ANDRE and BAILLAUD at Paris. First return of TEMPEL's first comet. Its orbit has the least eccentricity (e=0.46) of all the comet orbits yet known.

251 T_2. Annuaire 1884 p. 229. Discovered by TEMPEL at Milan July 3; last observed by HIND and PLUMMER at Twickenham October 20. The second of the periodic comets discovered by TEMPEL: period, about 5 years (U=5.2 years), the shortest period next to that of ENCKE's comet.

(163) F. A. N. 80: 337. Found with MOELLER's very accurate ephemeris, September 3 by STEPHAN at Marseilles, and observed there November 28 and 30; last observed December 23 by PETERS at Clinton. On account of its faintness, not seen elsewhere.

252. A. N. 92: 72. Discovered August 20 by BORELLY at Marseilles; last observed September 20 by STRASSER at Kremsmuenster and by HALL at Washington. From five normal places, with the perturbations by *Venus*.

253. A. N. 83: 50. Discovered August 23 by PAUL HENRY at Paris; last observed by PALISA at Pola November 28 and December 17, the latter observation only approximate. The elements above include the post-perihelion observation of November 28.

(171) Br. A. N. 93: 183. Found August 31 by STEPHAN at Marseilles; last observed by PLUMMER at Twickenham, October 26.

254. A. N. 87: 122. Discovered November 10 by COGGIA at Marseilles, and November 11 by WINNECKE at Strassburg. Observed for only a few days:—by WEISS at Vienna till November 15. The computed orbits show a resemblance to the very roughly observed comets (No. 127 *b*,) 1818 I, and the above elements by WEISS assume a period of 6.2022 years.

255. A. N. 94: 200. Discovered by WINNECKE at Strassburg February 20; observed February 20–25: last, at Pola by

PALISA and at Vienna by SCHULHOF. The elements given above are deduced from all the observations made during this short time.

256. Wien. Ak. S. B. 77 (1878). Discovered April 11 by WINNECKE at Strassburg, April 15 by BORELLY at Marseilles and April 18 by TEMPEL at Milan. Last observed June 17 by SCHULHOF at Vienna. The above elements are from nine normal places, embracing all the observations.

257. Wien. Ak. S. B. 86, A. N. 103: 63. Discovered by COGGIA at Marseilles April 17. At first faint, but it was approaching the *Earth*, and finally became one of the brightest of the more recent comets. In the northern hemisphere it was observed to July 17, (SCHMIDT at Athens saw the tail even to July 23) and then in the southern hemisphere from July 27 to October 18; last observed by THOME at Cordoba. The orbit by v. HEPPERGER is deduced from 618 observations divided into seventeen normals, and takes account of perturbations.

258. Wien. Ak. S. B. 1882, A. N. 104: 223. Discovered August 19 by COGGIA at Marseilles; last observed November 14 by PLUMMER at Orwell Park. This orbit, computed from seven normal places, is an ellipse of 306.043 years' period. The observations are not satisfied by a parabola.

259. Wien. Ak. S. B. 1878 July. Discovered July 25 by BORELLY at Marseilles; last observed at Hamburg by RUMKER October 20. An ellipse computed from nine normal places represents the observations rather better than a parabola. though differing very little from the latter. Very nearly the same orbit was found from five normals by GRUBER and KURLAEDER (A. N. 91: 79).

260. Wien. Ak. S. B. 1878 November, A. N. 94: 190. Discovered December 6 by BORELLY at Marseilles; last observed January 7, 1875 by BRUHNS at Leipzig. The above orbit embraces the few observations which could be obtained.

(131) W. A. N. 97: 338. Found February 1 by BORELLY at Marseilles, and visible for a short time only, during the early morning hours. Last observed February 15 by SCHIAPARELLI at Milan.

(96) E. Mem. de St. Petersb. 26 No. 2: 121. Found Janu-

ary 26 by HOLDEN and TUTTLE at Washington, and January 27 by STEPHAN at Marseilles; observed at Moscow by BREDICHIN to April 10, and after perihelion only three times, May 7 and 9 at Windsor by TEBBUTT, and May 17 at Melbourne by WHITE.

261. A. N. 100: 238. Discovered February 8th by BORELLY at Marseilles, and February 9 by PECHULE at Copenhagen, where it was also longest observed (to April 31.) These elements rest on five normal places.

262. A. N. 93: 45. Discovered by WINNECKE at Strassburg April 5, and by BLOCK at Odessa April 10. Last observed July 13 by SCHMIDT at Athens. The orbit is derived from about 280 observations,and takes account of perturbations.

263. Wien. Ak. S. B. 78: 976. Discovered April 11 by SWIFT at Rochester, April 14 by BORELLY at Marseilles, April 16 by BLOCK at Odessa. BLOCK had, indeed, seen the comet on April 10, but he had not recognized the cometary character. The orbits computed by NICHOL (A. N. 93: 42) and by POENISCH (A. N. 100: 63) both from normal places, show a very close agreement with ZELBR's orbit given above.

(189) d'A. Annales de l'observ. de Paris 14 p. B. 25. Found July 9 by TEMPEL at Arcetri, and by COGGIA at Marseilles; also July 13 by SCHMIDT at Athens; last observed September 10 at Athens.

264. Wien. Ak. S. B. 1882 January, A. N. 101: 239. Discovered October 2 by TEMPEL at Florence. Observed only to October 14; last at Leipzig by PETER, at Milan by SCHIAPARELLI, at Orwell Park by PLUMMER, and at Pola by J. PALISA. The elements above are derived from all the published observations, through four normals.

265. M. N. 38: 56, A. N. 91: 91. Discovered by COGGIA at Marseilles September 13. The last observation is by J. PALISA at Pola, December 10. Above elements from observations to October 31.

266. A. N. 97: 277. Discovered July 7 by SWIFT at

Rochester, and observed on only four days, July 7, 10, 19 and 23, — by PETERS at Clinton. The above is the most probable orbit from these four observations.

(96) E. A. N. 92: 193. Found August 3 by TEBBUTT at Windsor; last observed September 6 at Cordoba by THOME.

(251) T_2. Annuaire 1884 p. 229. TEMPEL'S second comet; found July 19 by TEMPEL at Arcetri, and last observed there December 18; seen also December 21.

(171) Br. A. N. 93; 185. Found January 14 by TEMPEL at Arcetri; first accurate observation February 26 by TEBBUTT at Windsor; and last observed May 23 by PETER at Leipzig.

267. Diss. inaug. Vratisl. 1883, A. N. 108: 102. Discovered by SWIFT at Rochester June 16; last observed August 23, at Cambridge, U. S., by WENDELL. The orbit depends on six normal places, embracing nearly all the observations.

(240) T_1. A. N. 94: 158. Second return of TEMPEL'S first comet. Found by TEMPEL himself at Arcetri April 24, and also last observed by him July 8.

268. A. N. 96: 31. Discovered by Hartwig at Strassburg August 24; last observed on September 18 at Konigsberg by FRANZ. The above elements from August 28, September 8 and 13.

269. Wien. Ak. S. B. 81 (1880). Discovered by A. PALISA at Pola August 21; last observed at Rome October 22 by TACCHINI. Above orbit from fifty-five observations arranged in five normal places.

270. A. N. 102: 88. The head of this comet was first seen by GOULD at Cordoba, February 4, the tail having been noticed on January 31. In its general appearance, as well as in the elements of its orbit it was remarkably like Comet 1843 I. On account of the rapid decrease of its brightness it could not be observed, either in the southern hemisphere or here, later than February 19 (last at Cordoba by GOULD). The investigations in regard to its orbit cannot be considered as en-

tirely definitive. The above orbit by W. MEYER, founded on seven normal places assumes hypothetically a period of 36.844 years going back directly to Comet 1843 I.

271. Wien. Ak. S. B. 1881 June, A. N. 100: 383. Discovered April 6 by SCHAEBERLE at Ann Arbor. Last observed, before perihelion, on June 8, by KORTAZZI at Nikolaiev, and after perihelion, September 8–11, by BIGOURDAN at Paris. The orbit by J. MAYER depends on eight normal places, and differs very little from one computed by BIGOURDAN from three normals April 8 to May 18 (C. R. 91: 74).

272. A. N. 105: 362, 106: 121. Discovered September 29 at Strassburg by HARTWIG and September 30 at Ann Arbor by Harrington; last observed by TEMPEL at Arcetri November 30. From seven normal places, September 30 to November 30, which are well represented by the above orbit.

(244 T_3.) A. N. 99: 14, C. R. 91: 967. Discovered October 10 at Rochester by SWIFT, also November 27 at Dun Echt by J. G. LOHSE. Observed to January 20 by WENDELL at Cambridge, U. S. The identity with Comet 1869 III (TEMPEL) (which is now designated as the third periodic comet discovered by TEMPEL) was soon recognized, and with this assumption the above ellipse representing satisfactorily both returns was computed.

COOPER at Sheffield detected a comet December 21, 1880 and afterwards saw it December 21 and 25, but it was not seen elsewhere. Dr. OPPENHEIM has attempted to derive an orbit from the three positions, which are merely estimated to half a degree:

T=Nov. 8, 19h 32m. π=184° 2′. ☊=257° 36′. i=50° 48′. Log. q=9.5874. R. These however represent the middle place to only 19′. (A. N. 100: 73. The Observatory 4: 30, 217.)

273. C. R. 92: 172. Discovered at Copenhagen by PECHULE December 16; observed at Paris by BIGOURDAN to March 31. Above elements are from observations of December 16th, January 1 and 19.

(163) F. Berl. Astr. Jahrb. 1882: [138]. First detected August 2, 1880 by COMMON at Ealing; afterwards found by TEMPEL at Arcetri, August 11, and first observed by the latter August 25. Observations continued at Washington by HALL to March 27, 1881.

274. A. N. 105: 315. Discovered by SWIFT at Rochester April 30, and only observed May 2–11; last (May 11) by BORELLY at Marseilles. The above orbit is derived from four normal places, May 3–11.

A comet was seen by BARNARD at Nashville, 1881 May 12 and 13, near *α Pegasi*, but it was not found May 14 and subsequently. *See* A. N. 100: 127, and Copernicus 1: 140.

275. C. R. 93: 660. A bright comet,—first seen in the southern hemisphere, May 22, by TEBBUTT at Windsor, and a month later it appeared in the northern hemisphere, and was visible to the naked eye until the beginning of November. It was observed three months longer, (nearly nine months in all) and was last seen February 14, 1882 by WENDELL at Cambridge, U. S. Soon after its discovery the resemblance of its orbit to that of the comet of 1807 was noticed, but further computation did not establish their identity. A great many computations of the orbit of this comet were made (more than thirty) but so far no one has taken in the whole series of observations. An orbit by BOSSERT was derived from eight normal places (with 423 observations, May 21 to September 29) and gives a period=2954.5 years. The orbit by DUNER and ENGSTROM shows a remarkably close agreement (A. N. 100: 284.) The latter was formed from four normal places and represents the observations from May 27 to September 2 within a few seconds. Other elements differ from BOSSERT's only in the 6th decimal, the period, also, coming out 2954 years.

276. Diss. inaug. Kiel 1884. A. N. 108: 228, 437. Discovered July 14 by SCHAEBERLE at Ann Arbor. visible to the naked eye at the same time as the preceding great comet, 1881 III. In Europe it was observed to September 13 by

TEMPEL at Arcetri; in the southern hemisphere by TEBBUTT at Windsor to October 15, at Melbourne by WHITE to October 8 (seen October 9 and 21;) at the Cape by GILL and ELKIN to October 18. The above is the most probable orbit from all the observations, and allows for perturbations.

277. Copernicus 3: 15, A. N. 105: 111. Discovered October 4 by DENNING at Bristol; last observed November 19 at Strassburg by WINNECKE. The orbit proved to be elliptic ($U=$ 8.86 years). In PLUMMER'S discussion, from eight normal places, perturbations are allowed for, and the star places are corrected from recent observations.

278. A. N. 102: 269. Discovered by BARNARD at Nashville, Tennessee, September 17; last observed at Cambridge, U. S., October 27 by WENDELL. The above orbit includes all the observations made in this short time.

(96) E. Bulletin de St. Petersb. 27, A. N. 100: 111. Found, by BACKLUND'S ephemeris, August 20, at Strassburg by WINNECKE and HARTWIG, and at Leipzig by PETER; also August 21 by TEMPEL at Arcetri and by SCHMIDT at Athens; more accurately observed August 24 by STRUVE at Pulkowa and August 25 by WINNECKE at Strassburg; last observed November 11 by TACCHINI at Rome.

279. C. R. 93: 1122. Discovered November 16 by SWIFT at Rochester; last observation January 12, 1882, by J. PALISA at Vienna. Elements from November 17, 27, December 12, 21.

280. A. N. 107: 94, M. N. 44: 12. Discovered March 17 by WELLS at Albany, U. S. Bright comet, and observed at the time of perihelion in full daylight. Last observed August 16 at the Cape of Good Hope by FINLAY. The above elements are derived from six normal places March 26 to August 7.

During the total solar eclipse of May 16, 1882, a comet was seen close to the *Sun* at Sohag in Egypt. Further information in regard to it will be found in A. N. 102: 271. The Observatory 5: 209, C. R. 94 and 95 [also Phil. Trans. Roy.

Soc. 175: 261]. Compare also HOLETSCHEK, Wien. Ak. S. B. 1883, November.

281. A. N. 104: 157. This great comet was discovered* with the naked eye, early in September at several places in the southern hemisphere: September 3 at Auckland, September 6 at Cordoba by GOULD, September 7 at Melbourne by ELLERY, September 8 at the Cape by FINLAY, September 11 at Rio de Janeiro by CRULS. It developed into one of the grandest comets of this century, comparable only with the Comet of 1811, and DONATI's Comet, 1858 VI.

On account of the unusual form of its orbit, and the great variety of new and strange physical phenomena, which could be observed with all our modern appliances, this comet must be regarded as standing alone in the history of astronomy. At the time of its perihelion, September 17 and 18, it was quite generally seen at many places in Europe and America,—even with the naked eye,—close to the *Sun*. COMMON at Ealing discovered it near the *Sun*, September 17, and the astronomers at the Cape observatory succeeded in observing it pass before the *Sun's* disk, where it completely disappeared. This would not be the place to go into further description. Observations of the comet's position were continued to June 1, 1883, when it was last observed by THOME at Cordoba. The above orbit depends on nine normal places, before and after perihelion, from September 8 to November 14. It shows, as was remarked very soon after the discovery, a striking resemblance to the orbits of the great comets, 1843 I and 1880 I, which is all the more surprising, since an identity of the two latter comets did not seem to accord entirely with the observations.

Besides a peculiar, broad, but faint* nebulous veil around the comet, SCHMIDT at Athens discovered on October 8th an irregu-

* A letter, recently received from Dr. GALLE, contains the following note in regard to this comet (1882 II): "The first actual observation of this great comet seems to have been made by FINLAY at the Cape, on September 7. It was seen with the naked eye at the Cape, as early as September 1, at Auckland September 3, and a few days later in South America and in Australia. The nebula near the comet was discovered by SCHMIDT at Athens, on October 9 (not October 8), and also, independently, on the same day, but a few hours later, by HARTWIG in the southern hemisphere." [W. C. W.]

lar nebulous mass, apparently 4° southwest of the main comet, and separated entirely from it. This seemed to form a sort of companion comet, following approximately the motion of the larger comet (A. N. 103: 209, also HARTWIG, A. N. 106: 231). For attempts to determine the orbit of this nebulous object (the orbits do not differ very much from that of the main comet) *see Zelbr*, Wien. Ak. S. B. 86, and v. HEPPERGER, ib. 87.

Similar nebulous masses were seen at a little distance from the comet, somewhat later by BARNARD at Nashville, BROOKS at Phelps and LA CAILLE at Olinda.

282. A. N. 104: 219. Discovered by BARNARD September 13 at Nashville, Tennessee; last observed December 8 by TEBBUTT at Windsor. Above orbit from five normals, September 19 to November 11.

283. M. N. 44: 88. Discovered February 23 by BROOKS at Phelps (N. Y.) and a little later on the same day, by SWIFT at Rochester (N. Y.); last observed April 15 by MILLOSEVICH at Rome. The above orbit is computed from March 3, 23 and April 12.

284. A. N. 108; 264. Discovered 1884 January 7th by Ross at Elsternwick near Melbourne; seen by ELLERY at Melbourne to February 19; last observation, however, not accurate Above orbit from five observations, January 12 to February 4.

On the 25 and 27 of December, 1883, a little before sunrise a bright comet was seen at New Norfolk, Tasmania, at an altitude of 8° or 10° above the horizon. Further particulars are found in A. N. 108: 275, 423 and The Observatory 7: 141.

(124) P. Bull. astr. 1: 26, A. N. 108; 10. For some time attention has been called by the very creditable work of SCHULHOF and BOSSERT to the return during this year, of the comet discovered by PONS in 1812 (for which an elliptic orbit had been computed by ENCKE) but quite unexpectedly on September 1, 1883, a comet was found by BROOKS of Phelps, N. Y., whose identity with the comet of 1812 was soon recognized. A great many observations were obtained in both hemispheres, and in

Australia and at the Cape it was followed to the end of April, and at Cordoba (Argentina) by W. G. DAVIS to May 26, 1884. A provisional correction to the orbit from five normal places (without, for the present, a change of the eccentricity) gave the above elements with a period of about 72 years.

285. A. N. 111: 15. Discovered by BARNARD at Nashville July 16; observed at Nice by PERROTIN to November 20. The comet, soon after the first computations, proved to be elliptic with a period of 5.4 years. The above orbit includes observations from July 26 to October 23, and agrees very closely with one deduced by MORRISON (M. N. 45: 50) from observations of July 25 to September 23.

286. A. N. 110: 207. Discovered by MAX WOLF at Heidelberg, September 17; observed by YOUNG at Princeton, N. J., to April 6. The above elements (derived from observations September 20–November 7) showed a small deviation from the observations. The orbit of this third comet of 1884 also proved to be elliptic, with a period of 6.8 years, and according to these elements a very near approach of the comet to the planet *Jupiter* must have taken place in May, 1875.

COMETS OF 1885.

W. C. WINLOCK.

[For the Messenger.]

The following list will bring the table of comets (1860–84) given in the SIDEREAL MESSENGER for January, 1885 (4: 5–8), down to date. Comet 1884 (Wolf) finally became Comet 1884 III. It may be a little premature to call the comet discovered by Mr. BROOKS on December 26, 1885, "Comet 1885 V;" but its designation will be changed, only in case a comet should now be found, passing perihelion before November 29, 1885.

Comet 1885 I=Comet (*d*) 1884.
=ENCKE's Comet.
Comet 1885 II=Comet (*a*) 1885.
=BARNARD's Comet.
Comet 1886 III=Comet (*c*) 1885.
=BROOKS' Comet.
Comet 1885 IV=Comet (*b*) 1885.
=TUTTLE's Comet.
Comet 1885 V=Comet (*f*) 1885,
=BROOKS' Comet.
Comet 1886 (FABRY)=Comet (*d*) 1885.
=Paris Comet.
Comet 1886 (BARNARD)=Comet (*e*) 1885.

THE NOVA IN ANDROMEDA.

W. H. NUMSEN.

[For the Messenger.]

In the December No. the question of sudden changes in the brightness of the nova had been discussed by various observers. Inasmuch as my telescope was turned upon this object upon nearly every clear night, from September 1 to November 10, perhaps my experience may not be altogether without interest. I think there can be no question that marked changes in the intensity of its light have taken place, even in the course of the same observation; but whether they were real, or merely atmospheric, well—there's where the difficulty comes in.

In the earlier stages of the nova this peculiarity of its light was not much noticed, the star seeming to shine with a pretty steady, planetary sort of light, especially on September 1 and 2, but later on after it had dropped to tenth magnitude and under, the twinkling and flashing out of its light seemed to increase. Generally, I was inclined to attribute this to the state of the atmosphere, and indeed upon some occasions felt sure that the phenomenon was merely an atmospheric one. But upon some other occasions I could not resist the impression that the star actually did flare up and go down again.

Especially was this the case on the night of October 10, when a watch of forty to forty-five minutes was kept upon it. The night was clear, no clouds, no wind and no remarks in my notebook as to definition being bad. On this night, to such an extent did it twinkle and flicker, that I could not satisfy myself as to what magnitude to assign to it.

At times it would be invisible, then plain and apparently about as bright as *y* or *z*, then again not much brighter than *w*. It seemed to throb and pulsate, and reminded me of the last expiring flashes of a candle going out. Invisible for awhile, then flashing out bright.

On the night before it was about as bright as *y* or *z*, and I put its approximate magnitude at about 10½, but on this night its changes in brightness were so marked that I could not satisfy myself.

On 14th it was estimated as between *y* or *z* and *w*, 10¾ to 11. On the 15th and 16th about the same. From these dates on it was never seen steadily, even with the best of air, but would only be seen flashing out at times after a careful watch, enough to satisfy me that it was still there. On the 21st, with powers up to 200, after a careful watch of twenty-five minutes, it was only suspected once or twice, but the *Moon* was very bright. On the 26th, with 200, it was certainly seen at intervals, but required steady watching, and was not much brighter, if any, than *w*. On the 31st, after thirty minutes watch I felt sure it was still there, for although invisible most of the time, yet at times a real stellar point would flash out.

On November 4 and 10 I was not certain as to seeing it. Only about fifteen minutes were devoted to it on the 4th, and the night was not so clear. On the 10th, the night being extremely clear, after twenty-five minutes' watching, towards the end I could not resist the impression that occasionally a faint point of light was visible at about the position where the nova was before, but could not locate it positively. When the star was at its lowest it was still considerably brighter than the small star about 1½′ to 2′ almost due preceding the position of the nova. I think this is the star mentioned by Mr. KNOTT at the November meeting of the Royal Astronomical Society, as being estimated by him at about 12.4 magnitude. It was first noticed about October 1, in looking around for some fainter comparison star, than I had been using, but there was too big a difference between it and the nova, so I used the star *w*. At the time I estimated its magnitude at about the 12th, although it was seen pretty easily on any good night with p. 120, and in fact was first noticed with that power.

The diagram, you were kind enough to print, was only intended to illustrate the positions of the unknown stars *x*, *y*, *z* and *w*, as numerous other stars were in the same field, some brighter and some fainter. On page 305 a small typographical error has crept in where you have the estimated magnitude of star *z* as 10¼ instead of 10½. In my later estimates of these four stars, I have assumed *y* as 10½. This would make *x* about 10.2, *z* 10.6 and *w* about 11¼. Of course having no standard comparison stars for such small magnitudes, I cannot pretend to very great exactness in the matter, but I think the above will represent approximately the relative brightness of the four different stars. ARGELANDER has both *d* and *e* as 9.5, but to me there is always a very perceptible difference between them, probably about .4 to .5. I think there is also fully .3 difference between *a* and *f*.

THE SUMMATION OF CO-ORDINATES.

HENRY M. PARKHURST.

[For the Messenger.]

In the rapid approximation of the course of a new comet, I have found two mechanical devices extremely convenient. The first is a line of squares, constructed in the following manner. At one-fourth of the distance between the two ends of the scale is the zero-point, from which the line is to be set off equally in both directions, by means of a scale of equal parts, the distances being the squares of the numbers marked upon the scale. It is convenient to have several of these lines, with different units of distance. In use, extend a pair of dividers from the smallest co-ordinate on one side of the zero-point, to the next smallest upon the other side, and then from the third co-ordinate outward, which will reach to the sum of the three.

The second device is no less simple. Upon a small sheet of squared paper, such as is used by surveyors, each tenth division being marked by a heavier line, is drawn a graduated arc of 90 degrees, with the center at one corner. A paper rule, divided in like manner, is fastened by a pin, to turn upon that corner as a center. Now let x, y, z, represent the geocentric co-ordinates of a comet, of which the right ascension and declination are required. First let the rule pass through the point of junction of x, y, or any multiple thereof, and the right ascension will be indicated upon the arc, and the curtate distance d upon the rule. Next, let the rule pass through the point of junction of d, z, or any multiple thereof, and the declination will be indicated upon the arc.

As an illustration of my method of approximation, from the ephemeris of the late Paris comet, for December 12, and 20, I obtained the heliocentric co-ordinates x, y, z, for each date. Their difference gave l, m, n, the motion in eight days. The momentum of the comet would carry it the same distance in the next eight days, and the *Sun's* attraction would cause it also to fall towards the *Sun*, the fall being x, y, z, each divided by $53r^3$. This gives x, y, z, for December 28. Thence we have a new l,m,n, giving the modified momentum, and with the new value of r^3 can determine the fall for the following eight days. Continuing this process, using three decimal places only, I followed the comet up to July, the time of perihelion closely corresponding to the elements given. It was only necessary to apply the *Sun's* co-ordinates for any desired dates, to obtain the geocentric co-ordinates, with which, by the squared sheet, about four inches by five, the positions of the comet could be obtained, nearly, if not quite as accurate as the orbit itself would be likely to give them. It only required about twenty-four figures for each heliocentric position, the value of *r* being taken from the line of squares, its cube from a table of cubes, and the fall being mentally computed; and about as many more for each geocentric position, for the co-ordinates and the final result. It is hardly necessary to say that this mode of working is only useful for rough approximations, since it is practically impossible to avoid the accumulation of errors from the continually varying fall towards the *Sun*.

Applying the same method to BARNARD'S comet, with equal success, and verifying by a direct computation of one position at the perihelion, I discovered that it will be in a good position for observation in this latitude, for the month after perihelion passage, next June, when it will be at least two hundred times as bright as at the time of discovery, although previous to that time it will have sunk below our horizon. It is to be hoped that further observations may not materially modify the form of the orbit.

BROOKLYN, New York, December 23, 1885.

SOLAR ECLIPSE OF 1866

A total eclipse of the *Sun* will occur on the 29th of August, 1886. The line of totality passes over the equatorial portion of the Atlantic ocean, and reaches the west coast of Africa near Benguela, in latitude twelve degrees south. This port is easy of access, and as it is the healthy season, there would be no difficulty in sending a party out in a Government vessel. The duration of the totality at this point is four minutes and forty seconds, affording a more than usually good opportunity for photographic and spectroscopic observations. The question as to the propriety of applying for an appropriation to defray the expenses of an observing party has been referred by the Department to the National Academy and a report may soon be expected. Should it be favorable, I beg to recommend that a special application be made to Congress, as the funds ought to be available by February 1, 1886, at the latest.—*Report of Superintendent of Naval Observatory.*

The Naval Observatory drops time-balls daily at the following cities: Philadelphia, Baltimore, New Orleans, New York, Hampton Roads and Savannah.

EDITORIAL NOTES.

The MESSENGER will be sent hereafter to such subscribers only as indicate a wish for its continuance.

President EDWHRD S. HOLDEN is at his post of duty in the University of California. While his time at present is largely taken by the new responsibilities assumed, neither astronomy nor the MESSENGER will be long without his attention.

Of late much space has been given in this journal, to the physical appearance and the motions of the BIELA meteors, because so little is definitely known in this branch of astronomy. We trust the various papers will be read with interest.

DISCOVERY OF THE NEW BROOKS' COMET.—The mode in which WILLIAM R. BROOKS, of Phelps, New York, captured this prize from the skies, and $200 from Mr. WARNER for this discovery reads like a romance, especially since we later learned that Mr. BARNARD, of Nashville, Tenn. was also scanning the same part of the heavens, and on the following evening independently discovered the same comet. Mr. BROOKS' own words tell his part of the story well:

"At the time of my discovery of the comet in the early evening of December 26, 1885, it was low in the western heavens, and rapidly settling down into the tops of the trees of my orchard; indeed for some time the limbs of the trees were visible in the field of the telescope, occasionally hiding the comet entirely from view. I had already obtained its approximate position, but had not obtained its motion with sufficient certainty to telegraph the discovery that evening, as I was very anxious to do. So I removed the telescope from its permanent stand, carried it around the house into the front yard, facing the west. It was a big and heavy armful, for the tube of the large telescope is of iron and about a foot in diameter.

I then called to my wife and father to bring out a table, placed the upper end of the telescope across the front fence, and with boxes, door-mats, books and papers placed upon the table, raised the instrument to the proper angle to point at the comet. While I stood in the road gazing anxiously into the telescope, my wife stood in the yard, holding and moving the telescope at my direction to follow the fast setting comet; while father placed books and papers upon the table to help support the instrument. In this way my last observations were made, and I was enabled to follow the comet until it almost touched the horizon. The message announcing the discovery was given to the telegraph offiice three quarters of a mile away before eight o'clock of the same evening."

Three important articles are deferred for want of space in this number.

THE DOUBLE-STAR H 2904.—After a careful examination of the measures of this pair, I am unable to agree with Mr. WILSON in his conclusion (S. M. January) that it is a binary system. By accurately plotting the measures on a large scale, it will be seen that its measured positions fall almost exactly on a right line—in fact, much more nearly so than is usnal where the motion is known to be rectilinear. The estimated positions of HERSCHEL are of no value in determining this question. The errors in his estimated distances will be found to be generally very large, the real distance being almost always in excess. If a line is drawn through the measured positions of the small star, the motion will be found to be in the direction of about 9°. In that case, HERSCHEL's estimate was less than half the real distance, an error by no means uncommon in his catalogues. This, however, would be materially lessened if the earlier measured distances were a little too large, or the later distances a little too small. In addition to this, it is, to say the least, very improbable that so wide a pair should prove to be a binary. I do not recall a single example of a recognized binary system where the components are so widely separated, I may add here that I made a series of measures of this pair at Madison in 1871, which are not given in Mr. WILSON's list. The apparent motion of the small star appears to be about 0."4 per annum, in the direction, as stated, of 9°; and on the assumption the nearest approach of the two stars will be somewhere about 1910, when the distance should be about 13½". Possibly on examination of some of the star catalogues would show whether or not the large star has any considerable proper motion. At all events, measures of the relative positions of the two stars for the next three or four years will be sufficient to determine the character of the movement. I have no doubt it will prove to be rectilinear.

Since writing the foregoing I have examined my star catalogues, and find that the star apparently corresponds to the following:—

B. A. C.	6814	O. Argelander 20054
Cape Catalogue	10699	Sag. 242 (Gould)
Lacaille	8262	Gould 1953 (Gen. Cat.)
Lalande	37813	Wash. Mu. C, Zones 138
Yarnall	8550	No. 27 (comp?)
		Mural C. Zone 170 No. 94.

It may be found in other catalogues which I have not access to at this time.

S. W. BURNHAM.

COMET (*e*) 1885 (BARNARD).

The following elements and ephemeris are by H. C. WILSON, assistant astronomer in the observatory of Cincinnati:

$T = 1886$ May 2.421 G. M. T.
$\pi - \Omega = 119° \ 52' \ 16''$
$\Omega = 68 \ 30 \ 03$
$i = 33 \ 30 \ 18$
$\log q = 9.675168$

The equations for the ephemeris are:

$x = r \ [9.581267] \sin (225° \ 53' \ 38'' + v)$
$y = r \ [9.966313] \sin (232 \ 35 \ 35 + v)$
$z = r \ [9.999632] \sin (141 \ 37 \ 33 + v)$

Greenwich mean midnight	App. R. A.	App. Decl.	Log. △	Log. r	Light
Jan. 28	2h 21m 00.s2	+13° 31′ 28″	0.2217	0.2813	2.23
29	19 43. 6	44 20			
30	18 29. 6	57 18			
31	17 17. 7	14 10 22			
Feb. 1	16 08. 1	23 32	0.2256	0.2672	2.34
2	15 00. 7	36 47			
3	13 55. 6	50 08			
4	12 52. 6	15 03 35			
5	11 51. 7	17 07	0.2294	0.2523	2.46
6	10 52. 9	30 44			
7	09 56. 1	44 29			
8	09 01. 4	58 20			
9	08 08. 6	16 12 17	0.2328	0.2368	2.61
10	07 17. 8	26 20			
11	06 28. 9	40 29			
12	05 41. 8	54 45			
13	04 56. 5	17 09 08	0.2357	0.2206	2.77
14	04 12. 9	23 38			
15	03 31. 1	38 14			
16	02 50. 9	52 56			
17	02 12. 4	18 07 46	0.2379	0.2034	2.97
18	01 35. 4	22 42			
19	01 00. 0	37 46			
20	2 00 26. 1	52 57			
21	1 59 53. 7	19 08 17	0.2395	0.1854	3.20
22	59 22. 8	23 44			
23	58 53. 1	39 19			
24	58 24. 8	55 01			
25	57 57. 9	20 10 53	0.2402	0.1664	3.48
26	57 32. 4	26 52			
27	57 08. 2	42 59			
28	56 45. 3	59 14			
March 1	56 23. 9	+21 15 38	0.2402	0.1462	3.82

The light of the comet on December 3 is taken as unity A comparison of the ephemeris with an observation on Jan. 6 gave C—O = −1s.5, +3″

THE PLANET SATURN.—On the night of Jan. 6, 1886, I obtained a good view of *Saturn* with the 11-inch equatorial, and saw what I had never been able to see before, viz.: three narrow yellow bands on the southern hemisphere of the planet. These were seen only at moments of exceptionally good definition. There was also a faint dusky streak through the middle of the white equatorial belt. I could not see the narrow black belt on the southern edge of the equatorial belt, which has been spoken of by so many observers. There was, it is true, a narrow strip which appeared a little (a very little) darker than the other portions of the southern hemisphere, but I thought it was due to contrast with the whiteness of the adjacent equatorial belt.

The inner, dusky ring was very distinct and seemed a little broader on the following side. It seemed also to approach the planet closer on that side by an appreciable amount—I should say about 0."25. Otherwise the rings appeared symmetrical with reference to the planet. The magnifying powers employed were 230 and 450. H. C. WILSON.

LACAILLE 8262.—In Volume II, page 256, of SIDEREAL MESSENGER, Professor HOLDEN has given a number of places of the star *Lacaille* 8262, from various authorities which indicate strong proper motion. I had not noticed, last month, that this star is identical with the principal star of the double *h* 2904 (B. A. C. 6814).

If HERSCHEL's estimate of distance be assumed as about 20" too small, the whole change in the double may be due to the proper motion of the principal component. An error of 20" would be unusually large for HERSCHEL, but not impossible. The mean of his position angles is very nearly correct, assuming the proper motion —0.s009 and —0."53 as given by Professor HOLDEN. Whether binary or not the star is worthy of numerous measures during the next half century. H. C. WILSON.

Meteors of 1885 Nov. 27:—Prof. N. R. LEONARD, observing with a number of assistants, on the evening of November 27, at Iowa City, Iowa made the following counts:

From 8*h* 36*m* to 8*h* 51*m*, 100 meteors, or over 6 per minute. From 9*h* 10*m* to 9*h* 30*m*, 100 meteors, or 5 per minute. From 10*h* 2*m* to 10*h* 20*m*, 50 meteors, or less than 3 per minute, showing thus a rapid diminution. Clouds interfered with further observations. Prof. LEONARD states that Prof. COWGILL, who observed at Manhattan, Kansas, saw a meteor below the clouds (the sky being completely clouded over) at 12*h* 50*m*, and during the few hours following, thirteen others were seen in like manner.

TUTTLE'S COMET.—This interesting periodic comet was seen at but two places, viz.: Nice, France, where it was first detected on the morning of August 9, 1882, and at the Warner Observatory on August 12. It was difficult of observation, in consequence of its rising so near the time of morning twilight as to leave an interval of but a few minutes wherein it would be possible to see it.

The next morning after receiving telegraphic notice of its discovery I set the telescope for it, but failed to find it, either in the field or in the immediate neighborhood. Feeling quite uncertain in catching the stranger I abandoned the search. But I had failed to see it in 1871, I was greatly chagrined at the thought of a similar disappointment now, so taking new courage I re-commenced the search and soon had the satisfaction of beholding it in the field, where I could hold it steadily. But, descending from the chair to start the driving clock for the obtaining of its approximate position, though returning in about ten seconds, I found that the increased twilight had entirely obliterated the comet which, by the test of this almost instant effacement, showed how exceedingly faint it must have been. LEWIS SWIFT.

WARNER OBSERVATORY, January 1886.

DISAPPEARANCE OF THE NEW STAR IN THE ANDROMEDA NEBULA.—This wonderful star, whose appearance will always be remembered as an important astronomical event of the year just completed, may be said to have practically disappeared. On the evening of December 26, I obtained, by a desperate and long continued effort, what I very quickly became convinced would be my last view of it. With the dome-room perfectly dark, the pupil of the eye well expanded, the object near the zenith and the seeing good, I was able, with the 16-inch refractor to get only an occasional view of the star. Cloudy weather has since prevented any opportunity for examination, but the attempt to see it would, I think, now be a vain one, as the interim of twenty days would cause a decrease of brightness of, at least, another magnitude, which, even then, I estimated to be as low as the 16th or 17th.

The apparition of this star in the center of so conspicuous a nebula will long afford matter for reflection, and a theme for discussion by savans. It raises the question whether, after all, there is, even in the heavens, such a thing as stability. It has not, at any time, appeared red to me, from which I argue that it was not of the order of variables—popularly so called—but rather a temporary star, like that of Tycho and several others which have appeared in various parts of the heavens.

Of GORE'S new star I have been able to make one observation and find it decidedly red in tint—the color of nearly all variable stars—and hence I infer it to be a variable star of perhaps long period, and not a temporary one. LEWIS SWIFT.

WARNER OBSERVATORY, January 1886.

SUSPECTED PROPER MOTION IN A NEBULA.—It is exceedingly doubtful if any evidence has been had of the detection of motion in any of the nebulæ. Such testimony astronomers hold in abeyance. In every case of supposed motion, investigation has shown that it was owing to mistaken entry, inaccurate observation or to error in position. But as motion of some sort, seems almost to be an attribute of matter as witnessed in the *Sun*, the planets and their satellites, the comet and stars also, it may, reasoning from analogy, be safely assumed that the nebulæ too have a motion, either axial or orbital, or more probably, of both kinds.

Nearly a year ago there appeared in several astronomical and scientific journals, a letter from Mr. H. SADDLER, of England, giving in detail the reasons for supposing that the nebula, General Catalogue 2091, manifests proper motion, Dr. DREYER, in reply, contended that the circumstances, when carefully weighed, afford no evidence whatever of motion, and his conclusion appears to me to accord with the facts. I have been led to these reflections by another case of supposed motion which has come under my own observation. About a year since, while seeking for new nebulæ I ran across a very close double, so close indeed as to require a power of nearly 100 for its separation. Examination showed the nebula to be G. C. 2425=H. I. 247, discovered March 18, 1790 and registered as elongated. AUWERS in 1830 calls it very bright, pretty large, little elongated. Sir JOHN HERSCHEL in 1860 describes it as pretty bright, pretty small, very little elongated. It would seem, therefore, that none of these observers, all of whom used large telescopes and high powers, suspected duplicity, while now the components are very easily separated. If they have proper motion in opposite directions it is not unreasonable to conclude that in ninety-six years the separation ought to be noticeable. This nebula is in R. A. $11h\ 22m$, Dec. north $59° 12'$. It should be watched and subjected to micrometrical measurements. LEWIS SWIFT.

WARNER OBSERVATORY, January 1886.

OCCULTATIONS AT THE CAPE OBSERVATORY.—Under date of November 13, 1885, Dr. GILL, Her Majesty's Astronomer at the Cape, writes that meridian observations of the *Moon* have been entirely discontinued at his observatory, and that the observations of occultations are now prosecuted with greater regularity than heretofore. He says: "I think it is only from such observations that very refined determinations of the *Moon's* place can be arrived at."

COMET PARIS.—This comet was observed December 2, and was found, contrary to the statement of the telegram, to be of moderate brightness. A small star was shining through the nebulosity when the telescope was first turned on it, but this was soon left behind by the rapid motion of the comet. E. E. BARNARD.

VANDERBILT UNIVERSITY OBSERVATORY, December 10, 1885.

OBSERVATIONS OF METEOR SHOWERS.—The following are additional observations of the radiant points, obtained here during the last two months:

Date		Radiant Point	
1885 November 14	144°+50°	near Theta Ursæ Mrjoris.
14	149 +21	Leonids.
16	150 +22	Leonids.
16	154 +41	near Mu Ursæ Majoris.
17	166 +31	near Xi Ursæ Majoris.
26	26 +44	Andromedes.
27	24 +44	Andromedes.
28	22 +43½	Andromedes.
30	21 +42½	Andromedes.
30	60 +49	near Mu Persei.
December 1	44 +56	near Eta Persei.
1	194¼+43	near Cor Caroli.
4	79 +24	Zeta Taurids.
4	105 +34	Geminids.
4	110 +25	near Delta Geminorum.
4	143 +48½	near Theta Ursæ Majoris.
7	83 +19	near Eta Geminorum.
7	115 +33	near Alpha Geminorum.
9	161 +58	near Beta Ursæ Majoris.
9	203 +57	near Zeta Ursæ Majoris.
10	105 +50	in the Lynx.
10	107 +33	Geminids.
10	117 +32	near Alpha Geminorum.
10	143 +39	in Leo Minor.
1886 January 2	228 +52	Quadrantids.
2	119 +16	in Cancer south of Zeta.
2	167 + 4	near Tau Leonis.
5	140 +57	near Theta Ursæ Majoris.

I have only given the dates when the showers were best defined. I observed 566 shooting stars between November 14, 1885 and January 5, 1886, but I have omitted several thousands of Andromedes seen on the night of November 27.

W. F. DENNING.

BRISTOL, England, January 6, 1886,

Professor H. L. SMITH, of Hobart College, recently saw Gamma[2] *Andromedæ* clearly double with a 4¼-inch short focus telescope. Observers will rightly say that is a triumph for Professor SMITH's eye and telescope. We are not aware that this star has been separated by so small a telescope but once before. It is usually regarded a hard double for an aperture less than 8-inches. SCHIAPARELLI's measure in 1877 was P. A. 104.°1, distance 0.″48; GLEDHILL, same year, 102.°4; 0.″84; BURNHAM, in 1878, 102.°7; 0.″48.

It is possible, as STRUVE suggests, that the distance between the components is increasing, though these measures seem to show the contrary.

THE RED SPOT ON JUPITER.—With my 10-inch reflector, power 252, I have seen the red spot on seven occasions during the present apparition of *Jupiter*. The spot crossed the planet's central meridian at the following times:

1885 October 24	17*h* 32*m*
26	19 10
December 1	19 0
9	15 40
28	16 21
1886 January 2	15 29
4	17 6

This remarkable object is much more distinct than in 1883 or 1884, but is still far less striking than it was in 1879, 1880 or 1881.

The rotation period of *Jupiter*, as I have determined it from observations of the red spot during the preceding three oppositions is as follows:

Date of limiting observations.	No. of rotations.	Period of rotation.
1882 July 29—1883 May 4	674	9*h* 55*m* 39.*s*1
1883 Aug. 23—1884 June 12	710	9 55 39. 1
1884 Sept. 21—1885 July 8	700	9 55 39. 2

The three results are almost perfectly coincident and prove that the motion of the spot has been very equable since the summer of 1882. Before that time it exhibited a slackening velocity which originated a constantly increasing rotation period.+When the spot became very faint in 1882, this retardarion appears to have ceased. W. F. DENNING.

BRISTOL, England, January 6, 1886.

The Paris comet (Fabry) will be pretty bright after perihelion. I have computed ihe following ephemeris from CHANDLER and WENDELL'S elements (Sci. Obs. Circular No. 62) which seem to be more accurate than those given in Dun Echt Circular No. 102:

COMET "FABRY."

	R. A.	Decl.	Log. *r*	Log. △	Light
Jan. 4	23*h* 40.*m*6	+21° 03′	0.1839	0.1282	1.7
Feb. 3	23 22. 2	+24 37	0.0093	0.1036	4.3
Mar. 5	22 57. 2	+27 28	9.7383	9.9440	31.6
15	22 38. 3	+10 50	9.6905	9.8357	64.9
25	22 42. 0	− 0 05	9.7383	9.7397	81.0
Apr. 4	23 08. 2	−25 18	9.8343	9.7398	52.0

H. C. WILSON.

BOOK NOTICES.

The Moon: Considered as a Planet, a World and a Satellite. By JAS. NASMYTH and JAS. CARPENTER. New York: SCRIBNER and WELFORD, 1885: $7.50: 8vo.

A royal volume this is, and one which will loosen the purse strings of many a lover of astronomy. The work has been out of print for some time, having been published in 1874, and the demand for it has brought out this, the third edition, which is less unwieldy than the former editions (which were quartos), and less costly. As there are few copies of the original work in this country, it may be well to describe it quite fully. The book is the product of thirty years of assiduous observation, with powerful telescopes. After numerous drawings of a given object had been made at times when it was most favorably seen, and these drawings had been severely scrutinized, revised and compared with the *Moon's* surface, a model was made. This, being set in the sunlight to show the lunar effects of light and shadow, was photographed. Thus a "highly satisfactory" representation was obtained. Most of the twenty-five magnificent full page plates (Woodbury types) scattered throughout the volume show different portions of the *Moon's* surface as viewed with a high magnifying power. Thus our satellite is brought to the fireside of the beholder. In the first three chapters an exposition of the phenomena attendant upon the cooling of a nebulous mass is given. After a solid crust had been formed, the molten interior is supposed to have expanded, rupturing the crust, and escaping: after the eruptive action died away, in the subsequent process of cooling the crust was wrinkled into mountain chains. The authors believe that most of the irregularities of the lunar surface can be accounted for by the alternate expansion and contraction of successive strata.

Chapters IV and VI treat of the form, magnitude, weight and general appearance of the lunar globe, while chapter V is devoted to its atmosphere. Chapter VII is devoted to topography, a map being given with the names of two hundred and twenty-nine craters. The next five chapters. are occupied with the discussion of the method of formation of each *class* of the lunar features. In the chapter on the *Moon* as a World, the reader is transported to the crater Copernicus, and remains for a lunar day, his experiences being vividly depicted. The services of our satellite to earth-dwellers are set forth next, and the volume closes with a resume of its own contents. By reason of the vivacity of its style and the sumptuousness,as well as accuracy of its illustrations, this work must be preferred to NEISON'S, by all except professed selenographers. It ought to have a large sale.

Doolittle C. L. A Treatise on Practical Astronomy as Applied to Geodesy and Navigation. New York, WILEY, pp. 642, 8vo.

This work is intended for students in Universities and Technical Schools, and as a manual for the field astronomer: the portion which bears upon Navigation is the fifty-page chapter on the sextant and its use in determining time and latitude. As an Introduction we find a chapter on Least Squares, and one on Interpolation. In Least Squares the author presupposes only such knowledge of the theory of probabilities as can be found in most treatises on Higher Algebra, and carries the reader by comparatively easy steps up to the integration of the well known gamma function, after which he discusses probable error..mean error, etc., and concludes by elaborating the method of solving normal equations. The criteria of PIERCE and others for rejection of doubtful observations are simply mentioned. This chapter is so lucid that it is delightful reading to one at all interested in the subject.

The treatise on Practical Astronomy proper begins at page 100 and the instruments treated of are the sextant, chronometer, clock, chronograph, portable transit, zenith telescope and theodolite. The various uses of these instruments are explained with fulness and clearness, and illustrated by a large number of examples fully solved: most of these examples have been taken from the reports of government surveys, while quite a number come from the author's own observations at the Sayre observatory. No antiquated instruments or methods are touched upon, it being the author's design to furnish a view of the best modern practice. In connection with the transit, the construction, and mathematical theory, use of HARKNESS'S spherometer-caliper are explained. The following subjects are also treated: the Celestial Sphere, Parallax, Refraction, Time, Latitude, Longitude, Precession, Nutation, Aberration and Proper Motion. In the difficult subject of Refraction, no attempt is made to follow BESSEL'S investigation, but DESCARTES' Laws are stated, and the use of the tables is explained.

Considerable care has been taken to have all formulæ printed correctly, and in a three hours' examination the present writer noticed nothing wrong, except the omission of a half-parenthesis in line five of page 145. At the end of the book are a few tables, chiefly for refraction and the reduction of circum-meridian altitudes to the meridian: these are printed in vexatiously small type.

Special mention should be made of the fact that the author's style is lucid, and in almost every instance the reader may see at once how any particular equation is derived: this makes the perusal of the work a pleasure rather than a task. On the whole the book is to be highly commended, since it fills the niche for which it is intended admirably.

H. A. H.

PAPERS RECEIVED.

1. On the effect upon the *Earth's* velocity produced by small bodies passing near the *Earth*. By Professor H. A. NEWTON.

2. Colored media for the photographic dark room. By Professor W. H. PICKERING.

3. Methods of determining the speed of photographic exposures. By Professor W. H. PICKERING.

4. The fixed idea of astronomical theory. By AUGUST TISCHNER.

5. The intimate connection between gravitation and the solar parallax. THOMAS BASSNETT.

6. Velocity of light in air and refracting media. By Professor SIMON NEWCOMB.

The Sidereal Messenger

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

VOL. 5. NO. 3. MARCH, 1886. WHOLE NO. 43.

THE WASHINGTON UNIVERSITY EQUATORIAL AFTER THE "LICK PATTERN."

H. S. PRITCHETT.*

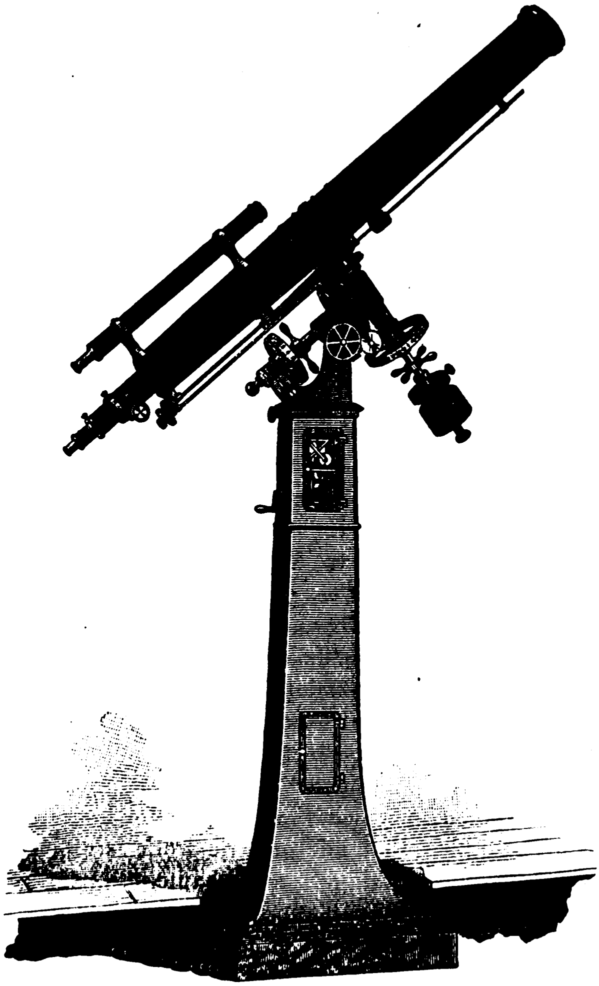
For the Messenger.

It has been frequently remarked that we shall never have the ideal telescope until an instrument-maker appears who shall first have been a practical astronomer. Whether this is true or not, it is certainly a fact that the aim of the telescope-makers has generally been directed toward the production of an instrument for looking, rather than for measuring. The practical astronomer desires an instrument which shall not only be optically perfect, but also that the instrument shall be easily controlled by the observer from the eye-piece, that the illumination should be capable of easy and quick adjustment,and that the circles can be read easily and quickly. In short, he desires a measuring machine capable of quick adjustment and easy handling. On the other hand, the maker of the telescope seldom makes a micrometer measurement and devotes his energies almost altogether toward perfecting the optical qualities of the glass. There are many telescopes of large aperture, in existence, at the present time, in which the facilities for handling the instrument are so poor, that micrometric work is difficult unless the astronomer is something of a mechanic.

A mounting for a 6-inch objective has recently been furnished by Messrs. WARNER & SWASEY, of Cleveland, Ohio, for the Observatory of Washington University, which seems to have solved some of the problems, which vex the observer, in

*Professor of Mathematics and Astronomy.

so satisfactory a way that a short description may not be uninteresting. The style of mounting was gotten up for the Lick Observatory, and for this reason has been termed by the makers the "Lick Pattern." The present mounting is the first made after this style.



Washington University Equatorial, St. Louis, Mo.

The accompanying cut shows at a glance the more prominent features of the mounting. The following points will commend themselves to working astronomers.

(*a*) The instrument is adjustible for a large range in latitude. The inclination of the polar axis to the horizon can be changed by a rack and pinion without disturbing the base.

(*b*) The construction and place of the driving-clock form very interesting features in this pattern. The clock is an improved form of the conical pendulum regulator, and is placed within the cast iron pier where it is entirely out of the way and well protected from dust. The performance of the clock is practically perfect.

(*c*). The attachments for slow motion in Right Ascension and Declination (particularly in Right Ascension) are of an entirely new design, and form one of the strong points in the mounting. Two clamp rods may be seen in the cut extending from near the eye-end to the junction of the two axes. These rods are really double—each containing a smaller rod inside. One set serves for clamp and slow motion in Right Ascension, the other for clamp and slow motion in Declination. The inside rod in each case is the clamp. The small handles are for the clamps, the larger for the slow motion. The gearing by which the slow motion in Right Ascension is communicated to the polar axis, without interfering with the driving-clock, is exceedingly ingenious and effective. The attachment mentioned gives to the observer a complete control of the instrument by a rigid attachment which is always in place, and which cannot slip or interfere with the running of the driving-clock. There are many smaller conveniences, such as a coarse graduation on the outside of the circles, large and convenient focusing screws, handles for turning the instrument in each co-ordinate, which add greatly to the convenience of the observer.

It has been the aim of the makers (Messrs. WARNER & SWASEY) to furnish a mounting in which the observer from his position from the eye-end could completely control the instrument. It is not too much to say that in the "Lick Pattern" this object has been very excellently accomplished. In the important details of the driving-clock, slow motion in Right Ascension, convenience of the reading the circles and handling the telescope, this style of mounting leaves little to be desired.

MEASURES OF THE VELOCITY OF LIGHT.*

(*Continued from page 15.*)

At the time STRUVE's result was published there was an apparent difference of one per cent. between its value and that of the light equation determined by DELAMBRE. The question then naturally arose whether the light equation, deduced on the hypothesis that the tangent of the angle of the constant of aberration was the ratio of the velocity of the *Earth* in its orbit to the velocity of light, might not need correction or modification. This question cannot yet be considered as definitely settled, since the modifications or corrections might arise from a variety of causes. One of these causes is connected with a very delicate question in the theory of the luminiferous medium; a question which can be most clearly understood when placed in the following form: It is a result of optical principles that a ray falling perpendicularly upon the bounding surface of a refracting medium retains its direction unaltered. Now, if this surface is carried along by the motion of the *Earth*, and the light comes from a star, and it is desired that this surface shall be so directed that there shall be no refraction, must it be placed perpendicular to the *true* direction of the star as freed from aberration, or to its *apparent* direction as affected by aberration? The difference of the two directions may exceed 20″, and since the index of refraction of glass exceeds 1.5 there will be a difference of more than 10″ in the direction of the refracted ray, according as we adopt one or the other hypothesis. Assuming that the standard direction would be perpendicular to the true or absolute direction of the star, it is easily shown that the constant of aberration determined in the usual way would be too large by a quantity depending on the ratio of the thickness of the objective to the focal length of the telescope. In an ordinary telescope the difference would be nearly one hundredth of the total value of the aberration, and would, therefore, closely correspond to the discrepancy between DELAMBRE'S result from the satellites of *Jupiter* and the modern determinations of the constant of aberration. The question of this particular cause

*Introduction to Parts III and IV of Vol. II of Astronomical Papers by Professor Simon Newcomb.

was set at rest by AIRY's experiments with a telescope filled with water, which showed that the result was independent of the thickness of the objective, and, therefore, that the apparent direction of the star was that on which refraction depended.

If, in accordance with the undulatory theory of light, we suppose the hypothetical entity called "the luminiferous medium" to be a substance, each part of which has its own definite and fixed location in space, then we must conceive that another unknown quantity may enter into the problem, namely, the motion of the heavenly bodies through this medium. We have relative motions in the solar system, exceeding fifty kilometers per second, and possibly greater relative motions among the stars. Now it is clear that the heavenly bodies cannot all be at rest relative to the medium, but must move through it with velocities at least of the order of fifty kilometers per second, and possibly greater without limit, since it is conceivable that the whole visible universe might be moving in a common direction relative to the medium.

It is easily seen that if we suppose the volocity of the *Earth*, through the medium, to have a small ratio, a, to the velocity of light, then the observed constant of aberration may be altered by an amount found by multiplying its value by a quantity of the order of magnitude of a. This alteration would be entirely insensible if the *Earth* does not move through the medium with any greater velocity than it does around the *Sun*, since the the value would then be only one ten-thousandth. It is remarkable that so far as yet investigated every optical effect arising from such a motion, which could be measured on the surface of the *Earth*, is of the order of magnitude of the square of a. Thus, no phenomenon has yet been discovered which can be traced to the motion in question.

Assuming that there is no general motion of the solar system through the ether of a higher order of magnitude than that of the relative motions of the fixed stars to each other, and that the ordinary theory of aberration is correct, there will be three constants between which a relation exists, such that when any two are found the third can be determined. These constants are:

1. The distance of the *Sun* in terrestrial units of measure;
2. The velocity of light in units of the same measure; and
3. The constant of aberration, or, which is supposed to be equivalent, the light equation.

Until our own time the first and third constants were used to determine the second. From the fact that light required about 500 seconds to traverse the distance from the *Sun* to the *Earth*, and that the distance of the *Sun* was, as supposed, 95,000,000 of miles, it was concluded that light moved 190,000 per second. The hopelessness of measuring such a velocity by any means at the command of physicists was such that we find no serious attempt in this direction between the date of the futile effort of the Florentine Academy, and that of the researches of WHEATSTONE, ARAGO, FIZEAU, and FOUCAULT nearly two centuturies later. One of the most curious features presented by the history of the subject is that two entirely distinct methods, resting on different principles, were investigated, and put into operation almost simultaneously. The revolving mirror of WHEATSTONE, and its application to determine the duration of the electric spark and the velocity of electricity, come first in the order of time. But before this ingenious instrument had been applied to the actual measurement of the velocity of light, FIZEAU had invented his toothed wheel, by which the same object was attained.

FIZEAU's paper on the subject was presented to the Academy of Sciences July 23, 1849.* We have already shown that his method and that of Galileo rest fundamentally upon the same principle. The arrangement of his apparatus was substantially as follows:

A telescope was fixed upon a house at Suresne pointing to the hill Montmartre. On this hill was a second fixed telescope looking directly into the first, the distance between them being about 8,633 meters. In the focus of this second telescope was fixed a small reflector, so that a beam of light from the first would be reflected directly back to it. By means of a transparent glass, fixed in the eye-piece at an angle of 45°, a beam of light was sent from the first telescope to the second, and, on its

* Comptes Rendus, vol. xxix, 1849, p. 90.

return through a total distance of seventeen kilometers, could be seen as a star by an eye looking through the first. Alongside the eye-piece of the latter a revolving wheel, with 720 teeth cut upon its circumference, was fixed in such a way that the beam of light both in going and coming had to pass between the teeth. When the wheel was set so that the tooth was in the focus, the beam would be entirely cut off in its passage through the telescope. Changing the position of the wheel through half the space between the middles of two consecutive teeth, the light would go and come freely between the teeth. When the wheel was set in revolution a succession of flashes would be sent out. If, on the return of each flash, a tooth was interposed, it would be invisible to the eye looking through the telescope. FIZEAU found that with a velocity of 12.6 turns per second each flash which went out was on its return cut off by the advancing tooth. With a velocity twice as great as this it was seen on its return through the opening next following that through which it went. With three times this velocity it was caught on the second tooth following, and so on.*

This experiment of FIZEAU was soon followed by the application of the revolving mirror of Sir CHARLES WHEATSTONE. Shortly after measuring the duration of the electric spark, this investigator called attention to the fact that the same system could be applied to determine the velocity of light, and especially to compare the velocities through air and through water. In 1838 the subject was taken up by ARAGO, who took pains to demonstrate that it was possible, by the use of the revolving mirror, to decide between the theory of emission and that of undulations by determining the relative velocities in air and in a refracting medium.†

The difficulties in the way of securing the necessary velocities of the mirror and of arranging the apparatus were such that ARAGO never personally succeeded in carrying out his ex-

* It is curious that the author's account of this remarkable experiment, which forms an epoch in the history of physical science, is contained within the limits of two pages, and terminates without any definite discussion of the results. It is merely stated that the result is 70,948 leagues of twenty-five to the degree, but the velocity, in kilometers, which must have been that first obtained, is not given, nor is it stated what length the degree was supposed to have in the computation.

† Comptes Rendus, 1838, vol. vii, p. 954; Œuvres de Francois Arago, vol. vii, p. 569.

periments. This seems to have been done almost simultaneously by FOUCAULT and FIZEAU about the beginning of 1850. Both experimenters seem to have proceeded substantially on the same principle and to have reached the same result, namely, that the motion of light through water was slower than through air in the inverse proportion of the indices of refraction of the two media.*

An important and most necessary modification of ARAGO'S plan was made by these experimenters. As originally proposed, the plan proposed was to send an instantaneous flash of light through water and through the air and to receive it on the revolving mirror and determine the relative deviations in the positions of the images produced by the two rays. This system would, however, be inapplicable to the measurement of the actual time of transmission, owing to the impossibility of making any comparison between the time at which the flash was transmitted and that at which it was received on the mirror.

This circumstance would, indeed, have rendered the actual realization of ARAGO'S project* nearly impossible for the reason that the flashes of light, seen through the water, would have reached the mirror at every point of its revolution; and only an exceedingly small fraction of them could have been reflected to the eye of the observer.

This difficulty was speedily overcome by FOUCAULT and FIZEAU by a most ingenious arrangement, of equal importance with the revolving mirror itself. Instead of sending independent flashes of light to be reflected from the mirror, a contiuuous beam was first reflected from the revolving mirror itself to a fixed mirror, and returned from the fixed mirror back on its own path to the revolving one. A succession of flashes was thus emitted as it were from the fixed mirror, but their correspondence with a definite position of the revolving mirror was rendered perfect. Moreover, by this means, the image was rendered optically continuous, since a flash was sent through and back with every revolution of the mirror, and after the velocity of the latter exceeded thirty turns per second, the successive flashes presented themselves to the eye as a perfectly continuous image.

* Comptes Rendus, xxx, 1850, pages 551 and 771.

It was not until 1862 that this system was put into operation by FOUCAULT for the actual measurement of the velocity of light through the atmosphere. A new interest had in the mean time been added to the problem by the discovery that the long accepted value of the solar parallax was too small, and that the measurement of the velocity of light afforded a method of fixing the value of that constant. The central idea of the method adopted by FOUCAULT was that already applied in comparing velocities through different media. The element sought is made to depend upon the amount by which the revolving mirror rotates while a flash of light is passing from its surface to the distant reflector, and coming back again. As the details of FOUCAULT'S method will be best apprehended by a comparison of them with those adopted in the present investigation, a complete description of his apparatus will here be passed over. It may, however, be remarked, that what he sought to observe was not the simple deviation of a slit, but the deviation of the image of a reticule. The deviation actually measured was 0.7 millimeter, and the system adopted was to determine at what distance, with a definite velocity, this amount of deviation could be obtained. His result for the velocity of light was 298,000 kilometers per second.

The next measures of the element in question were those of CORNU. The method which he adopted was not that of the revolving mirror, but FIZEAU'S invention of the toothed wheel. His earlier measures, made in 1870, and communicated to the French Academy in 1871, led to a result nearly the same as that of FOUCAULT.* This result was, however, not so satisfactory that the author could record it as definitive. He, therefore, in 1874, repeated the determination on a much larger scale and with more perfect apparatus. The distance between the two stations was nearly twenty-three kilometers, and, therefore much greater than any before employed. He was thus enabled to follow the successive appearances and extinctions of the reflected image to the thirtieth order; that is, to make fifteen teeth of his wheel pass before a flash returned from the distant, and to have it stopped by the sixteenth tooth.

(*To be Continued.*)

*Comptes Rendus, vol. lxxiii, 1871, p. 857.

RETURN OF THE BIELA METEORS.

E. E. BARNARD.

Though I had the great misfortune to lose the opportunity of witnessing the maximum of the return of the BIELA meteors, the night of November 27, and from thence till December 2 being cloudy, yet observations on November 25 and 26 gave abundant proof of a large return of the shower of 1872. After a long, cloudy spell it cleared up on the night of November 25 for a short interval, and the frequency of bright meteors was quite noticeable. A careful observation on that night could not be made, as I was forced to divide my time between the meteors and the vain search for a reported comet, with a tail one degree and a half long.

NOVEMBER 25.

5*h* 30*m*, Nashville mean time, a third or fourth magnitude meteor in quite good twilight shot across the western part of *Pegasus*. Motion west, pretty rapid, color white. 6*h* 15*m*, 4th magnitude, white, slow, appeared at $\alpha = 0h\ 20m, +27°$, slow path 5° or 6° long directly towards λ *Pegasi*.

6*h* 50*m*, 1st magnitude, white, not fast. Appeared 0*h* 15*m*, +25°. Disappeared 23*h* 30*m*, +17½°, place good. 7*h* 34*m*, 4° southeast of λ *Pegasi* to 22*h* 15*m*, —11°, of 1st magnitude, reddish, pretty rapid slender train for a moment. Ten minutes previous to the last observation saw three small meteors, two of them from *Andromeda*, motion southwest.

7*h* 39*m*, white, quick, 3rd magnitude. Appeared 20*h* 15*m*, +11°. Disappeared 19*h* 15*m*, +9° like a flash of light. 7*h* 47*m*, faint, 6th magnitude. Appeared 0*h* 0*m*, +21°. Disappeared 23*h* 35*m*, +15°.

Between 7*h* 47*m* and 7*h* 52*m*, five small ones seen, the last at 7*h* 52*m*, 4th magnitude, white, first appeared at 23*h* 55*m*, +11°. Disappeared at 23*h* 45*m* +3°. 7*h* 58*m*, two seen near same region, the brightest appeared at 21*h* 10*m* +19°. Disappeared at 20*h* 29*m*, +25½° at the point occupied by a 5th magnitude star.

8h 19*m*, 3rd magnitude, white, quick, appeared at 2*h* 55*m*, +21°. Disappeared at 22*h* 25*m*, +17°. The sky had become pretty well covered with haze and broken clouds here. The rest of the observations through gaps in the clouds. 8*h* 23*m*, white, quick, 5th magnitude, path 4° long, passed 3° northwest of ε *Pegasi*, motion west slightly south.

8*h* 40*m*, white, very rapid, 5th magnitude. Appeared at 0*h* 30*m*, +45°. Disappeared at 22*h* 0*m*, +64° approximate place, 7*h* 45*m*, 3rd magnitude, white, swift from α *Cygni* to 21*h* 55*m*, +23°. Sky pretty well covered with clouds and the meteors seen here and there between the clouds. These paths are all taken from Burritt's Geography of the Heavens, which is engraved for the epoch 1840.0 so far as I can find out. As I have stated the number of meteors on the night of 25th can not fairly be judged from these observations for the reason assigned. As the night of the 26th promised to be clear, I determined to do nothing but watch for and record meteors. To my left, i. e., north, the dome of the equatorial obstructed part of the sky to about 15° above *Polaris*. My western sky could be seen possibly about 50° beyond the zenith. My view was unobstructed to the south, southeast, east, northeast. The following table gives the result of my observations until clouds prevented further watch. There are fifteen watches comprising a total watch, during which my eyes were not once removed from the sky, of 2*h* 22.5*m*. The actual number of meteors counted was 285, but the number actually seen, including outside of the watches, would far exceed exceed 300. The following notes refer to the individual watches and refer to the corresponding numbers of watches as given in column six of the following table:

(1). All but one from the direction of *Andromeda*. Most near α *Andromedæ*, with short paths, these were faint. One, from *Andromeda*, in east motion northeast. One of the faint meteors passed over α *Andromedæ* and reached the 5th or 6th magnitude 5° south or west of α. The point of appearance was at α.

COUNTS OF METEORS ON NIGHT OF NOVEMBER 26TH, 1885.

From	Till	Interval	Number of meteors counted	Hourly rate	Number of counts
5h 47 m	6h 7m	0h 20 m	20	60	1
6 11.5	6 22	10.5	22	126	2
6 27	6 30	3	4	80	3
6 46	7 0	14	20	86	4
7 4	7 14	10	24	144	5
7 17	7 19	2	4	120	6
7 24	7 31	7	16	137	7
7 35	7 47	12	20	100	8
8 4	8 17	13	32	148	9
8 20	8 34	14	25	107	10
8 38.5	8 48	9·5	25	158	11
8 51	8 59	8	25	187	12
9 2	9 8.5	6.5	25	231	13
9 11	9 13	2	4	120	14
9 55	10 6	11	19	104	15
	Sums	2h 22.5m	285		

The nunbers refer to the individual watches.

(2). All from *Andromeda.* One went southeast, two went northeast, the rest nearly all west. Mostly small, several of 4th magnitude. Nearly all near *α Andromeda.* Hazed up now with dense smoke.

(3). All from *Andromeda*, the last one, at 6*h* 30*m*, nearly equal to 1st magnitude, stationary (not quite) at 10½° east of *β Andromedæ*, path about ½° long toward southwest. One seen just before this passed on the line from *α Andromedæ* to *α Pegasi* (*perfectly* on the line). It started about 2° from *α Andromedæ* toward *α Pegasi* and did not reach the latter star by 3°. This meteor was of 3rd magnitude, moderate motion. Dense smoke and wet haze now covered over the heavens. The meteors seem to come in groups. For a minute or so there will be perfect lull, then several would shoot out closely following each other. The meteors mostly white, none reddish. The ones with short paths, i. e., near *α Andromedæ*, were moving slow. They seemed to burn up and slowly increase in light. The sky has been fair till towards the last when smoke ond dense haze prevented observation.

All from *Andromeda.* Only one of these moving northeast and the others westerly. Several of 3rd or 4th magnitude. In first part sky rather thick, but quickly cleared and sky good, but during most of the watch heavy smoke covered all the southern sky within 20° of λ *Pegasi.*

(5). All but one from *Andromeda.* This one was in the north and doubt if it was from *Andromeda.* Three seen in southeast, motion southeast, but from direction of *Andromeda.* Sky good, but at first smoke covered part of south sky.

(6). The last one at 7*h* 19*m*, passed directly from β *Andromedæ* towards λ *Pegasi.* Path 6° long, rapid, 4th magnitude, slight train.

(7). Only one not from *Andromeda.* It appeared away over to the northwest, motion *toward Andromeda.* At 7*h* 31*m* a double meteor shot from *Andromeda* towards northwest, passing west of *Cassiopea*, 4th and 5th magnitude, both white. A fine one seen at about middle of watch in southeast, low down near horizon, brighter than 1st magnitude, path short, white, from the direction of *Andromeda.*

(8). All from *Andromeda.* Most of them toward the west. Nearly all appeared west of Great Nebula, one or two in southeast. The radiant, from merely watching the meteors, and not from any reduction seems to be some 4° or 5° northeast of β *Andromedæ.* After this stopped to fill lamp.

(9). One moving westward from south of *Pegasus* was doubtless not an *Andromeda* meteor. Three seen moving southeast, one northeast. The others mostly west and northwest. Sky good, a double meteor seen during this watch.

(10). All from direction of *Andromeda.* Three in extreme southeast, one far south. Two in northeast, rest more or less westerly. Sky has been fine. Five or six of 3rd or 4th magnitude, all white. Great intervals of quiescence in the radiant in those two last counts, and indeed in all the counts. During this count for about one minute, fully half a dozen shot rapidly following each other, from the direction of *Andromeda*, in a south and southwest direction, evidently a group traveling together.

(11). All but one from *Andromeda.* This one was very rapid and white from *Polaris* to south. Moments of quiescence as in previous counts. Majority of the meteors toward west. A couple of 4th magnitude, all rest small

(12). All from *Andromeda*, none specially bright, all white, mostly to west.

(13). Two not belonging to *Andromeda*..

(14). All from *Andromeda*, clouding in east, and *Moon* whitening east sky. Stopped to give a hurried search for the supposed comet before *Moon* rose. During this time meteors were frequent and a number passed through the telescope.

(15.) *Moon* up. Thick masses of haze and clouds here and there over the sky. This count was at a great disadvantage from the causes stated, and of course cannot be taken fairly to represent the hourly rate. Considering the clouds and *Moon* I think the number seen at this count shows handsomely for the meteors.

The majority of the meteors were seen to the westward of the Great Nebula, with motion toward the west. I have been careful to note any moving toward the north, northeast, south, southeast and south. Those not stated to move in one of those directions were moving in a westerly course.

The meteors of the 25th were generally larger, probably the larger particles of this meteoric swarm lie on the outside.

A very noticeable feature in the observations of the 26th was the grouping of the meteors; for a minute or so there would be a perfect cessation; then a rapid discharge of half a dozen or so would occur following one right after the other and in several instances two moving side by side.

I therefore conclude that there is a tendency to group together in these meteors while traveling through space. The majority of the meteors observed were small, a great many so faint that close attention was required to see them. The meteors of this radiant are white. Every one seen was more or less white, save the large bright 1st magnitude, reddish meteor seen on the 25th.

VANDERBILT UNIVERSITY OBSERVATORY, Nashville, Tennessee, December 11, 1885.

FLUCTUATIONS OF THE ANDROMEDA NOVA.

JOHN H. EADIE.

The interesting account given by E. E. BARNARD in the December number of the SIDEREAL MESSENGER of the rapid fluctuations in the light of the new star in the *Andromeda* nebula, encourages me to mention some observations of my own, which seem to confirm those made by him.

During the month of September I observed this star on eighteen different evenings with 3¼ inches aperture, comparing it with other stars in the neighborhood. From my notes, made at the time I find on September 5, 10:53 p. m. "a good deal of unsteadiness"—in light of the star—"like flickering, but this is possibly due to wind blowing at the time."

Sept. 16, 8:45 p. m. "Curious undulations of light * * * so that the star seemed to disappear for an instant and then become steady for a moment, * * * probably atmospheric, but not noticed in neighboring stars. Sept. 20, 9:56 p. m. "There is a certain unsteadiness about the light of the nova, momentarily appearing dim and then brightening again. Different from neighboring stars." In October sometime after the star had got beyond the reach of my glass, I saw it again with the 9-inch refractor of HENRY M. PARKHURST in Brooklyn.

It was then faint and was a most tantalizing object to observe. It would be visible for a second or two, then suddenly disappear from view and so remain for a brief period when it would again become visible, only to go through the same changes as before—while other stars of nearly the same magnitude were not apparently so affected. Mr. PARKHURST confirmed my observations in this respect.

I have been looking over GORE's Catalogue of known variable stars and I find in his note on the new star in *Corona*, in 1866, the remark that some observers noticed that the star twinkled much more perceptibly than others in the neighborhood, so much as to render comparisons at times difficult.

Rapid fluctuations have been seen in some of the nebulæ, such as the ring nebula in *Lyra*, as well as those mentioned in Mr. BARNARD's article above referred to.

Similar momentary changes have been, from time to time, noticed in the tails of comets. Rev. T. W. WEBB, in *Celestial Objects* says that "corruscations or flashings have been often remarked in the tail; that of 1556 was said to waver like the flames of a torch in the wind; and numerous other instances might be given, before and since the use of telescopes. The accurate HOOKER took many precautions before he satisfied himself of this reality in 1680 and 1682 and SCHROETER stoutly maintained their existence in 1807, referring them to electricity or some analagous cause; others negative them as too rapid for the progressive motion of the light by which we should see them,—an objection, applying only to fore-shortened tails,—and treat them as illusions depending on our own atmosphere, or the uncertainty of weary sight."

In an article in the October number of *The Observatory*, on the Pons-Brooks Comet, E. E. BARNARD speaks of a continued disturbance of the cometary light about one degree behind the nucleus, as observed by him, and he also says that at this distance back from the nucleus "there seemed to be a decided pulsation in the light of the comet; though the appearance was possibly imaginary,the body of the comet seemed rapidly to swell and contract, so that a small star close to it would seemingly be involved in the nebulous light and the next instant free of it. Nevertheless the definition was good and the phenonenon striking. In the great comet of 1882 I noticed on two or three occasions a momentary extension of the tail, especially on its southerly side—or rather the matter comprising the tail near its extremity appeared to momentarily fluctuate in brightness. It is very probable that many other instances of this nature might be given by those having access to the necessary data, but I think those mentioned show a striking similarity in the action of the light of the different bodies referred to, and which differs greatly from that of the majority of the fixed stars and nebulæ.

What the cause of these rapid changes is I am not prepared to say. If these changes are real, they are suggestive of electrical origin. If they are only apparent and entirely due to the action of our atmosphere, it would be interesting to hear from those who are able to give a reason for so great an effect of the atmosphere upon the light of the particular objects above mentioned, while others of an apparently similar nature and often in same neighborhood were not at the same time so affected.

BAYONNE, N. J. December 6, 1885.

ELECTRIC PHENOMENA IN OUR SOLAR SYSTEM.

JOHN HAYWOOD.*

For the Sidereal Messenger.

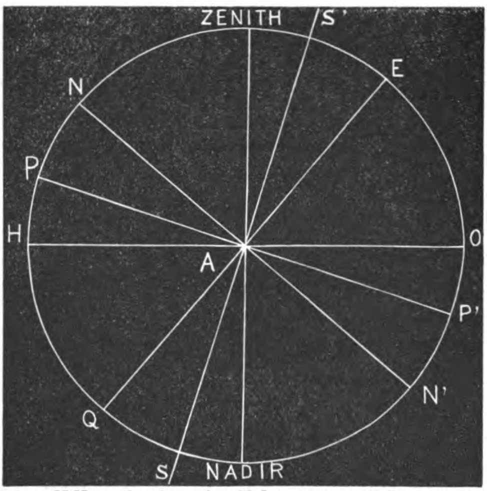
I wish to state the probability of a relation between certain phenomena with a view to help to further observation.

The northern and southern aurora is pretty generally understood to be of an electrical nature. How is it caused? We notice, in the northern hemisphere, that these lights make their appearance in the colder part of the year, for the most part, and at night of course. They have a relation, by coincidence, or otherwise, to the position of the *Sun*. To those living north of the Tropic of Cancer, at the time of the winter solstice and at midnight, the *Sun* is nearer to the nadir point than at any other time of the year. In this latitude, about 40°

*Professor of Mathematics and Astronomy, Otterbein University, Westerville, Ohio.

north, at that time the *Sun* is about $16\frac{1}{2}^\circ$ north of the nadir; and of course a line drawn from the *Sun* to the *Earth's* center and produced would intersect the upper meridian $16\frac{1}{2}^\circ$ south of the zenith. The angle made by this line with the horizon of this latitude at that time, varies through the night from 0° at sunset and sunrise to $73\frac{1}{2}^\circ$ at midnight.

Now if we conceive a radiant force in the solar rays, electrical and repulsive, there would be a flow of electricity from the side of the *Earth* next to the *Sun*, to the opposite hemisphere: that is in our case, before supposed, from near the nadir to near the zenith. This, under favorable circumstances, would be intense enough to be visible, and present all the appearances of the Aurora Borealis as it is seen by us; and seen still better in regions further north. This would be seen in the north because we are in the north ecliptic hemisphere; that is, the north pole of the ecliptic at that time is $73\frac{1}{2}^\circ$ north of our zenith; and the south pole is $106\frac{1}{2}^\circ$ south of the zenith. Therefore the electric flow along or near the *Earth's* surface in the south would be far below our horizon. *[diagram below.]* It is quite likely

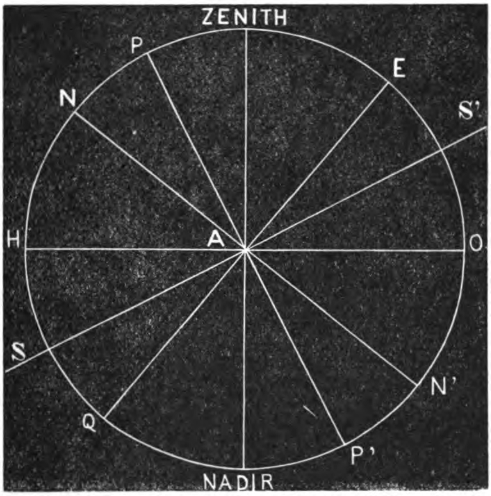


H O, horizon; N N', axis of earth; E Q, equator; P P', poles of ecliptic; S S', points in sun's path.

too that the display in the north is augmented by the favorable conditions of temperature.

Now conceive the terrestrial conditions in respect to electrical excitation to become sufficiently favorable. This electrical outflow may become intense and abundant enough to flow out into space in the direction of the radius vector, produced, and becomes a veritable tail if seen from the *Moon*, or some other planet.

On the other hand, at the time of the summer solstice, and at midnight, our situation would be quite different in respect to the *visibility of these lights. [diagram below.]* Now, the line



H O, horizon; N N', axis of earth; E Q, equator; P P', poles of ecliptic; S S', points in sun's path.

joining the *Sun* and the center of the *Earth*, produced, intersects the upper meridian $26\frac{1}{2}°$ above the southern horizon. The north pole of the ecliptic is now $26\frac{1}{2}°$ north of our zenith, and the south pole is $153\frac{1}{2}°$ south of the zenith; and the angle this radius vector makes with the horizon in this latitude, and at that time, varies between 0° at sunrise and sunset, and $26\frac{1}{2}°$ at midnight. These numbers, of course, are different for different latitudes. Now the auroral display, although in the higher regions of the atmosphere, and perhaps above it, would be below our horizon, commonly being manifested mostly in the hemisphere opposite to the *Sun* and well towards its center.

These electric phenomena I think to be a sort of secondary result. The primary action of the *Sun's* electric force would be exerted upon the hemisphere facing the *Sun*, and with greatest intensity upon the portions where the *Sun's* rays are nearly vertical. The most conspicuous electrical phenomena are thunder storms. These we find occurring usually in the summer, and soon after midday, following the time when the *Sun's* rays are more nearly vertical, and therefore the solar radiation has the greatest intensity. It does not require a very great stretch of the imagination to conceive these thunderstorms to result from the direct action of the *Sun* upon the *Earth*; and more especially upon the atmosphere with its store of watery vapor. The electricity thus developed is driven by the same energy to the remoter hemisphere and dissipated in aurora when sufficiently intense; if less intense, quietly and invisibly. Perhaps the phenomena of heat lightning, seen in summer evenings, is due to this action; the electricity developed when the *Sun's* rays are most intense, scudding away to the opposite hemisphere: and in this case having sufficient intensity to be visible.

Therefore, admitting these explanations, thunder storms in the northern hemisphere would tend to a display of aurora at the antipodes in the southern hemisphere, and *vice versa.*

Also, it is not difficult to see a resemblance to the peculiar phenomena of the comæ and tails of comets. Granting a highly receptive quality to the physical nature of the comets, the radiant electric force of the *Sun*, which causes thunder storms and aurora on the *Earth*, may develope comæ and tails on comets. But there is a very wide chasm between the terrestrial aurora and the tails of comets. An additional link in the chain of evidence is needed, perhaps a number of them, to justify the conclusions arrived at so summarily. The auroral light, seen on the dark part of the *Moon's* disc near conjunction, assists somewhat in this difficulty. Reference is made to a note on this subject published in a former number of the SIDEREAL MESSENGER. Also the chief signal officer, Gen. HAZEN, kindly referred me to some foreign publications giving an account of observations of the same phenomenon. I have not access to these, but assuming that they verify the statement as to the existence of these lights, they, to a certain extent, lend probability to the analogy suggested, and assist in bridging the chasm.

But there still remains the difficulty that an outflow of light, coresponding to the tail of a comet, has never been seen in the case of the *Earth* or *Moon*, or any other planet. It is not likely that an observer on the *Earth* can see such an outflow from the *Earth*. Even if there were an outflow of a number of thousand miles, it is doubtful if it could be seen as to its extent. There is more hope of successful observations of the *Moon*. Some observer, in some part of the world, may catch a view of the *Moon* at a happy moment, and see an auroral light extending sensibly away from the planet. Indeed, at the new *Moon* in January, the writer imagined he caught a glimpse of a faint, thin light extending upward from the *Moon* as it was setting behind a cloud. The time was about three days past conjunction. The appearance, however, was too faint and evanescent to do more than arouse a suspicion of its existence.

Perhaps some of the unexplained appearances at the time of a total solar eclipse may have some bearing on this case.

Still another possible test may happen in this way. In the event of an inferior conjunction of *Mercury* or *Venus*, occuring near the time of a total solar eclipse: since the illuminated hemisphere would be turned from the *Earth*, it would be invisible, unless made visible by an auroral light like that seen on the *Moon*. Further, if there were an outflow of electricity from the planet it might possibly be seen. This would go far to establish the character of the phenomena.

Perhaps in some such ways the phenomena of comets may be brought more nearly home to us.

NORMAL SOLAR SPECTRUM.

PROFESSOR H. A. ROWLAND.

This photographic map of the Solar Spectrum is now complete from wave length 3680. to 5790. and the portion above 3680. to the extremity of the ultra violet, wave length about

3100., is nearly ready. Negatives have also been prepared down to and including *B*, and it is possible they may be prepared for publication.

These photographs have been made with one of Professor ROWLAND'S concave gratings of 21½ ft. radius of curvature and 6 in. diameter, mounted so as to preserve the focus constant and give a normal spectrum of the same scale for any given spectrum. A scale of wave lengths has been added so that the whole makes a map of the spectrum, down to wave length 5790., more exact and giving greater detail than any other map now in existence. The error in the wave length at no part exceeds one fifty-thousandth of the whole, and is generally caused by a slight displacement of the scale which is easily corrected. The wave lenghts of more than 200 lines in the spectrum have been accurately determined to about one five hundred-thousandth part and these can serve as standards to correct any small error of the scale. It is to be noted, that the photograph of the spectrum can have none of the local irregularities of wave length, which occur in all engraved maps, and which amount to more than one twenty-thousandth part in all so far published. This often so distorts a group of lines as, in conjunction with the imperfect intensities, to render them almost unrecognizable.

The definition of the spectrum is more than equal in every part, down at least to wave length 5325., to any map so far published. The 1474 line is widely double, as also b_3 and b_4, while *E* is given so nearly double as to be recognized as such by all persons familar with spectrum observation. Above the green the superiority increases very quickly, so that at *H* we have 120 lines between *H* and *K* while the original negatives show 150 lines. The photographs show more at this point than the excellent map of LOCKYER of this region. Above *H* to wave lengths 3200. the number of lines in excess of all published maps is so great as to make all comparison useless. However, above *H* the determination of the wave length is more uncertain than in the visible parts,and must remain so until a special investigation can be made.

The plates all contain two strips of the spectrum, except No. 2, which contains three. They are three feet long and one foot wide.

Plate No. 1.	Wave	length	3710. to 4185.	Scale	4	times	Angstrom.
2.	"	"	3100. to 4135.	"	3	"	"
3.	"	"	3680. to 3730.	"	3	"	"
4.	"	"	4075. to 4530.	"	3	"	"
5.	"	"	4480. to 4935.	"	3	"	"
6.	"	"	4875. to 5325.	"	3	"	"
7.	"	"	5210. to 5790.	"	2	"	"

These can now all be furnished to order except No. 2, the negative of which is being made.

The prints are made on heavy albumen paper carefully washed to prevent fading. The price has been put as low as possible. The set of seven plates, unmounted, $10; mounted on cloth, $12.00.—*From Johns Hopkins University Circular*.

EDITORIAL NOTES.

So much useful matter has been contributed to the MESSENGER during the last three months, that it has been quite impossible to present it all to our readers as promptly as might be expected.

THE DOUBLE STAR CETI 82.—Mr. SADLER, of England, well known to observers in the United States, calls attention to double-star *Ceti* 82. In Mr. BURNHAM'S seventh catalogue, its number is 395. From a notice in the *English Mechanic* (May 29 1885), the star is evidently a binary. At the time of its discovery Mr. BURNHAM estimated the position and distance of its components at 135°: 0.″5: 6.0, 6.0 magnitudes. According to Mr. SADLER'S statement, the pair has the large proper motion of 1″.355 annually in the direction of 91°, and its place for 1885 is 0*h* 31*m* 26*s*; −25° 24.′0.

DOUBLE-STAR 395. Under date of February 15, 1886, Mr. BURNHAM, of Chicago, says:

"A comparison of the observations first made of 395 (B. A. C. 160) with the measures of STONE (Cin. Obs.[6]) makes it certain that this is a physical system, if the large proper motion of 1.″436 in 90.°3, assigned by ARGELANDU, is correct. I do not know of any more recent measures. Unfortunately the race of double-star observers is rapidly becoming extinct, so far as the more difficult and interesting pairs are concerned."

WORK AT THE NAVAL OBSERVATORY FOR 1886.—By direction of GEORGE E. BELKNAP, Superintendent, the following programme of work, at the Naval Observatory will be pursued during the year 1886:

The Great Equatorial.—

1. Observations of a selected list of double-stars, such as have rapid orbital motions, or which present some other interesting peculiarity.

2. Observations of the satellites of *Saturn* and *Mars*.

3. Observations of some of the fainter stars in the *Pleiades*, to connect them with the bright ones recently measured with the Yale College heliometer.

4. Completion of the observations begun year before last for stellar parallax, and reduction of the same.

5. Reduction and discussion of all observations made with this instrument as rapidly as may be possible with the force available.

The Transit Instrument.—

1. Observations of the *Sun* daily.

2. Observations of the *Moon* through the whole lunation.

3. Fifteen to twenty observations of the major planets near opposition.

4. Five observations at least of each minor planet near opposition, when practicable.

5. Observations of the list of miscellaneous stars.

The 9.6-inch Equatorial.—

1. Observations of all the minor planets, whose brightness at opposition is greater than their mean brightness.

2. Observations of comets to determine position and physical peculiarities.

3. Observations of occultations of stars by the *Moon*, when of importance.

4. Observations of variable stars. [A photometer for this instrument has been ordered from Messrs. A. CLARK & SONS; a spectroscope by HILGER is ready for attachment].

The Prime Vertical Transit Instrument.—Observations of a selected list of stars, in conjunction with the Royal Observatory at Lisbon, whenever the latter Observatory shall assign a date to begin the work.

The Mural Circle.—This instrument will not be in use during the year, as the Repsold Meridian Circle at the Naval Academy at Anapolis has been kindly placed at the disposal of the Observatory by Captain F. M. Ramsay, for the purpose of carrying out the programme laid down for the Mural Circle last year. This programme is as follows:

Observations of stars down to the 7th magnitude,south of ten degrees north declination, the positions of which have not been recently determined at some northern observatory; the observing list to be formed of all stars from GOULD'S Uranometria Argentina visible here, and not found in YARNALL'S Catalogue, the Transit-Circle list of B. A C. stars,or the recent Catalogue of the Glasgow University, together with the 303 zero stars for the continuation of the Southern Zones, and the 59 refraction stars contained in the programme of work in the Leiden Observatory. (*Vid.* Vierteljahrschrift des Ast. Ges. 1881.)

Time Service and Chronometers.—The time balls at Washington, New York, Philadelphia, Baltimore, Hampton Roads, Savannah and New Orleans will be dropped daily at noon of the 75th meridian; and the noon signals will be extended to such other places throughout the country as may be desirable, as rapidly as arrangements can be made.

The time-ball at San Francisco will be dropped daily at noon of the 120th meridian by signal from the branch Observatory at the Navy Yard, Mare Island.

A competitive trial of forty-three chronometers will be held; twelve to be purchased by the Burean of Navigation.

The rating of chronometers on hand will be continued as heretofore.

Miscellaneous.—Photographs of the *Sun* will be taken daily, when practicable, with the photo-heliograph provided for photographing the Transit of *Venus.*

The examination of nautical instruments will continue.

Meteorological Observations will be made as usual.

THE BROOKS' COMET. On the evening of Dec. 27th, 1885, while seeking comets with my 5-inch refractor, I discovered a fairly bright comet some distance south of *Altair*. The comet was low and rapidly passing into dense haze near the horizon. I began a series of pointings upon it with 6-inch equatorial, securing five pointings before the comet finally disappeared in the haze. The resulting place of the comet derived from these observations was

$$\alpha = 19h\ 55m\ 25s$$
$$\delta = +\ 4^\circ\ 5'$$

At Nashville M. T. 7*h* 7*m* 58*s*. No motion could be detected in the short interval that the comet was under observation. I at once announced the object to Prof. SWIFT, but the next morning (28th) received a telegram from him informing me that it had been found by Mr. W. R. BROOKS on the night of the 26th, thus, of course, giving the comet to Mr. BROOKS, to whom it justly belonged, though my discovery was entirely independent. The regular telegraphic announcement of this comet was not received here until the evening of Dec. 28th.

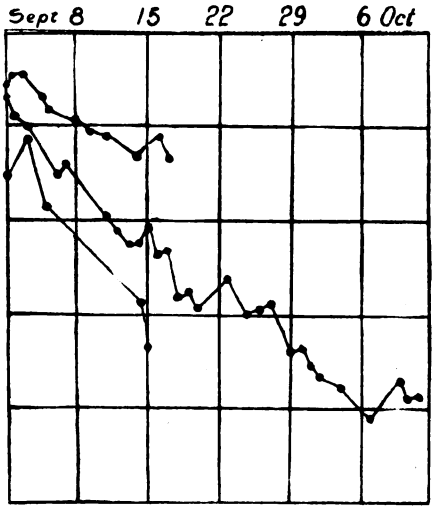
VANDERBILT UNIVERSITY, Jan. 15, 1886. E. E. BARNARD.

DOUBLE-STAR H, 1968. Mr. SADLER says: "There seems to be considerable change of the distance of H 1968, probably also from proper motion. HERSCHEL gives 61.°3: 20″ ±, in his 5th catalogue, while Professor STONE at Cincinnati found 71.°9: 7.″46 in 1879.

THE NOVA IN ANDROMEDA.—Having completed the reduction of my series of photometric observations of the nova with the aid of photometric determinations of the comparison stars kindly furnished to me by Prof. PICKERING, I send you the following table:—

Sept. 1	8.42	Sept. 14	9.89	Sept. 25	10.46	Oct. 9	11.21	Oct. 21	11.59
2	8.69	15	9.66	26	10.69	10	11.47	22	11.56
4	8.67	16	9.78	27	10.71	11	11.36	24	12.14
6	9.12	17	9.93	28	10.68	14	11.40	25	12.41
7	9.10	18	10.18	29	10.89	15	11.57	26	12.79
11	9.56	19	10.26	30	10.83	16	11.21	31	18.06
12	9.79	26	10.50	Oct. 1	11.03	17	11.12	Nov. 2	12.80
13	9.94	23	10.24	4	21.29	18	11.53	4	12.94

I also send you the diagram I furnished to the *New York Herald*, up to October 12, giving my first approximation.



The diminution in brightness, measured in magnitudes, was nearly uniform, with the exception of three or four well marked waves, when the star grew brighter for a few days, and then recommenced its diminution. Had it returned to the former line, these waves might be supposed to be errors of observation; but each time, the new line, while parallel to the other, was nearly a magnitude brighter than the continuation of the old line. The crest of the first wave is shown at Sept. 15. The angularity during that week disappears in the final revision. The second crest is at Sept. 23, and the third at Oct. 17. The diagram shows on Oct. 7 a position by estimation which is omitted in the table. On Nov. 3 there appeared to be the crest of a fourth wave; but it was then too faint in my telescope to make this certain. The shorter lines in the diagram were derived from European observations. HENRY M. PARKHURST.

Galle's Catalogue of Comets from 1860 to 1884, as published in the *Astronomische Nachrichten* (Nos. 2665 and 2666) and translated from the German by W. C. Winlock, U. S. Naval Observatory, Washington, D. C., has already appeared in recent numbers of this journal. Besides the information contained in this catalogue concerning recent comets, generally, it is all important that American observers notice and adopt the natural, easy and exact mode of designating and cataloguing them which is used in this excellent paper. A few copies of the catalogue have been reprinted in pamphlet form, with care, which will be sent to any address on receipt of 50 cents for each copy.

Comet Barnard.—The following elements and ephemeris were computed by H. V. Egbert, assistant at Dudley Observatory, from the following positions determined by himself, except the first.

1885			R. A.	Decl.
Dec. 3	11h 11m 09s	Nash. M. T.	4h 21m 36.s76	+4° 44′ 13.″9
12	8 58 00	Alb. M. T.	3 59 56. 20	+5 34 16. 9
25	6 22 14	Alb. M. T.	3 27 20. 02	+7 14 09. 5

ELEMENTS.

$T = 1886$, May 3.6513, Greenwich M. T.

$\omega = 119° \; 30.'1$ } 1886.0
$\Omega = 68 \; 15.5$
$i = 84 \; 44.1$

log. $q = 9.68293$

Motion direct.

Stellar Photography.—In the last annual report of Harvard College Astronomical Observatory information concerning important work in stellar photography appears. A lens of eight inches aperture, and forty-four inches focus, has been mounted equatorially and provided with a driving-clock. The work done by this instrument is various. When the clock is detached, trails of stars are taken due to the motion of the telescope; an equatorial star leaving a mark no brighter than sixth magnitude. Stars as faint as the fourteenth magnitude have been photographed without the clock-work. In this way the positions of faint polar stars may be determined with great accurracy. This means is also used to determine the measure of stellar brightness, and to form star-charts as large as the scale of Peters and Charcornac. But the most striking results have been obtained in photographing stellar spectra, which have been secured from stars of the eighth magnitude, in which lines are shown in a paper positive, sufficiently distinct to be clearly seen.

COMET 1883 I. (BROOKS). In a recent private letter from Assistant O. C. WENDELL, Harvard College Observatory, we have the following important facts concerning the orbit of the BROOKS' comet of 1883.

BRYANT'S orbit (Table of Elements January MESSENGER is based on these single observations, with an interval between the extreme ones of forty days. His orbit is a parabola and satisfies the middle place as follows--

$$O-C$$

$$\Delta \lambda' \cos \beta' = +34.''1 \qquad \Delta \beta' = +74.''0$$

The orbits which Mr. WENDELL has computed are all based on forty-one observations, combined into three normal places, and including between the extreme normals an interval of forty-one days. He calculated first a parabola, satisfying the middle place within about 4'' of longitude and 1'' of latitude. To reduce these residuals still farther, he calculated a second parabola, but the values came out almost identically with the first. So that the parabola did not completely satisfy the data.

Then he computed a final elliptic orbit with the following results:

T=1883, Feb. 18*d* 22*h* 45*m* 56*s* (Paris M. T.)

$\pi = 29° \ 1' \ 58.''3$

$\Omega = 278 \ \ 8 \ \ 36. \ 3$

$i = 78 \ \ 4 \ \ \ 4. \ 9$

$\log. q = 9.8807707$

$\log. e = 9.9996026$

Motion direct. Middle Place $(O-C)$

$\Delta \lambda' \cos \beta'$	$\Delta \beta'$
+0.''05	+0.''03

These useful data will be given in the MESSENGER'S reprint of GALLE'S Catalogue of Comets, as they were kindly furnished by Mr. WENDELL for that purpose.

MIRA CETI. This wonderful variable star when brightest ranges between a second and a fourth magnitude; it then gradually declines, and after 74 days it becomes invisible to the naked eye, and so continues for five or six months. Its mean period from minimum to minimum is about 333 days. In the *Companion* to the *Observatory* (English) the maximum for 1886 is set down for Feb. 13. We notice that the *Astronom. Gesallschaft*, 1885, predicts two maxima for 1886, occurring respectfully Jan. 7 and Dec. 5.

W. H. NUMSEN, Baltimore, has been observing this star since Dec. 11, 1885, and he says the maximum seems to have occurred between the beginning and middle of last January. He is undoubtedly right.

It is also noteworthy that the RADCLIFFE observations of magnitude of the nova of *Andromeda* contain some of the same reference stars which were used by Mr. NUMSEN, as seems evident from a comparison of the diagram in the December *Monthly Notices* with those published in the MESSENGER.

COMET (*a*) 1885 (BARNARD).—*Who saw it last?* My last view of this comet was obtained on the evening of September 2. As I have noticed no published account of its having been seen later, and as I remember how excessively faint it was, and the prolongd and desperate effort it required to obtain, if possible, one more observation of it, I am naturally anxious to know if it was seen at a later date. Prof. EGBERT's excellent ephemeris terminated on that day, so, setting the telescope with great exactness for it, starting the driving-clock, and using the periscopic comet eye-piece—power 132, field 32′—and with the seeing of the best, indeed, unequalled in clearness by any night spent in this observatory, I placed my eye, with well expanded pupil to the glass. A careful search showed only some very faint stars, none bright enough to at all interfere with the visibility of the comet. As I persistently gazed, more faint stars revealed themselves and inspired me with hope. At length, after a search of fifteen long minutes, the comet was detected, almost exactly in the center of the field. In all my experience in comet-seeking and in nebula work, I am sure I have never observed an object so faint, or one which required so prolonged an effort to see.

On the same night—Sept. 2—as I was returning from town, whither I had been to telegraph Prof. PICKERING of BROOKS' discovery of a comet, I, from a dark street, saw with perfect distinctness, with the naked eye, the nova in the *Andromeda* nebula. This plainly indicates the purity of the atmosphere on that occasion. The next evening, although a fine one, and though, through the telescope, the star appeared of equal brightness, yet I was unable to see it with the unassisted eye. LEWIS SWIFT.

WARNER OBSERVATORY, February. 1886.

THE DOUBLE-STAR, H, 2904. In a private letter, under date of January 28, 1886, HERBERT SADLER, of the Royal Astronomical Society, calls attention to the pair H, 2904, and says he does not think it at all probable that the pair is a binary one. Sir J. HERSCHEL's distances of the double-stars, observed with his 20-feet reflector, in sweeping for nebulæ, are, as might be supposed, much underestimated as a rule. He further says:—

"A proper motion of 0.″437 per annum, in the direction of 197° on the part of the large star, will account for the observed movement. This would give 33.″0 for Sir J. HERSCHEL's distance in 1834.60; the observation in his fifth catalogue was made, as I find on consulting his MSS, in 1830.62. In 1890 the position angle will be 125°.5, and the distance 15.″6, and about the year 1912 the small star will be on the parallel at 15.″5 distance. The large star was only nightly observed by LA CAILLE."

The following orders have not been previously acknowledged:

H. S. Pritchett, Washington University Observatory, St. Louis, Mo. John Goldie, Galt, Ontario, Canada. George Gildersleve, 43 Charles St.

Baltimore. John R. Hooper, Box 196, Baltimore, Md. Geo. R. Vickers, No. 9 German St., Baltimore, Md. Charles S. Rockwell, Tarrytown, N. Y. Royal Observatory, Greenwich, England. Observatory of the Cape of Good Hope, Capetown, South Africa. Wm. B. Phelps, Fargo, D. T. (Vol. 3). J. W. Thompson, Salem, Ohio. F. G. Blinn, East Oakland, California. Daniel Appel, 11 Irving St., Cleveland, Ohio. S. Wilson Fisher, 1502 Pine St., Philadelphia, Pa. John H. Eadie, Bayonne, N. J. Public Library, Chicago, 2 copies, 1886. Professor H. A. Howe, University Denver, Colorado. John W. Osgood, Cincinnatus, N. Y. John O. Williams, Bevier, Macon, Mo. Cincinnati Observatory, Mt. Lookout, Hamilton Co., Ohio. Professor John Haywood. Otterbein University, Westerville, Ohio. Prof. H. M. Perkins, Delaware, Ohio. G. D. Hulett, Oswego, N. Y. Henry M. Parkhurst, 25 Chambers St., Brooklyn N. Y. Professor Geo. B. Merriman, New Brunswick, N. J. Professor Wm. A. Rogers, Harvard College Observatory. Professor M. R. Conable, 1126 Girard St., Philadelphia, Pa. J. J. Gilbert, U. S. Coast and Geodetic Survey, Olympia, W. T. J. D. Devor, Elkhart, Ind. John Tatlock. The Literary Dept. Mutual Life Insurance Co., New York City. William Evans, 252 South Front St., Philadelphia, Pa. William C. Pond, 719 Asylum Ave., Hartford, Conn. Messrs. Andr, Fred, Host and Sohn, Booksellers, Copenhagen, Denmark. Kaiserl, Univesitats Sterwarte, Kasan, Russia. William Strong, Kalamazoo, Michigan. Miss Anna Winlock, Cambridge, Mass. Professor C. S. Howe, Akron, Ohio. Mechanics Institute, San Francisco, California. Lewis H. Roberts, Clinton, Iowa. Mr. Perrotin, Directeur de l'Observatoire, Nice, Alpes Maritimes, France. University of Minnesota, Minneapolis, Minn. Library U. S. Naval Observatory, Washington, D. C. Lick Observatory, San Jose, P. O. California. Prof. J. T. Anderson, Fayette, Mo. Bert Luty, Allegheny, Pa. Public Library of Cincinnati, Cincinnati, Ohio. R. R. Beard, Pella. Ia. B. G. Way, 111 Fulton St., Brooklyn, N. Y. Arthur C. Perry, 261 Broadway, New York City. Wellesley Coll. R. R. Wellesley, Mass. Prof. Winslow Upton, Providence, R. I. University Reading Room, Eugene City, Oregon. James Jackson, Paterson, N. J. W. A. Kelso, 827 S. 18th St., St Louis, Mo. Albion College Library, Aibion, Mich. Library of McKim Observatory, De Pauw University, Greencastle, Ind. E. Crocker, Berea, Ohio, Chester Guild, 88 Summer St., Boston, Mass. J. Stahn, 13 Ensor St., Baltimore, Md. Chicago Public Library, Chicago, Ills.

A Hand Book of Descriptive Astronomy. By GEORGE F. CHAMBERS, F. R. A. S. Third Edition, Oxford, (England) 1877. pp. 928.

Through the kindness of the author, a copy of the third and last edition of this invaluable work has been placed on our book-table. It is not a new book; neither is it one with which the experienced astronomer or observer is unacquainted either in this country or in any other. Attention is called to it now chiefly because of inquiries so often, from students and readers of popular astronomy to recommend some standard work, as a reference book which is accurate in detail, and one which contains most of the results of recent important astronomical research. In these particulars this book has no equal in the English language. Others are more full and specific in special lines of study; but, as a hand-book for the working astronomer, or as a text-book in descriptive astronomy for the student this work is unquestionably the best.

For those who have not seen the book, it may be well to add, that the text is free from the language, technical terms and symbols so much employed in practical astronomy dependent on the higher mathematics. The print is good, illustrations abundant, citations of authority very full, judgment on varying points of opinion of astronomers, when expressed, fair and candid, and the necessary tabular data are generously full and conveniently arranged, considering the interests of all for whom the book is designed.

A Cycle of Celestial Objects, observed, reduced and discussed by Admiral WILLIAM HENRY SMYTH, R. N., K. S. F., D. C. L. Revised, condensed and greatly enlarged by GEORGE F. CHAMBERS, F. R. A. S. Second Edition, Oxford, (England) 1881. pp. 696.

This book is not as well known in America as the one above referred to. The circumstances attending the appearance of the second edition are these: Admiral SMYTH'S original *Cycle of Celestial Objects* was published, in two volumes, in 1844. Though it was widely and favorably received, the first edition passed out of print in a few years, and a second was not prepared during the long and distinguished life of its author. This work, however, was entrusted to another, by the name of ISAAC FLETCHER, who doubtless would have done it well, but for the greater attractions of a political career open to him, which so hindered and delayed the revision, that he came to his death, in 1877, without doing very much to accomplish the important task. The original author's relatives and immediate friends then charged Mr. CHAMBERS with the serious responsibility of publishing the new edition of the book. All the materials which had been gathered by Admiral SMYTH during his long life, and those by Mr. FLETCHER during 32 years, came into Mr. CHAMBERS' hands in 1879, who immediately undertook the revision and completed it in the space of two years

The aim before the present author was, to revise, prune and amplify

Admiral SMYTH's Bedford Catalogue, so as to provide a telescopist's manual for refractors to eight inches of aperture, and to bring its astronomy down to the year 1880, just as the original edition was useful for glasses of 5 inches aperture, to 1845.

Of the revision of Bedford Catalogue there was urgent need, in view of the seriously erroneus measures of an important class of double-stars. Attention was first called to this by Mr. BURNHAM of Chicago; a few years later, and in 1879, by Mr. SADLER of England, in a communication to the *Monthly Notices* of the Royal Astronomical Society brought the matter again to public notice, after which Mr. BURNHAM made a critical examination of the catalogue, and the result of his labors was given in an article of thirty-five pages in No. 8, Vol. 40, of the *Monthly Notices,* all but six of which were devoted to the measures of double-stars made by himself and other observers of recognized ability in comparison with the measures of Admiral SMYTH's Catalogue. This was indeed, timely work on the past of Mr. BURNHAM, which naturally and irresistably found its proper place in the revision of the *Cycle.* And the author has very appropriately recognized the services of Mr. BURNHAM in the preface to the second edition, as follows: "Mr. BURNHAM has not only furnished me with an almost inexhausible supply of double star measures of great precision and late date, but has read all the proof sheets and made innumerable suggestions. Of these some are being treasured up for a future edition, having come to hand too late for use in this one.

These facts indicate something of the skill and labor that have been expended in bringing out this revision and they are certainly reasonable grounds of confidence for it in addition to the recognized authority of the reviser.

The *Cycle* contains 1604 celestial objects, arranged in the order of Right Ascension, giving the number of the star, the constellation, reference numbers in other important catalogues, declination, precession, double-star measures by all prominent observers, position angle, distance and epoch, and such additional historical notes and comments as may serve to make knowledge of them as complete as possible. The running head line at the top of each right hand page gives the first and last right ascensions of the two pages open to the eye at once, which is an exceedingly convenient arrangement to aid in finding particular objects, scattered through 680 pages. At the close of the volume is an analytical index which presents the entire list of celestial objects by constellations. This book is also heartily commended to the readers of the MESSENGER.

The Sidereal Messenger

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—Galileo, *Sidereus Nuncius*, 1610.

Vol. 5. No. 4. APRIL, 1886. Whole No. 44.

THE IMAGES OF THE STARS.

BY ASAPH HALL.

For The Messenger.

The variability of the images of stars from night to night, when seen in the same telescope, is very great, and the blurred and indefinite shape the stars sometimes assume is one of the chief difficulties in making accurate measurements for the more delicate determinations of astronomy. Since the quality of the image varies with the season, this difficulty becomes a serious one in the determination of quantities that have a year for their period; such as the constant of aberration, and the parallaxes of the stars. Observations for these determinations must be made at times of the year six months apart, and if the stars are so situated that the maximum coefficients occur in summer and winter, there is apt to be a decided and continuous difference in the quality of the images which may produce a sensible error in the measurements. This difficulty becomes more apparent as we use large objectives and high magnifying powers. A part of the trouble comes from the increased aperture of the objective, which increase gives a greater opportunity for changes of temperature to affect the images, but there appears to be a considerable part of the change that is independent of the objective and which depends on the season.

At Washington, my experience during the year is as follows: We get fair images of the stars occasionally in the latter part of February, and in March we generally have a few good nights. In April and May the weather is changeable, and good seeing is rare. June brings somewhat better images of the stars; and the longest period for good work is from July to October. But there is sometimes a break in this period during September, with a return of good images until the middle of October. In the early part of October I have seen very fine images of the stars and planets in the morning sky. After the middle of October the seeing becomes bad, and continues so through November and the early part of December. When the cold weather has completely set in we sometimes have good images for a few days in the latter part of December and in the early part of January, before the wet winter weather begins. This is the general course of the images throughout a year.

It would be interesting to examine the meteorological changes in connection with the variations of the images of the stars, but this I can do only in a very imperfect manner. It does not appear that moisture in the air of itself prevents good seeing or injures transparency, since in the months of July and August a damp night, preceding a rain will frequently give very fine seeing. Such nights are calm and quiet, and are those on which we hear distant sounds so distinctly. On these nights, the 26-inch CLARK refractor will bear the highest powers, and there seems to be almost no limit to its performance. It will resolve the most delicate double-star, and bring to view faint objects that on common nights are far beyond its reach. As autumn comes on and the weather becomes colder, the moisture produces a different effect, so that in November a night before a storm generally gives blurred and fuzzy images of the stars. I have sometimes imagined that these bad images may be caused by ice crystals forming in the atmosphere, which scatter the light and produce a confusion of the image. As the weather gets still colder and drier, the images become better, so that occasionally in mid-winter we have a good night. But damp and chilly weather at this season nearly always produces bad seeing, and as the stars become blurred and indistinct we may be pretty sure that a storm of snow or rain is approaching. It is possible that the changes caused by the seasons may be avoided in a good degree in the equatorial regions of the *Earth*.

Besides the regular changes brought about by the seasons of the year, there are changes produced by local causes. Thus from one day to another there will be a great difference in the appearance of the stars, even when the sky remains apparently quite clear. In fact, such changes occur from one hour to another during the same night. Probably these sudden changes are caused by the passage of large bodies of air of different temperature and moisture, since after a short time, perhaps even a half-hour, the images which have suddenly become poor will as suddenly become good again. I have found that during any night the best seeing is generally in the morning sky, say from three o'clock until sunrise. This is especially the case in the summer and autumn months, when the hours preceding morning twilight are frequently excellent. At that hour of the night, the temperature has become steady, and the conditions of the observing room and of the instrument are the best. It is surprising to notice how great is the difference in the quality of the seeing on different nights, and this is shown best of course with faint and difficult objects. *Mimas*, the inner satellite of *Saturn*, is a good example. Generally this satellite can not be seen at conjunction, and even at elongation it is not an easy object; but on a fine night it can be seen at conjunction with ease in our 26-inch refractor. The difference of visibility is so great that at times one is inclined to believe that such objects are variable in light; but probably the true explanation lies in the varying transparency of our atmosphere.

Such considerations bring us to a question which is destined, I think, to become an important one in the future of astronomy, that is, the selection of the best sites for our large telescopes and delicate photographic apparatus. There are certain evident advantages to the astronomer in being near large libraries, and in having convenient access to mechanics and workshops; and our human nature is such that it is pleasant to be near clubs and hotels, theaters and churches. But the great foes of the astronomer are the variability and sudden changes of our atmosphere. As observations become more and more refined, as well as the tools with which we work, the need of better positions for our instruments will be seriously felt, and will finally outweigh the little inconveniences of life.

THE RELATION BETWEEN METEORIC ORBITS AND RADIANTS.

S. J. CORRIGAN.

For the Messenger.

In the February number of the MESSENGER, I set forth a method of computing the orbital elements of meteoric streams from the observed position of the radiant point, the formulæ of that method having been derived from fundamental equations of motion as found in works on "Celestial Mechanics."

This method is a facile one and gives results of sufficient accuracy in all cases, but the determination of the elements may be effected by an equally easy process, devised by me some years ago, which is perfectly rigorous and which has, moreover, the advantage of disclosing certain facts concerning a mooted question in "Meteoric Astronomy," which facts do not *explicitly* appear in the former method.

The question to which reference is made is that relating to the cause of the phenomena of stationary radiants. The labors of expert observers seem to leave no doubt as to the existence of meteor streams emanating from the same, or very nearly the same, point of the celestial sphere for a considerable length of time, and several hypotheses have been framed to account for this phenomenon which seems to conflict with the heretofore generally accepted hypothesis, viz.: that the meteors, like the comets, move around the *Sun* in orbits whose eccentricities are approximately that of the parabola.

I now propose this second method of computation, mainly for the purpose of demonstrating that the position of a radiant is, in most cases, not a *true* but only an *apparent* position, and that stationary or long-enduring radiation of meteors from nearly the same point in the heavens, does not necessarily imply a real connection between all the meteors emanating from such stationary radiant, nor that they all belong to the same stream, but rather that there is probably no connection whatever.

From the actual application of this method to certain cases of well-marked stationary radiation, I also hope to prove that the hypothesis of nearly parabolic motion is not weakened by the existence of such radiants, but corrobated, and that it is unnecessary to construct any other hypothesis to explain the phenomenon.

The principle upon which the method above mentioned is founded, may be briefly stated as follows: It is well known that the radiant point of a meteor stream is the vanishing point of the parallel lines apparently described on the celestial sphere by the individual members of the stream during their flight through the *Earth's* atmosphere; it may therefore be regarded as situated at an infinitely great distance from the observer.

Then, since the members of the stream approach the orbit of the *Earth* with nearly parabolic velocity, while the latter body is also in motion, it follows that the *true* position of the radiant point will be affected by the composition of the velocities of the *Earth* and of the meteors, in a manner perfectly analagous to that in which the position of a fixed star is affected by aberration.

In other words the observed position of the radiant is not a *true* but only an *apparent* position.

Since the axis of the meteor stream, or the line passing through the *true* position of the radiant and through the center of the *Earth*, may be taken as the tangent to a parabola at a point where the radius-vector is equal to R, or the radius-vector of the *Earth*, it becomes very easy to compute the elements of the parabolic orbit if we can reduce the observed radiant to its *true* position. This reduction may be effected in the following manner:

Let L = Longitude of *Sun*
" π' = " " *Sun's* perigee
" R = *Earth's* radius vector
" e = Eccentricity of *Earth's* orbit

In the first place the orbit of the *Earth* being slightly elliptical, the true direction from which the *Earth* is moving at any instant will not be equal to $(90°+L)$ as it would if the orbit were a circle, but would differ from that value by a small angle, i, which depends upon the eccentricity of the *Earth's* orbit. From an equation of curvature and the polar equation of the ellipse we obtain $\tan i = \frac{e \sin (L-\pi')}{1+e \cos (L-\pi')}$ (1)

Then if, instead of taking the *Sun's* true longitude L, we use $L' = L - i$, the change of direction will be taken into account. Then to derive the *true* position of the radiant, we have only to solve two right-angled spherical triangles, having one common angle B, the sides opposite to this angle being b', or the latitude of the observed radiant, and b or the latitude of the *true* radiant; the sides adjacent to the right angles are $90°+(L'-l')$ and $90°+(L'-l)$, which are arcs of the ecliptic included between that longitude from which the *Earth* is moving, and the apparent and the true longitudes of the radiant point, respectively.

The composition of the velocities of the *Earth* and of the meteors will have the effect of extending the hypothenuse in the direction of the *Earth's* motion; t' or the hypothenuse of that spherical triangle whose other sides are the *observed* co-ordinates $90°+(L'-l')$ and b', being greater than t, or the hypothenuse of that triangle whose other sides are the *true* co-ordinates $90°+(L'-l)$ and b.

Having the observed longitude l' and latitude b', the following equations will give l and b, or the true longitude and latitude of the radiant point.

$$\left.\begin{aligned} \sin t' \sin B &= \sin b' \\ \sin t' \cos B &= \cos b' \cos (L'-l') \\ \cos t' &= -\cos b' \sin (L'-l') \end{aligned}\right\} \qquad (2)$$

From which we obtain B and t':

$$\text{Then } c = \sqrt{\left\{1 - \frac{R}{2}\right\}} \qquad (3)$$

$$\sin (t'-t) = c \sin t' \qquad (4)$$

From (4) we obtain t; then from the equations

$$\left.\begin{aligned} \sin t \sin B &= \sin b \\ \sin t \cos B &= \cos b \cos (L'-l) \\ \cos t &= -\cos b \sin (L'-l) \end{aligned}\right\} \qquad (5)$$

we obtain l and b, or the true longitude and latitude of the radiant point. Finally, from the following equations we may readily obtain the parabolic elements:

$$d = 180^\circ + (L - l)$$
$$\cos a = \cos b \cos d$$
$$\cot i = \cot b \sin d$$
$$q = R \sin^2 a$$
$$v = 180^\circ - 2a$$
$$\pi = L + 2a$$
$$\Omega = L \text{ when } b \text{ is positive}$$
$$\Omega = 180^\circ + L \text{ when } b \text{ is negative}$$

i is always taken to be less than 180° and the motion is retrograde when $\cot i$ is negative.

To show the change produced in the position of the radiant by the composition of the velocities of the *Earth* and of the meteors, I have taken a peculiar case of stationary radiation mentioned by Mr. DENNING in No. 8 Vol. 45 of the *Monthly Notices of the Royal Astronomical Society*, page 444 *et seq.* I quote therefrom: "Let us take the instance of the display from near Epsilon *Persei*, at R. A. 61.°8; Dec +36.°8, No. IV of my list in the *Monthly Notices* for December, 1884, page 101, which I regard as one of the very best cases of stationary radiation.

A shooting star of about the third magnitude was doubly observed from this shower at York and Oxford at 11*h* 28½*m*, on August 10, 1872. The estimated duration was 0.5 second and the actual length of the path traversed in the atmosphere was 20.4 miles, so that the resulting velocity was about 41 miles per second; the radiant point was at R. A. 61°; Dec. +39°. A great fireball from the same stream was observed at Bristol and many other parts of England on November 6, 1869 at 6*h* 50*m*. Prof. HERSCHEL discussed a considerable number of observations and found the radiant point at R. A. 62°; Dec. +37°. The meteors had a real path of about 175 miles, traversed in about five seconds the velocity being some 35 miles per second and somewhat greater than that of a body moving in a parabola, etc., etc.

The facts contained in the above statement by Mr. DENNING offer an excellent means of learning something of the nature of stationary radiants. From the position of the radiant point of these two fireballs I have computed the elements of their orbits by the method which I have just given, and also by that which I set forth in the February number of the MESSENGER, and the results agree exactly. They are as follows:

Elements	Meteor of November 6, 1869	Meteor of August 10, 1872
Longitude of node	224° 27′	138° 35′
" " perihelion	272 54	263 19
Inclination	38 44	33 29
Perihelion distance	0.1873	0.7952
Motion	Direct	Retrograde

The apparent longitude of the November radiant was 67° 4′ and its latitude +15° 45′, but the true longitude as obtained through the computation by the above given method was 23° 49′, and the true latitude +15° 47′.

The apparent longitude of the August radiant was 66° 41′ and its apparent latitude +17° 52′, but its *true* longitude as computed was 80° 42′ and its true latitude +29° 16′.

Thus we see that two meteors having their apparent radiants within two degrees of each other and affording, as Mr. DENNING states, an excellent example of stationary radiation, are, in reality, members of entirely distinct streams, as their elements show, and that their *true* radiants are separated by the great distance of more than fifty-eight degrees. The agreement of the elements derived through the two different methods proves the accuracy of the computation on the hypothesis of parabolic motion, and also that the *observed* position of the radiant is only an *apparent* position.

We have, finally, to consider whether the hypothesis of nearly parabolic motion is sufficiently satisfactory.

The question as to what form of conic section any heavenly body revolves in is determined by finding, through places observed at certain intervals, the form of orbit that will pass through these places, or an orbit that will possess such elements that will enable one to compute therefrom places that will well agree with those observed. This virtually amounts to the determination of the linear velocity of the body upon which the form of orbit depends. The rapidity of flight of a meteor precludes the institution of such a comparison, but we can directly compare the linear velocity, as deduced from computation with the velocity when it is actually obtained from observation, as it was in the case of the two meteors under consideration. In the case of the meteor of 1872 the observed velocity was about 41 miles per second and the velocity given by my computation was 41 miles per second, an exact agreement. The observed velocity of the meteor of 1869 was 35 miles per second, while my computation gives only 26 miles; but this difference may very easily have resulted from errors of observation in the case of a body moving so swiftly.

It would seem therefore that the above comparisons of linear velocities and also the comparisons of computed and observed velocities in the case of the twenty meteor streams whose elements were given by me in the February No. of the MESSENGER, furnish strong evidence in favor of the hypothesis of approximately parabolic motion.

This being granted, it seems unnecessary to propose abnormally great velocities for the meteors to explain the phenomenon of stationary radiants.

WASHINGTON D. C. February 8, 1886.

SOLAR AND MAGNETIC OBSERVATIONS.—We are glad to learn from private advices, that a small observatory will soon be fitted up with the necessary instruments for continuous solar and local magnetic observation, in which daily solar photographs of the *Sun* will form an important part of the work done by the observers. We are not aware that work of this kind is now anywhere systematically undertaken in the U. S.—ED.

THE COMETARY METEOR SHOWERS.

W. F. DENNING.

For the Messenger.

The very valuable data, in connection with meteoric orbits, given by Mr. S. J. CORRIGAN in the February issue of the MESSENGER, leads me to send you some further details of meteor observations which seem to require mathematical investigation. This branch of astronomy is so recent that it is far from being understood in all its relations. Our aim therefore should be to obtain full and exact observations, and thoroughly sift them, so that theory and observations may mutually harmonize.

The physical connection of comets and meteor streams has been definitely proved in a few instances. The character of their orbital agreements is such that no one can doubt the fact of their identity. But these instances may be regarded as special. Very rich meteor displays like the *Lyrids*, *Perseids*, *Leonids* and *Andromedes* are not typical of the multitude of very feeble showers which the *Earth* encounters. It is fair to suppose that every variety of orbit exists among them, and that, in certain cases, abnormal features are recognized which are not to be satisfactorily explained on prevailing ideas.

My present intention is simply to refer to the acknowledged cometary showers. In connection with these it is important to ascertain whether the epoch and radiant point show an exact coincidence with that computed for the cometary orbit and whether the maximum displays of the meteors agree with the periodical returns of their derivative comets. It is also necessary to determine the visible duration of the meteor showers, and to note whether the point of radiation is stationary or shifts from night to night amongst the fixed stars. Having obtained some evidence on these matters during the last ten years I have summarized it as follows:—

The April Meteors (Lyrids).—This shower is far less rich than formerly. The radiant point of its associated comet

(I 1861) is at 270.°5 +32° April 20+ (A. S. HERSCHEL). The early determinations of the meteor shower by GREG, HERSCHEL and others, placed the radiant several degrees to the north-east of the cometary radiant, hence their assumed identity was considered questionable. I find that the radiant of the meteors is at 269.°1 +33.°4, which is very close indeed to that indicated by the cometary orbit. The maximum occurs on April 20 with the *Sun* in longitude 31°. The shower endures for five or six nights and the radiant point moves very rapidly amongst the stars. In 1885 on three very clear nights I obtained sharply defined radiants at the following places:—

1885	G. M. Time.	Radiant Point.		No. of Meteors.
April 18	12*h* to 14*h* 30*m*	260°	+33½°	6
19	10*h* 30*m* to 14*h*	267½	+33	10
20	11*h* 30*m* to 15*h* 30*m*	274	+33½	14

The motion is in R. A. toward the east, carrying the observed radiant from the stars of *Hercules* to those of *Lyra*.

The August Meteors (Perseids).—This stream contributes an annual display not differing much in intensity. Prof. HERSCHEL gives the radiant of its companion comet (III 1862) as 43° +57.°5 August 10—. I find the meteor radiant is at 44.°4 +57.°4 on August 10. The accordance is excellent. The shower is definitely and certainly sustained over at least twenty-six nights. I have carefully traced the radiant point during this period as it successively assumes positions to the eastward though the displacement is far less rapid than that observed in the case of the *Lyrids*. I select nine positions derived from a mean of all my observations:—

Date.	Radiant Point.		Horary No. of Meteors.
July 26	27°	+55°	1
29	30	+55	3
August 1	33	+56	5
4	36	+56	6
7	40	+57	10
10	45	+57	57
13	51	+57	7
16	59	+57	3
19	68	+57	1

The shower advances through 41° of R. A. (=22½° at equator) during the period of its display. After the maximum on the night of August 10 the displacement of the radiant is considerably more rapid than before it, and the decline of the shower is more abrupt than its increase. I believe the display really extends to August 22, for on that date in 1884 I suspected feeble traces of it from the point 77° +56½°. Its tenuity on the occasion referred to may be understood when I mention that its estimated strength was about one meteor in three hours for one observer! This shower of *Perseids* supplies very swift meteors, almost invariably accompanied with streaks. Their observed motions and appearances during the period from July 25 to August 19 are very similar. When the radiant is rather near the horizon, in the early part of the night, the meteors apparently move slower and have much longer paths than when the radiant has attained a great altitude.

The November Meteors (*Leonids*).—This shower has been very inconspicuous during the last ten years. The parent comet (I 1866) was at its aphelion in 1882 outside *Uranus*, so that bright displays of meteors were not to be expected. On the morning of November 14, 1879, I saw a few fine members of this stream, but the return was not a notable one. Prof. HERSCHEL computes the radiant of TEMPEL's comet (I 1866) as 150.°5 +23.°5 November 13—, and I find the radiant point from my observations of the *Leonids* at 148.°3 +22.°7 November 13. The agreement is satisfactory, though the meteors apparently diverge from a point slightly west of the computed place from the cometary orbit. The shower certainly endures for eight nights (November 9–16), but I have not been able to determine whether there is any decided displacement in the radiant point during that interval. The recent displays have been so feeble and the weather in this climate is so rarely clear for several nights together in the autumn, that in this case my design has been frustrated. In 1879 and 1885, however, I fixed the radiant as follows:—

Date.	Radiant.
1879 November 13	148° +23°
1885 " 14	149 +21
1885 " 16	150 +22

The figures show a slight advance in the direction of increasing longitude, but the evidence is too meagre to be conclusive on the point. The meteors belonging to this stream are similar to the August *Perseids.* They are brighter than the average and move very swiftly, leaving vivid streaks upon their courses.

The Meteors of Biela's Comet (Andromedes).—This shower is apparently more recent than the others, especially in regard to its more imposing apparitions. Prof. HERSCHEL gives the radiant of BIELA's comet as 24.°5 +40° November 27+. WEISS gave 23.°4 +43° Nov. 28+ and HIND (1866) 25.°25 +42° November 28+. From a discussion of the observations obtained during the great meteoric display of November 27, 1872, Prof. HERSCHEL found the central radiant at 25.°1 +42.°9 from a compact group of thirty-five positions. From the similar observations made during the equally brilliant return of the shower on November 27, 1885, I find the mean radiant at 23.°7 +44.°3 from thirty-three of the best positions. These several values for the cometary and meteoric radiant agree within small limits, and from whatever aspect the question is regarded, the identity of BIELA's comet and this celebrated meteor swarm appear conclusively demonstrated. The maximum number of meteors come just when the comet, or what remains of it, is not very distant from that point of the orbit intersected by the *Earth* on November 27. This is also true of the November *Leonids* with regard to the date of November 13. The *Andromedes* are very slow meteors with thick trains and short paths. The shower probably endures about a week and there is evidence of a slight retrograde motion of the radiant (MESSENGER, February 1886 p. 61) which however requires further investigation as it rests only on one year's results and the motion is inconsiderable.

In the instances of the *Leonids* and *Andromedes* the agreements with Comets I 1866 and BIELA (1826) are very concise and exact. But in regard to the *Lyrids* and *Perseids* the resemblances are less striking because the periodical returns, either of the meteors or their parent comets are not yet determined. The other conditions are however eminently satisfactory. The displacements observed in the radiant points of the latter showers coupled with their durations may aid us in learning something as to the width and construction of those regions traversed by the *Earth.* Do the nightly variations in the radiants, as observed, correspond with that computed for extensive streams of meteors following the same general orbits as the Comets I 1861 and III 1862? The question is an important one and offers a new test as to whether the *Lyrids* and *Perseids* are actually associated with the comets to whose orbits they show such a striking resemblance.

In a subsequent paper, I hope to refer to another class of meteor showers which apparently endure for long periods, and maintain stationary radiant points. In concluding this note on the cometary meteor showers, I may mention that on about November 16 or 17, 1965 or 1966 the *Leonids* of TEMPEL'S comet and the *Andromedes* of BIELA'S comet will probably occur simultaneously! In the case of BIELA'S comet there is a rapid retrograde displacement of the node which operates to bring the showers earlier every year. In 1798 BRAUDES at Hamburg saw the shower on December 7, whereas it now occurs on November 27. On the other hand the node of TEMPEL'S comet is increased by planetary perturbations twenty-nine minutes of arc during one revolution of 33¼ years. Thus the displacement is in a contrary direction to that affecting BIELA'S comet. The cummulative results of this will be apparent in constantly decreasing the interval of thirteen days which now separates the two meteor showers. In about 1965–66 when the *Leonids* will probably return in great strength, the *Andromedes* will also be due on about the same day and it is quite possible the two meteor showers may occur together and give rise to a spectacle, surpassing everything previously recorded, in the annals of meteoric astronomy.

BRISTOL, England, February 19, 1886.

ORBITS OF METEORS.

O. C. WENDELL.

For the Messenger.

The following twenty-eight orbits of meteor showers I have computed from DENNING'S list of radiants as given in SIDEREAL MESSENGER 1886, February No. p. 61.

Number	Day of Shower	Long. of Per.	Long. of Node	Inclination	Perihelion Distance	Motion
	1885					
1	Nov. 14	17.°5	232.°3	59.°0	0.910	Retrograde
2	14	59. 0	232. 3	14. 5	0.996	"
3	16	54. 3	234. 3	15. 3	1.000	"
4	16	43. 2	234. 3	47. 6	0.991	"
5	17	82. 0	235. 4	39. 9	0.947	"
6	26	111. 5	244. 5	16. 6	0.841	Direct
7	27	109. 6	245. 5	16. 0	0.859	"
8	28	108. 1	246. 5	15. 7	0.874	"
9	30	107. 1	248. 5	14. 4	0.890	"
10	30	145. 4	248. 5	24. 9	0.613	"
11	Dec. 1	127. 2	249. 5	25. 3	0.767	"
12	1	92. 3	249. 5	75. 4	0.961	Retrograde
13	4	178. 5	252. 6	1. 3	0.363	Direct
14	4	221. 1	252. 6	55. 1	0.069	"
15	4	260. 2	252. 6	84. 5	0.005	Retrograde
16	4	352. 2	252. 6	70. 9	0.583	"
17	7	181. 8	75. 6	5. 8	0.360	Direct
18	7	227. 6	255. 6	87. 1	0.059	"
19	9	21. 7	257. 6	87. 8	0.781	Retrograde
20	9	81. 2	257. 6	83. 8	0.999	Direct
21	10	186. 8	258. 7	49. 9	0.344	"
22	10	221. 8	258. 7	37. 7	0.100	"
23	10	232. 7	258. 7	79. 8	0.051	"
24	10	338. 8	258. 7	58. 6	0.414	Retrograde
	1886					
25	Jan. 2	100. 1	282. 1	75. 2	1.000	Direct
26	2	227. 0	102. 1	9. 3	0.214	"
27	2	15. 4	102. 1	3. 3	0.529	Retrograde
28	5	187. 8	285. 1	48. 2	0.564	Direct
Comet 1873 VII		85. 5	248. 6	26. 5	0.770	Direct
" 1884 I		93. 4	254. 2	74. 1	0.776	"
" 1884 I cor.		95. 9	257. 6	83. 5	0.778	"

There is a marked resemblance between meteor elements Nos. 11 and 20 and those of comets 1873 VII and 1884 I (Pons-Brooks) respectively, as will be seen above. In the first case there is a very close agreement in all the elements save the longitude of perihelion. In the second, there is a general resemblance in all the elements with those of the Pons comet, although it is not as close as could be desired. If, however, we assume that the meteoric stream has a considerable breadth, at the node, which is perfectly admissible, we may determine the resulting change in the other elements, or, suppose we apply the change to the comet's orbit, which will answer equally well. Then meteor node — comet node = $d\Omega = +3.°4$. Now when $d\Omega$ is not large we have the following differential expressions.

$$d\pi = 2 \sin^2 \tfrac{1}{2} i \, d\Omega$$
$$d i = \sin i \cot (\pi - \Omega) \, d\Omega$$

Solving these equations we obtain for $d\pi$ $+2.°5$ and for di $+9.°4$, and these applied to the comet's perihelion and inclination give for π 95.°9 and for i 83.°5 as appear above in the last case in the table which I have called Comet 1884 I corrected. Then we shall also have for q (the anomaly being determined with reference to the descending node.)

$q = R \sin^2 \frac{\Omega + d\Omega - \pi - d\pi}{2}$ which, being solved, gives $q =$ 0.778, as before.

This general agreement, although quite marked, cannot yet be regarded as conclusive from the fact that the orbit of the comet is about two-tenths the *Earth's* distance from the *Sun* inside the *Earth's* orbit, and so would seem to preclude the possibility of meteors from such a distance reaching the *Earth*, although there is, beyond question, much lateral spreading in their orbits.

Farther observations, however, will undoubtedly throw more light on both these cases.

HARVARD COLLEGE OBSERVATORY, February 22, 1886.

THE PREDICTION OF FINE SEEING.

DAVID P. TODD. *

For the Messenger.

I find myself often wondering whether, in the elaborate records of meteorological observations at the command of the officers of the Signal Service, there may not be locked up, in great part, the data necessary for the prediction of fine seeing. It will appear that the matter is of the last degree of importance to the astronomer; for, in most kinds of work, there is, I think, a strongly marked tendency to restrict observation to the better nights, and to let the very bad ones, however clear the sky, pass unused. If, as a practical matter, fine seeing can be promised the astronomer one or two days, or even a few hours ahead of time, it would be of the greatest assistance in enabling him to plan his work accordingly.

But for the present solution of the problem we need, first, a considerable series of concerted observations of the conditions of vision, night after night, at ten or twelve observatories. From these, all local and immediate causes of bad vision must be carefully eliminated. It may be expected, then, that the collation of these observations with the appropriate meteorological data, will suggest to those expert in such matters, the proper connection between the two. At the very least, it can be ascertained whether the upper or the lower atmosphere affects the seeing more. We naturally expect the latter to exercise the more powerful influence; and if it really does, the correct solution of the question is all the nearer at hand. But there are times within the range of experience of every observer when all ordinary indications of fine seeing are delusory, and the trouble appears to be in the upper atmosphere. Precise knowledge on these points would well repay the labor of deriving it; and there is no country where the research can be so advantageously prosecuted as in our own. Captive balloon-data would be of the utmost importance.

* Lawrence Observatory, Amherst, Mass.

At Amherst, near the center of Massachusetts, I conceive that the meteorological conditions for observational work are fully up to the average of the Eastern States. But I have found very few nights in which a power of 600 would give satisfactory results with my objective, a Clark glass of fine figure, and 7¼ inches aperture. Still more rarely are the conditions of exceptional vision permanent throughout the night. In general, the winter seeing is the worst; but I have had occasionally a fine night in the coldest weather. All told, the Spring and Autumn months are the best.

In something more than four years, I remember to have had only two nights on which the atmosphere was beyond criticism, both as to transparency and steadiness—nights when the telescope could be worked up to the full limit of its defining and illuminating power. One of these was the 6th of November, 1883, and the other the 9th of February, 1886. On neither of these, however, were these perfect conditions permanent throughout the entire night, the former suddenly turning into a pouring rain, while at 13*h*.5 on the latter, the seeing had become only ordinarily good, and was rapidly getting worse. Another night, the 7th of March, 1886, started in very well, but clouds came up soon after twilight had gone, and a good part of the night was thus lost. To begin the line of possible research, to which I have alluded, it might be well if others would examine their records of these nights, as some little light might thus be shed on the question whether fine seeing is only local or general.

AMHERST, MASS., March 16, 1886.

PROPOSED MAPS FOR TRACING METEOR PATHS.

T. W. BACKHOUSE.

I have long thought that the existing star-charts are inadequate for meteor observers.

The British Association maps prepared for them, though very useful, seem not sufficiently accurate for present requirements. Many observers make their own maps by inserting in skeleton charts, drawn on a preferred projection, just such stars as they need. This appears an unnecessary individual expenditure of labor, as if suitable maps were prepared they would do for all engaged in shooting-star investigations.

I therefore propose to get some printed, and shall be glad to receive suggestions from meteor observers who have any to make on the subject.

The following points sketch my present plan; about those to which ? is added I feel more doubtful than as to the others:—

There should be fourteen maps, engraved with the utmost attainable accuracy, on the gnomonic projection, with cetres at

R. A. 0°	D. ±90°
45, 135, 225, 315	±45
R. A. 0°, 90, 180, 270	D. 0°

Diameter 140°. Square; length of edge 24? inches. The maps will thus overlap each other a great deal, one advantage of which would be the facility of transference of a meteor-path from one map to another.

R. A. and D. circles to be finely drawn (in same coloured ink, and at same printing as the stars) for every degree of D., and for every degree of R. A. except near the poles. The R. A. and D. to be given in degrees marked at each interval of five; and the hours of R. A. to be marked also?

The sky to be represented as seen with the naked eye, but without the Milky Way. Stars and cumuli to be inserted to 6.5? magnitude; and fainter stars also, separately, when they are cumulatively as bright, like as in the 'Uranometria Argentina' maps. To attempt completeness in this respect, all the stars to the adopted limit of magnitude in the catalogues of the 'Uranometria Argentina,' of the 'Harvard Photometry,' and of HEIS will be taken; and other catalogues consulted for supplying omissions, with the chief object of ascertaining the individual stars of which the double and multiple stars in HEIS are composed, as he does not give them: about such catalogues information would be very useful and is solicited.

The positions of the stars to be taken from the various Greenwich (especially the Nine-Year for 1872) RADCLIFFE and Cape Catalogues; for the epoch 1900? An accompanying catalogue of the stars mapped to be printed, like those of ARGELANDER and of HEIS?

The name to appear in each constellation, and be frequently repeated—abbreviated (or by symbol for the zodiacal constellations?)—near its borders, to facilitate recognition of outlying stars [without it being necessary to show by lines the boundaries of constellations*]. The usual constellations to be adopted; not BODE's.

Every star to have a designation, and one only; to be taken in order, thus:—1. Greek letters; 2. In some cases, Roman capital letters, as in *Camelopardus* and for variable stars; 3. FLAMSTEED's Nos.; 4. Roman small letters; 5. B. A. C. Nos.?; 6. Nos. from the 'Uranometria Argentina' to be distinguished by G (for GOULD)?; 7. Nos. from 'Harvard Photometry' (H. P.)?; 8. LALANDE's (Ll.) Nos. ?; 9..... ? [Nos. from HEIS ?; 10..... ?. But in some cases where a pair of stars has one name, it may be needful to give not only this name, but the designations of both stars. Where more than one star has the same Greek letter, as o^1, o^2 *Orionis*, it would probably be advisable to follow the order of R. A. in the numbering. But on the whole question of nomenclature it will be matter for consideration whether to adopt GOULD's rules or those of some one other standard authority.*]

Many observers give the position or direction of meteors observed in degrees of R. A. and D.; while others make reference to stars. The latter method seems to be simpler and more exact; but it is unsatisfactory on turning to a map to find that

* Added by E. F. SAWYER, Cambridgeport, Mass., in answer to personal request by the author for his views.

stars conspicuous in the heavens are wholly omitted, or marked in without a name of any kind, The above suggestions are made with a view to supply such deficiencies.

Magnitudes to be represented by black circles of various sizes: perhaps with a white centre to the brighter stars ?, shaped differently, as in PROCTOR'S 'New Star Atlas;' care being taken that the white and black have one center. [The authorities for magnitudes being the 'Uranometria Argentina,' 'Harvard Photometry,' and the Uranometria Nova Oxoniensis,' all the magnitudes to be reduced to one standard.*] Stars that vary considerably to be depicted of the minimum magnitude, with surrounding circle of maximum.

All designations of stars to be in ink of some other color than that for the stars themselves—say blue?

Precession to be shown in various parts of the maps, in some such way as in PROCTOR; exhibiting apparent motion of stars in one hundred years relatively to lines of R. A. and D. Perhaps this would involve giving lines of latitude and longitude also.

The position of the horizon, say of Greenwich, at midnight, for fortnightly intervals, to be shown by a line, on both edges of each northern and equatorial map; with an accompanying list of hours at which the horizon has the same position on other dates.

A copy of each of the three patterns of lines of R. A. and D. used in the fourteen maps to be printed on tracing-paper, and supplied with each set of maps. Means should be afforded of measuring 1° in every direction at any part of a map.

The sets of maps not to be bound, but each map be separately removable from a cover.—*In February Observatory.*

BIELA'S COMET.—The story of BIELA'S comet, as told by Prof. H. A. NEWTON, in a lecture delivered before the Shffield School, Yale College, is being reprinted in *Nature.*

---

* See foot note, p. 116.

ELEMENTS OF THE ORBIT OF COMET BARNARD 1886.

J. MORRISON PH. D., F. R. A. S.*

These elements are founded on the observations made at Munich on December 12, 1885, January 21, 1886, and at Washington on March 1, 1886, which are as follows:—

Munich M. T.	R. A.	Dec.	Comp. Star.
d h m s	h m s	° ′ ″	
Dec. 12 11 52 55	4 0 14.77	+5 33 36.2	ν *Tauri* Ber. Jahr.
Jan. 21 7 6 27	2 31 29.01	+11 59 59.1	31 *Arietis* 9 Yr.Cat.
Washington M. T.			
Mar. 1 7 39 48.1	1 56 28.44	+21 11 40.9	W (2) 1*h*; 1210.
"	1 56 28.39	+21 11 40.7	W (2) 1*h*; 1217.

The first and seeond were taken from the *Astronomische Nachrichten* No. 2709 and the mean of the Washington observations was used as the third, all of which were corrected for aberration and parallax by means of approximate parobolic elements previously computed.

As the observations have conducted to hyperbolic elements which will require further confirmation, we give here the principal results obtained during the computation in order to show the degree of accuracy to which it has been carried.

From the approximate parabolic elements the first values of P and Q are derived as below. The notation employed is the same as that of WATSON's Theoretical Astronomy.

	I	II
log. P	0.0097530	0.0097462
log. Q	9.7170577	9.7170622
ζ	26° 19′ 25.″943	26° 19′ 25.″528
log. m_0	9.8916592	9.8916612
z'	28° 41′ 54.″63	28° 41′ 54.″094
log. r'	0.3078051	0.3078071
log. ρ'	0.2171495	0.2171524
log. ρ	0.2106958	0.2106942
log. ρ''	0.2389634	0.2389680

* Assistant on the American Ephemeris and Professor of Chemistry, National University, Washington, D.C.

l	67° 23′ 3.″833	67° 23′ 3.″90
l'	68 5 38. 165	68 5 37. 643
l''	69 22 32. 234	69 22 30. 663
b	−9 27 42. 069	−9 27 42. 024
b'	−2 14 44. 702	−2 14 44. 717
b''	+10 48 44. 672	+10 48 44. 663
log. r	0.4147679	0.4147669
log. r''	0.1500719	0.1500766
☊	68° 18′ 44.″184	68° 18′ 43.″486
i	84 27 0. 123	84 27 4. 648
$\frac{1}{2}(u''-u')$	6 33 36. 5115	6 33 36. 552
$\frac{1}{2}(u'-u)$	3 37 30. 5920	3 37 30. 4535
$\frac{1}{2}(u''-u)$	10 11 7. 1035	10 11 7. 0055
log. s^2	0.1133348	0.0133345
log. s''^2	0.0055391	0.0055391
log. P_1	0.0097462	0.0097461
log. Q_1	9.7170622	9.7170626
log. X	−0.0000068	−0.0000001
Y	+0.0000045	+0.0000004

The three values of log. p (the semi-parameter) are 9.9818784, 9.9818782 and 9.9818784, which prove the accuracy of the entire computation up to this point. On completing the computation from the extreme values of r and u, as thus obtained the following hyperbolic elements are found:

T = 1886 May 3.06939 Washington M. T.
ω = 119° 34′ 50.″649 }
☊ = 68 18 43. 486 } Mean Equinox 1886.0
i = 84 27 4. 648 }
e = 1.00067106
log. a = 2.8539414
log. q = 9.6807028

The three values of T come out thus, Dec. 154.06939*d*, Dec. 154.06940*d* and Dec. 154.06940*d*, and therefore the residuals for the middle place are zero.

JUPITER.—The great red spot on *Jupiter* presents the same outlines as in former years. January 25, when the seeing was exceptionally good, it showed a patch of white over the middle, giving a ring form to the spot, the same as seen during the last opposition, only not so conspicuous. The ephemeris based on the observations of the two previous oppositions represents very closely the position of the spot on the disk. G. W. H.

EDITORIAL NOTES.

GALLE'S Catalogue of Comets from 1860 to 1884, as translated by W. C. WINLOCK, from the German, in *Astronomische Nachrichten*, (Nos. 2665 2666) will be sent to any address on receipt of fifty cents.

THE NAVAL OBSERVATORY.—The Secretary of the Navy, some months ago, asked the advice of the National Academy of Sciences, on the following points:—

1. As to the expediency of making the change in the time of beginning the astronomical day, recommended by the International Meridian Conference of 1884.

2. As to the advisability of asking Congress to make an appriation for the observation of the total eclipse of the *Sun* to occur in August, 1886.

3. As to the advisability of proceeding promptly with the erection of a new Naval Observatory upon the site purchased in 1880.

The Academy through its appropriate committee has recently made a report giving its advice in clear and decisive language.

On the first point, the committee recommends that a change in the beginning of the astronomical day be made, as soon as sufficient concert of action can be secured among leading astronomers and astronomical establishments of the civilized world, in 1890 if practicable; if not, in 1900.

2. The committee decline to recommend the application for an appropriation to aid in observing the solar eclipse of August, 1886.

3. On the third point, after a very full consideration, the committee unaminously reported as follows:—

(1) It is advisable to proceed promptly with the erection of a new Observatory upon the site purchased in 1880 for this purpose.

(2) It is advisable that the Observatory so erected shall be, and shall be styled, as the present Observatory was styled origi-

nally, the "National Observatory of the United States," and that it shall be under civilian administration.

(3) It is advisable that the instruments in the present Observatory, with the exception of the 26-inch telescope, the transit circle, and the prime vertical transit, shall be transferred to the observatory at Annapolis, with such members of the astronomical staff as may be required to operate them; also that such books of the library as relate chiefly to Navigation shall take the same destination; the instruments above particularly specified, with the remainder of the library, being reserved as part of the equipment of the new National Observatory, to which also the remaining officers of the astronomical staff shall be assigned for duty.

(4) It is advisable that the Observatory at Annapolis should be enlarged, if necessary, and adapted to subserve as effectually as possible the wants of the naval service, whether practical, scientific, or educational; that it shall be under the direction of the Department of the Navy, and shall be styled the Naval Observatory of the United States.

After reading the entire report of the committee and the various letters and papers appended thereto, any candid person will say that the action of the committee was right, needful and wise, and, it is to be hoped that Congress will soon take notice of these matters and put them on a just basis.

CHRONOGRAPH PENS.—In the December number of this journal, Prof. E. S. HOLDEN has a note on chronograph pens, and recommends one which requires filling every twenty minutes.

I think the necessity for so frequent attention is a fatal defect. At the Dearborn Observatory, both the Meridian Circle and the Equatorial, are so far away from the chronograph that it is necessary to use a pen which does not require frequent refilling, and also one that is absolutely certain to write without clogging. I soon found that the ordinary glass pen required close watching. I made a great many experiments, and tried numerous devices to secure a pen which was certain to write with any ordinary ink, and finally adopted a right line drawing pen. It is constructed on the same plan as a drawing pen, but without an adjusting screw, which is not necessary. I have had one of these pens in use for a couple of years, during which period it has never clogged. The blades are seven-eights of an inch in length and one-quarter inch wide at the top. This pen will record on the chronograph sheet for forty-five minutes without re-filling. It may be filled by plunging in the ink bottle. If kept clean when not in use I presume it would last for a number or years.

Previous to the construction of the pen described, I used a right line pen, with a small brass cup soldered on one of the blades, in which was coiled a spiral of very thin copper. A small hole was drilled in the side, so that there was communication between the cup and the pen. The cup was one-half inch in diameter and three-eights inches deep. It would hold ink enough to record for a number of hours without re-filling. The spiral of copper kept the ink from running outlby capillary attraction.

One may get a heavy or fine line, simply by making the point of the pen sharp or blunt. This kind of a pen will record on the chronograph sheet—riding on the side on one blade, or used in the ordinary way. I presume a right-line pen, with index and longer blades than the one described, might be made to hold ink enough for two hours' recording.

G. W. HOUGH.

ELEMENTS OF COMETS FABRY AND BARNARD.– The computation of Comet Fabry seems to indicate that that body is identical with Comet 1790 III. The plane of this comet's orbit and also that of BARNARD'S comet are nearly perpendicular to the plane of the ecliptic, and also to the line of sight from the *Earth*. They are thus favorably situated for the determination of the position in its own plane, or, in other words, of the elements π — ☊, the perihelion distance and the time of perihelion passage; but very unfavorably situated for the determination of the inclination and also of the node. We shall have to wait until the *Earth* approaches nearer to the plane of the orbits before a very accurate determination of these elements can be made. It would not be surprising if Comet Barnard should prove to be identical with Comet 1785 II, and Comet Fabry with Comet 1790 III. Should this be the case, they will probably be seen in the north-western sky, early in May, with tails six or eight degrees in length. The identity is by no means established, but there is a strong probability in favor of it. S. J. CORRIGAN.

WASHINGTON, March 9, 1886.

SATURN AND μ GEMINORUM.—I was quite disappointed in not being able to observe the close conjunction of *Saturn*, with star μ *Geminorum* on January 9 last.

The following observations were made:

1886 Jannary 9*d* 9*h* 15*m* (75°) M. T. Clouds had cleared away sufficiently to see *Saturn* and stars in its vicinity. With naked eye could not separate star from planet. Neither could I with opera-glass, although stars of the magnitude of μ were plainly seen with naked eye.

10*h* 30*m*. With a fairly good telescopic observation μ *Geminorum* — by eye estimate — appeared distant about the major-axis of ring from conjunction with preceding edge of ring. Star appeared reddish. Clouds prevented observation at time of conjunction. A. C. P.

A LIST OF THE WARNER PRIZES.—Agreeably to your request, I send a correct list of the WARNER astronomical prize awards with the names of the recipients, as follows:

Oct. 10, 1880	SWIFT	$500	A periodic; Special.
May 1, 1881	SWIFT	200	
July 13, "	SCHAEBERLE	200	
Sept. 17, "	BARNARD	200	
Nov. 16, "	SWIFT	200	
Sept. 13, 1882	BARNARD	200	
Feb. 23, 1883	BROOKS	250	Special.
Sept. 1, "	BROOKS	200=Comet 1812.	
July 16, 1884	BARNARD	200	
July 7, 1885	BARNARD	200	
Aug. 31, "	BROOKS	200	
Dec. 2, "	BARNARD	200	
" 26, "	BROOKS	200	
		$2950	$2950

Comet Essay, Boss				200
Red Sunset	1st Prize,		K. J. Keissling, Hamburg	200
" "	2nd	"	James E. Clark, York, England	150
" "	3rd	"	Rev. S. E. Bishop, Honolulu	50
" "	3rd	"	Mr. H. C. Maine, Rochester, N. Y.	50
Remuneration to Judges				150
			Total	$3750

Several essayists will receive medals of honor. The judges were Prof. Daniel Kirkwood, of Bloomington, Indiana. Prof. M. W. Harrington, Ann Arbor, Michigan. Prof. Ormond Stone, University of Virginia, Virginia.

There was a tie between Bishop and Maine, and rather than trouble the judges again Mr. Warner gives each the offered special prize.

It is probably well known that Mr. Warner only offered one prize of $200 for the best paper, but among the thirty-five received, so many were almost equally interesting and instructive and on which so much thought and labor had been bestowed by their authors, he informed the judges that he would give $100 (which he afterwards increased to $150) for the second, and $50 for the third best paper.

Nearly all the authors take the ground that the phenomenon is caused by some kind of foreign matter in the upper atmosphere, but they are not agreed as to the source from whence it came. As Prof. Kirkwood in a private letter remarks "after all, the rapid motion of the Krakatoa dust westward is still unexplained."

The Warner Comet Prize is continued from March 1 1886 to March 1 1887. It is reduced to $100, but is open to the world.

LEWIS SWIFT.

Warner Observatory, March 13, 1886.

Comets Fabry and Barnard.—As these interesting comets grow brighter, amateurs who have small telescopes or opera-glasses, may do real service in their study, by making sketches of them, at every opportunity, exercising care to plot all stars in, or very near, the tail of each one as accurately as possibly. Local time to nearest five minutes is also desired, by which astronomers may identify the stars and make the sketches useful in increasing the number of observations for detailed study of the theory of cometary tails. Assistant H. C. WILSON, of the Cincinnati Observatory, will give attention to this subject as related to these comets, and any such observations sent him will contribute to a worthy purpose.

DOUBLE STAR A. C. 5 (8 SEXTANTIS).—This star is worthy of some attention by observers just now. It was discovered in 1852 by ALVAN CLARK and was first measured by DAWES in 1854. The position angle was then 50° and the distance about 0.″5. Since then the distance has decreased and the observed position angles do not agree at all well. In 1881 BURNHAM could detect no elongation. On the nights of March 4 and 6, 1886, I observed the star with the 11-inch equatorial. The elongation was very plain, but I could not separate or even notch the stars with power 450. The mean of the two nights measures gives about 130° for the position angle. The star is probably a rapid binary. Its position is 9*h* 47*m* −7° 32′; magnitude 6.0 and 6.5.

H. C. WILSON.

DARK TRANSIT OF JUPITER'S SATELLITE III.—Observers have frequently recorded the fact that *Jupiter's* fourth satellite appeared dark while in transit across the disk of the planet, but I do not recall an instance where this phenomenon has been noted with regard to satellite III. On the night of March 6, 1886 at 12*h* 40*m*, Mt. Lookout mean time, I noticed that the third satellite in transit appeared quite dark. It was then traversing one of the dusky circumpolar belts on the northern hemisphere of the planet and appeared much darker than the belt. The shadow of the same satellite was near the following side of the disk traversing the white belt immediately south of the one just mentioned, and was of inky blackness. The shadow of satellite II was just entering upon transit.

H. C. WILSON.

ASTRONOMICAL WORK FOR AMATEURS IN PREPARATION.—From a recent private letter, we were much interested to learn that Mr. WESTWOOD OLIVER has in preparation a practical manual of "Astronomical Work for Amateurs." He has for his assistance prominent Fellows of the Royal Astronomical Society, whose names are favorably known in America, such as the following: E. W. MAUNDER, W. F. DENNING, T. E. ESPIN, A. C. RANYARD, T. S. ELGER, J. E. GORE, J. R. CAPRON, HOWARD GRUBB, W. S. FRANKS, T. W. BACKHOUSE and others. The aim of this work will be to help the persons of limited instrumental means, to turn their attention to astronomical researches of real scientific utility, special attention being directed to the comparatively new fields of spectroscopy and celestial photography. The book will be published by Messrs. LONGMANS & Co. Mr. OLIVER invites suggestions from practical workers, which may be sent to him at Lochwinnoch, Scotland.

THE RED SUNSETS.—The sun-glows have greatly diminished during the last six months, and a short summary of very full records kept during that time presents some interesting items not heretofore published.

The tabular statement below exhibits the number of observations of red sunrise or sunset, and midday halo for six months, using only such as were made on days when the atmosphere was unquestionably clear, carefully excluding such "white-sky" days as former experience has demonstrated to be capable of hiding from sight, any amount of glow.

Up to last August, the richer glow had been invariably accompanied by cooler weather, but with the last of August, the reverse began sometimes to be noticed. On several of the latter occasions the color extended beyond its usual limits.

A rich midday halo has sometimes followed a morning devoid of color, and a rich sunset has closed a day which gave no halo.

Some of these variations can be readily accounted for by atmospheric changes, but scarcely so the thirteen days in the table when there was no color.

On these days special note was made that the sky was decidedly blue and clear. Nine were for halo and four for sunset.

	Falling Temp.	Rising Temp.
Midday Halo	19	6
Sunrise or Sunset	24	17
No Color	7	6

BALTIMORE, Feb. 16, 1886. J. R. H.

TUTTLE'S COMET.—On account of the few observations made on this comet, it may not be uninteresting to insert the observations made by Prof. STONE at this observatory. The comet was described as large, round and pretty bright, and although brighter at the center was without any well-defined nucleus. It was only seen for a very few minutes after rising on account of the approaching twilight. The observations were made with the 26-inch equatorial, power 108 and square bar micrometer.

1885	G. M. T.	App. R. A.	log. p △	App. Dec.	log. p △
Sept. 15	21h 50m 23s	9h 22m 58.s22	9.655n	−0° 48′ 59.″4	0.736
Sept. 16	21 40 51	9 26 8. 08	9.659n	−1 41 42. 0	0.738

COMET (a) 1885 (BARNARD)—was observed a number of times at this Observatory during the months of July and August, and once on September 3, cloudy weather preventing further observation. Although Mr. EGBERT's ephemeris terminated on the 2nd, a rough exterpolation gave the place for the 3rd, with all needed accuracy. With power 175 the comet was seen without any difficulty, although the night was poor, appearing certainly as bright as many nebulæ described in the General Catalogue as very faint. However when power 108, which contained the bar micrometer, was used the comet became so faint that it could not be seen at all when near the bars of the micrometer. F. P. LEAVENWORTH.

LEANDER MCCORMICK OBSERVATORY, March 11, 1886.

NEW INSTRUMENTS BY FAUTH & Co.—While in Washington recently, we visited the works of Messrs. FAUTH & Co., and as usual, found them busy finishing new instruments for orders waiting. That which first attracted our attention was their large new dividing engine. It is mounted on a solid stone pier, is constructed to divide the largest circles now in use, and is to be provided with a case for constant temperature when at work. Messrs. FAUTH assured us that the engine will divide accurately to nearly one second of arc, by automatic action, and with the automatic error correction attachment small errors are further considerably reduced. The engine cost over $7000.

Messrs. FAUTH & Co. have recently completed the following instruments:—

A large magnetic outfit for the Superintendent of the United States Navy Department. Largest ever made, cost $1600.

A meridian circle for Buchtel College, to be more fully described hereafter.

A complete astronomical outfit for the University of California, consisting of 6½-inch equatorial, astronomical transit, zenith instrument, chronograph, spectroscope, etc.

A large astronomical transit, chronograph and mean time clock for the High School of Oakland.

We were also interested in noticing the new form of equatorial mounting that Messrs. FAUTH are now contriving. Among other improvements the attachment of a small chronograph to the pier to be operated by the equatorial driving-clock is a new and useful idea, at least, for some observers.

Primary Phenomenal Astronomy for Teachers and General Readers. By F. H. BAILEY, Northville, Michigan, 1886. pp. 97, paper covers. Price 25 cents.

Mr. BAILEY is doubtless already known to most of our readers as the inventor of two very useful pieces of apparatus for the general illustration of phenomenal astronomy, the "Astral Lantern, or Panorama of the Heavens," and the "Cosmosphere, or Miniature Universe." Particular notice of these will be given at another time.

Of late Mr. BAILEY has given attention to the preparation of a small book to show how primary phenomenal astronomy ought to be taught and studied. His work is for teachers and those who depend on self-help in pursuing this delightful branch. The plan is to study the phenomena and the theory of astronomy as related parts of this great science—the phenomena first, then the theory, as a consequence following clear and definite generalization, from the abundance of fact within easy reach of the ordinary student. In this plan of instruction, MR. BAILEY is right unquestionably. His mode of studying the motions of the celestial sphere and the constellations is natural and systematic. Teachers in elementary astronomy will find this little book a help in presenting difficult points to young minds.

The Sidereal Messenger

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

VOL. 5. NO. 5. MAY, 1886. WHOLE NO. 45.

THE ORIGIN OF THE RED GLOWS.*

REV. SERENO BISHOP, HONOLULU, HAWAIIAN ISLANDS.

These brilliant phenomena first began to be observed on the 28th day of August, 1883. They have continued with varying but diminishing intensity for more than two years. They first appeared in great splendor along an equatorial belt of 18,000 miles or more. They gradually extended with reduced brilliancy to the Temperate zones, exciting the wonder of Europe and the United States in November, 1883.

The most conspicuous of these phenomena take place during one hour or more before sunrise and after sunset. They may be considered as a great intensifying and prolongation of common twilight sky reflections, in consequence of a recent introduction into the higher regions of the atmosphere of some kind of finely divided matter which powerfully reflects the *Sun's* rays, especially the red. The usual order of changes is as follows:

Clouds not obscuring the view, the horizon where the *Sun* has just set is occupied by a bright silvery luster. Above this, to a height of 30° or 40° a yellowish haze fills the western sky. Although seemingly opaque and dense, the presence in it of *Venus* or the crescent *Moon* shows it to be entirely transparent.

* The essay winning the third prize in the series of the Warner Red Light Prize Essays, the committee of award being Prof. Daniel Kirkwood, Bloomington, Indiana; Prof. M. W. Harrington, Ann Arbor, Michigan, and Prof. Ormond Stone, University of Virginia, Virginia.

This haze rapidly changes in color and extent, ranging through greenish yellow and olive to orange and deep scarlet. As the dusk advances, orange and olive tints flush out on all sides of the sky, especially in the east. The chief body of color gathers and deepens over the sunset, rapidly developing the red. In from twenty to thirty minutes after sunset, deep scarlet has overpowered all other hues, flaming along 60° of horizon, and 10° of altitude. This rapidly sinks and intensifies. There is a dark interval above the red. The stars begin to appear. While yet the color flames low, above the dark space appears a repetition of the orange and olive hues. Seen against the night-sky, these secondary reflections or after-glows are seemingly more brilliant than the primary ones. Again the colors change and deepen into red, and after the stars are all out, and the earlier flame has sunk below the horizon, and far later than any common twilight, a vast blood-red sheet covers the west. It has been seen rising as high as 20°. As it sinks and rests low on the horizon, in the dark night sky, it precisely simulates the appearance of a remote and immense conflagration, for which it has in many places been mistaken. I have known our usual thirty minutes of twilight to be prolonged to ninety, before the last glow disappeared.

In the dawn recur the same appearances, but in inverse order. In September, 1883, they were singularly impressive and even terrific, as the first low sullen incandescence rose and spread and glared among the stars, as if the very heavens were in conflagration. Then, as well as at nightfall, a marked division occurs between the night-glow and that nearest to the *Sun*. During the earlier weeks of the display, the dark interval was often extremely distinct. One observer (*a*) described it as a "black bow." Another saw the shadow of the remote horizon sharply projected upon the under surface of the haze-canopy, but with fine serrations, probably the shadows of platoons of cumuli (*b*). Evidently at that early date the canopy of floating haze had a well-defined under-surface.

a Nature, vol. 29, p. 549. *b* Nature, 29, 549.

From the beginning, the upper limit of the night-glow has always been indefinite, since its light was reflected to it from the broad surface of the first glow, while the latter showed a clean shadow of the horizon from the *Sun* itself. In general it may be said that the tropical displays of these glows at their birth during the first week in September, as far surpassed the mild Glows seen world wide in November, as the plunging surges of a tempest surpass the tripping crests of a breeze. The entire dome of sky, above and around, seemed to heave with billows of lurid light, as the portentous masses of color poured out of the pellucid blue, while the west outflamed in broad conflagrations.

In September, during the day, as well as after sunset, many portions of the haze-canopy were noticeable as having a wavy or rippled structure (*c*). A conspicuous object when the *Sun* is high has been from the first, the opalescent silvery glow around the *Sun*. This occupies a circle of 25° radius or more. The outer part develops a pinkish hue, which against the blue sky shows lilac or chocolate tints. These have a singular effect when seen through rifts of cloud, as Capt. PENHALLOW (*d*) saw them on September 18, 1,000 miles N. E. of Honolulu. This sun-glow has been particularly discussed by M. A. CORNU in the *Comptes Rendus*, of September 23, 1884. He remarks peculiar modifications therein of the atmospheric polarization of the *Sun's* rays. Prof. F. A. FOREL has repeatedly discussed this sun-glow, which he has named (*e*) the "Cerclede Bishop," after the first observer of the phenomenon at Honolulu. Prof. HUGGINS found this sun-glow putting an end to his previously successful photography of the solar corona.

The height of the main body of this haze in the atmosphere has been variously estimated at from fifteen to forty miles. The present writer, as the result of much and early observation, has no doubt that in the early part of September, 1883, no part of its under surface was less than thirty or forty miles above

c Nature, 29, 174. *d* Nature, 29, 174. *e* Archives des Sciences Physiques et Naturelles, tome 13, p. 465.

the ground. All estimates should be based upon the first reflections and not upon the secondary glows. No decisive tests of the nature of this reflecting matter have been secured. The spectroscope has distinctly indicated the presence of large quantities of aqueous vapor (*f*), accompanied by other peculiar influences. Fresh fallen rain and snow have repeatedly yielded a dust of microscopic particles possessing the same constitution as the fine ash-fall from Krakatoa.

The most generally accepted theory of the source of this new matter in the sky, attributes it to the great eruption of the crater of Krakatoa or Krakatao in the Straits of Sunda on the 27th of August, 1883, one day before the first definite record of red glows, which were seen on the 28th, at both Mauritius and the Seychelles, 3,500 miles west of Krakatoa. Before considering the evidences in support of this theory, notice needs to be taken of two other hypotheses, which have been advocated.

One of these assumes the meeting of our globe with some cosmic cloud of impalpable dust, which was arrested in the upper strata of the atmosphere.

The other hypothesis supposes the cosmic cloud to have been composed of hydrogen, which united with the oxygen of the atmosphere to form the aqueous vapor evidently constituting so considerable a part of this haze.

The latter hypothesis seems open to the objection that such uniting of the two gases is usually attended with active combustion, none of which was observed.

Both hypotheses suffer from the total absence of evidence that any such cosmic cloud did approach the earth on or before August 28, or since that time. The matter actually introduced into our atmosphere is brilliantly conspicuous in the sunlight. Yet we are asked to believe that a vast nebula of such matter approached unseen and enveloped the *Earth*. In 1861, the tail of an immense and brilliant comet actually swept the *Earth*. Yet so tenuous was the impinging matter that no traces of its

f C. Michie Smith, Nature, 29, p. 28.

presence were left behind. A cloud sufficiently dense to create the present haze, must, in its approach, have presented the aspect of a most compact and refulgent body. So far from being possibly unobserved, it must have terrified mankind.

Another and most serious objection lies in the original narrow localization of this haze in an equatorial belt. It is difficult to conceive of a cosmic cloud, possessing a mass adequate to the immense effects produced, which should not occupy such dimensions as to completely envelop the globe at once, producing glows simultaneously all over the *Earth*, not to consider the improbability that the course of such a dense little nebula after collision should precisely coincide with the Equator. It must be remembered that stray cometary or nebulous matter (not solid meteors) afloat in cosmic space, since it possesses small mass and feeble centripetal force, necessarily assumes immense volume and extreme attenuation, compared with which this haze is solidity itself. The entire quantity of this peculiar matter actually diffused in our atmosphere, must originally have been equivalent to many cubic miles of solid matter, which represents a volume of cometary material immensely exceeding the dimensions of the largest planet. The actual localization of the first glows in the Tropics thus precludes reference to cosmic sources, and compels us to seek a terrestial one.

Many have felt that the long protacted continuance of this haze in the air necessitates the supposition of renewed supplies from fresh sources, as if perhaps the *Earth* were continuing to traverse successive regions of cosmic vapors (which no one has seen). Had there been but one original introduction of the haze, must it not long since have been precipitated and disappeared? But we have to consider how slow is the subsidence of even coarse common dust, especially in currents of air. The haze matter in question has probably forty miles to fall. If only twenty miles, or 105,600 feet, it must fall one hundred and forty-four feet in a day to reach the ground in two years. It seems improbable that these ultra-microscopic particles could descend at one-tenth of such a velocity (*g*). It seems likely, on the contrary, that the finer particles of this matter will continue suspended and produce their glows for many years to come.

Leaving these nebulous imaginings, let us pursue the plain, if humble, historical method of inquiry. When and where were these phenomena first observed? Under what peculiar conditions and with what attendant circumstances did they appear? In what successions of time and place did they first occur, and to what actual point of origin on the *Earth's* surface may they be traced?

Pursuing this indispensable method of physical investigation, we find that the earlier appearances of the sunset glows, were as a rule immediately preceded by a peculiar veiling and discoloration of the *Sun's* disc, commonly termed the "Green Sun." While the sky was cloudless, or faintly obscured by undefinable haze, the disc of the *Sun* was described (*h*) as pallid, livid, bluish, coppery, greenish, "bird's-egg hue," "plague-stricken." It could be directly viewed with the naked eye, and its spot distinguished. At the altitude of 40° the *Sun* generally resumed its ordinary aspect, but again turned pallid and green as it descended in the west. In some cases the sunset glares immediately succeeded, while in others they were not reported, the haze probably having been too dense for the *Sun's* rays to penetrate it obliquely, so as to be reflected from its under surface. The first appearances of the red glows were so intimately associated with the green suns that it is impossible not to treat them as different aspects of one and the same phenomenon.

It seems in place here to cite Mr. WHYMPER's observation (*i*) of green sun and wonderful sky-glows combined. On the 3d of July, 1880, on the upper slopes of Chimborazo, Mr. WHYMPER witnessed an eruption of Cotapaxi, smoke from which drifted over the observer's position. Seen through it, the *Sun's*

g John Le Conte, Nature, 29, p. 404. *h* Nature, 28, pp. 576, 577 — Vol. 29, pp. 28, 6, 133, 181, 549. *i* Nature, 29, p. 199.

disc assumed a peculiar green, while the changing colors of the sky "surpassed in vivid intensity the wildest effects of the most gorgeous sunsets."

From such records as were accessible, I have constructed the accompanying tabulated statement of the earlier recorded appearances of the green suns and the red glows. The latitude and longitude of each locality are given in the table, with the date of the first appearance of the phenomenon at each point. The distance from Krakatoa is estimated in English miles, the number of hours in transit and the velocity of the current calculated. The source of information is specified for each of the seventeen different localities, three of which were on vessels at sea in the Pacific. To these, Maranham might be added. I lack the needed reference. At six of these localities, both the green sun and the red glows were reported as having been seen on the same day. At four points only red glows were reported, and at seven only green suns.

The most remarkable fact evidenced by this table is that the earliest appearances of these phenomena are thereby traced along a line of points, successive from east to west, lying very near the Equator, beginning at the Seychelles Islands in the Indian Ocean, and running thence, in successive days, through Cape Coast Castle, Trinidad, Panama, and Fanning's Island, arriving at Strong's Island on September 7, having traversed a great circle for 17,600 miles in about two hundred and thirty hours.

It thus appears that the original haze cloud, which first produced the red glows, swept west from the Indian Ocean in an equatorial stream or belt, which traversed more than two-thirds of the circumference of the globe at an average velocity of nearly eighty miles an hour. A precise estimate of its velocity between successive points is prevented by the imperfection of the observations made. The date at Cape Coast Castle is uncertain by one day. The dates at Seychelles and Mauritius are probably vitiated by the copious diffusion of volcanic smoke

LOCALITY.	LATITUDE.	LONG.	DATE.	DISTANCE.	HOURS.	VELOCITY.	GREEN SUN.	RED GLOW.	REFERENCE.
Krakatoa..........	6° 10' S.	105° 30' E.	August 27th A. M.						
Mauritius.........	20 20 S.	57 40 E.	" 28th, P. M.	3,600	30	120		R. S.	Nature, Vol. 30, p. 279
Seychelles.........	4 30 S.	55 20 E.	" 28th, P. M.	3,480	30	116	G. S	R. S.	" " 30, 280
Cape Coast Castle	5 25 N.	1 15 W.	Sept. 1st, A. M.	7,420	90	82	G. S.		" " 29, 133
Trinidad..........	10 30 N.	61 26 W.	" 2d, A. M.	11,600	127	91	G. S.	R. S.	" " 28, 577
Barinas, Ven......	7 44 N.	70 22 W.	" 2d, A. M.	12,220	128	96	G. S.		" " 29, 76
Panama...........	9 .. N.	79 35 W	" 2d, A. M.	12,860	128	100	G. S.		" " 29, 152
C. S. Hurlburt....	17 .. N.	125 .. W.	" 3d, P. M.	16,000	201	80		R. S.	" " 29, 549
Fanning's Island..	2 40 N.	159 .. W.	" 4th, P. M.	18,400	218	84	G. S.		" " 29, 549
Jennie Walker....	8 20 N.	155 25 W.	" 4th, P. M.	18,200	218	84	G. S.	R. S.	" " 29, 549
Zelandia..........	5 .. N.	163 .. W.	" 5th, A. M.	18,800	230	82	G. S.		" " 29, 181
Maalaea...........	20 49 N.	156 28 W.	" 5th, A. M.	18,300	229	80		R. S.	" " 29, 573
Honolulu.........	22 17 N.	157 52 W.	" 5th, P. M.	18,400	241	79	G. S.	R. S.	" " 29, 174
Strong's Island...	5 .. N.	162 .. E.	" 7th, (6) P.M.	21,100	256	83	G. S.		" " 30, 537
New Ireland.......	5 .. S.	152 .. E.	" 1st, P. M.	3,200	107	30		R. S.	" " 29, 259
Madras............	13 13 N.	80 12 E.	" 10th, A. M.	1,900	332	6	G. S.	R. S.	" " 29, 28
Ongole............	15 32 N.	80 8 E.	" 10th, P. M.	1,900	342	6	G. S.	R. S.	" " 28, 576
Soudan............	15 .. N.	32 .. E.	" 24th.	5,100	672	8	G. S.		" " 29, 181

prior to the regular movement of the upper stream. It seems quite clear, however, that an average velocity of about ninety miles an hour during the first half of the course of this haze-stream became reduced to about sixty miles in its later stages. These data appear to favor the conclusion of Mr. S. E. Bishop, (*j*) that a stream of vapors was discharged over and upon the upper surface of the atmosphere of the Indian Ocean, by a powerful *initial* impulse, which drove it straight in a great circle, independently of atmospheric currents, and that this stream gradually suffered retardation as it descended into the atmosphere, finally ceasing over the Caroline Islands.

Without necessarily accepting this writer's theory, showing how such an impulse would be generated by the rotation of the *Earth*, it seems clear at least, that the inception of the equatorial haze-stream, and its attendant glows has been traced with positive certainty as far as the western side of the Indian Ocean and back to the 28th day of August. Eastward of this, our search is arrested by a vast pall of volcanic smoke proceeding from the greatest eruption described in history. But if we stretch our line back through this obstructing veil, thirty hours in time and 3,500 miles in distance, we find ourselves confronted by the great final explosions of Krakatoa on the morning of August 27th. Projected aloft from this crater by a succession of colossal explosions, a vast dome or cone of volcanic smoke on that day covered a region of not less than four hundred miles in diameter with absolute darkness for many hours, and spread a deep gloom for not less than 1,000 miles in every direction. From the summit of this immense reservor of vapors piled to an unknown height, the great equatorial haze-stream, appears to have issued, and sped westward around the globe. We have unquestionably traced it to its source in the vapor-mass that overhung the Indian Ocean less poetic than a cosmic nebula, but possessing reality, and with it have found the one sole and indisputable origin of the red glows which attended its course.

j Hawaiian Monthly, April 1884.

This does not imply that the swift equatorial smoke-stream embodied the whole of the glow-producing medium. It seems more probable that the larger portion of the vapors which became slowly and irregularly diffused over the globe during the ensuing seventy days, were drifted from the broad vapor-mass after the special stream had ceased. Thus we find the Indian peninsula untouched by the narrow stream which must have passed south of the Equator. But fourteen days afterwards, the haze arrived in full force and produced the geeen suns and red glows throughout Ceylon and Southern India, shortly afterwards appearing in Aden and the Soudan. We also find the glows at New Ireland, 3,200 miles due east from Krakatoa, in four days after the last explosions. In all these cases the transportation was comparatively slow, and probably due to atmospheric currents.

We need to consider the adequacy of the eruption of Krakatoa to have produced atmospheric effects of such magnitude and extent, not only "*belting* the globe with flaming skies," as in September, but by November enveloping the entire sphere in these fiery glares. Can Krakatoa be shown to have probably ejected a *quantity* of tenuous matter sufficient for this result? And can it be believed to have delivered such matter at such a *height* that in its descent it would form a haze canopy from thirty to forty miles above the surface?

We have absolutely and precisely traced the glows to their source, and so have the right to affirm that Krakatoa proved its colossal capacity to emit these vapors in such quantity and to such a height, by having actually done so. It is the objector's part to prove that it could not have done so, and did not. But waiving this advantage, we cite a preliminary official report on the nature and effects of the eruption of Krakatoa, made by Mr. R. D. M. VERBEEK (*k*). He makes an estimate of the quantity of those solid ejecta of the crater, which were so coarse as to be speedily precipitated. This amounted to eigh-

k Nature, vol. 30, pp. 10-14.

teen cubic kilometers or four and a half cubic miles, two-thirds of which fell as ashes and pumice within a radius of nine miles. He believes that at least an equal mass was delivered at the highest part of the column in the form of vapors and impalpable dust. It would be easy to present considerations to show that this finer portion must have vastly exceeded the coarser. But this might be speculative. We know that four and a half cubic miles of solid matter would overlay the entire atmosphere of the globe with a solid film of one seven-hundredth of an inch in thickness. This would doubtless be equivalent to many miles in thickness of such tenuous vapor and dust as have been floating in the upper ether.

As to the height of the column of ejecta emitted from Krakatoa at its highest activity, some estimate may be formed from known facts. The heaviest throes were very precisely determined (*l*) to have occurred at 9:55 and 10:45 A. M. on August 27. The latter one was immediately followed by a continuous down pour of mud and ashes upon the ship Charles Bal, then thirty miles distant (*m*). Seventy miles away, trees were extensively shattered by the weight of wet ashes (*n*). Batavia, one hundred miles away, was covered three inches deep with white ashes during the hours of total darkness following the greatest eruption. It seems impossible to find room for these facts on any estimate of the height of the eruptive column, as less than one hundred miles. It is true that *light* ashes might have great lateral diffusion from a column of far less height, but mud and wet ashes must have plunged quite directly downwards, so that a lateral throw of thirty to seventy miles must involve a vertical ascent of not less than one hundred.

The height supposed would have driven the eruptive column entirely through the atmosphere, and far above it, so as to deliver its contents over the surface of the atmosphere, to settle slowly down through its upper strata.

That the great column did actually thus lift and rend asunder the mighty mass of the atmosphere above the crater is made

l Nature, 30, 12. *m* Nature, 29, 140. *n* Leisure Hour, July, 1885, page 487.

probable by the unique oscillations of the barometers. A series of atmospheric waves was sped three times around the globe at the rate of seven hundred miles an hour (*o*). The length of each undulation was one million meters, that of the lowest audible sound waves being twenty-four meters. Twenty miles away from the crater the mercury rapidly oscillated between the 28th and 30th inches. It is thus evident that in the vicinity of Krakatoa the upper layers of the atmosphere were swinging up and down through a vertical distance of from ten to twenty miles every fifteen minutes. What could have done this less than an explosion driving clear through its entire depth?

As general evidences of the ultra-colossal character of the Krakatoa explosion may be adduced the following: 1. The waves driven upon the coasts of Anjer and Merak, thirty miles away, were found to have exceeded thirty-five meters or one hundred and twelve feet in height (*p*). Over the entire Anjer plain, fifteen miles by five, the inundation had uprooted every tree, and coral blocks of from twenty to fifty tons in weight had beeh torn from the bed of the sea and borne inland two or three miles (*q*).

2. The detonations of the eruption were heard throughout a circle whose radius is 1,800 geographical miles (*r*) equal to one-fifteenth of the surface of the *Earth*. Yet the heaviest could not be heard within a radius of forty miles from the crater. The sounds must have proceeded from tremendous rendings of the air at an immense height, whence the sounds were easily spread to vast distances, while from localities beneath, the massive torrents of descending ejecta cut off the sounds like a wall.

3. Ashes fell (*s*) at Singapore, 335 miles; at Buncalis, 915 N. W.; at Keeling, 1,200 miles S. W.; on the Australian coast, 1,050 miles E. S. E.; on the Arabella, 970 miles W. N. west. The entire area of ash-fall was officially estimated as at least

o Nature, 29, p. 181. *p* Nature, 30, 14—Leisure Hour, Sept. 1885, p. 636. *q* Leisure Hour, August, 1885, p. 556. *r* Nature, 30, 10. *s* Nature 40, 13.

750,000 kilometers (*t*), or as large as the Southern States east of the Mississippi.

The history of the eruption shows that upon the collapse of the mountain, on the morning of the 27th, the eruptions became submarine (*u*); the ocean waters rushed into the burning depths. Under the pressure of many miles of water the lava and the waters commigled and struggled with geyser-like discharges of augmenting violence, until finally there arose a continuous column of white-hot water and lava. Through the wide throat, apparently three miles in diameter, the vast column drove upwards, expanding and exploding as it flew into steam and pumice, till reaching one hundred miles or more in height, its mingled solids and liquids had exploded in the vacuum into thinnest ether.

The ashy ejecta, as analyzed, were mainly of glass in the form of pumice, together with the solid constituents of sea-water (*v*). This vitreous matter, being comminated by the force of the explosions to dust of ultra-microscopic fineness, formed together with the vaporized sea-water, a vast bulk of extreme tenuity and lightness above the atmosphere. Falling thence upon the upper strata of the atmosphere, and precipitating its coarser dust, its finer portions have continued suspended for more than two years in their ethereal encampment, and there are likely to abide for many years to come.

From the beginning the white sun-glow has been very uniform, while the night-glows have been quite irregular, although it is believed they have always been perceptible. In the northern tropics there has been a marked increase of brilliancy and continuity during each of the two winters. Probably the haze is distributed through the atmosphere in unequal and irregular drifts.

John Aitken's demonstrations of the necessity of dust nuclei to the formation of ice spicules in the atmosphere (*w*) indicate that such ice-particles probably play a prominent part in the glows. Not improbably they would be in larger quantity

t Nature 40, p. 13. *u* Nature 30, p. 12. *v* Nature, 30, p. 13. *w* Nature, 29, p. 463.

in the Tropics during the winter, and so the glows increase at that season. Varying atmospheric conditions would also at all seasons vary the amount of congelation.

In conclusion the writer takes the opportunity to venture the surmise that a thorough study of the Krakatoa smoke-belt of September, 1883, and of its dynamic conditions, may furnish material aid in elucidating the still mysterious problem of the Belts of the planet *Jupiter*.

THE COMETS FABRY AND BARNARD.

WM. W. PAYNE.

It is a noticeable incident in the history of comets that two should happen to be in the same part of the heavens, and appear somewhat alike, as was true of comets Fabry and Barnard last month, especially since observers then knew that these comets could not possibly belong to the same cometary family. During the months of April and May these visitors are at their best, and hence a brief review of their study to the present time may be both timely and profitable.

Comet Fabry was discovered in Paris by M. Fabry on Dec. 1, 1885, and was immediately announced by telegraph as a faint object. On the evening of Dec. 2 it was seen by E. E. Barnard, Nashville, Tennessee, who speaks of it as moderately bright. He saw a small star shining through it when the telescope was first turned upon it, but this was soon left behind by the rapid motion of the comet.

The elements of the orbit of this comet were computed by Chandler and Wendell, H. Oppenheim, S. Oppenheim, Weiss, Schulhof and others. Those computed by H. Oppenheim are as follows:

$$T = 1886 \text{ April } 5.5398, \text{ Berlin M. T.}$$

$$\left.\begin{array}{rl} \omega = & 126^\circ\ 50'\ 27.''6 \\ \Omega = & 36\ \ 19\ \ 54.\ 0 \\ i = & 82\ \ 11\ \ 15.\ 0 \end{array}\right\} 1886.0$$

$$\log. q = 9.804021.$$

Mr. S. J. Corrigan, Nautical Office, Washington, calls attention to some points of special interest pertaining to this comet, viz: that its orbit resembles that of Comet 1790, III, that the plane of its orbit is so nearly perpendicular to the plane of the ecliptic, and the line of sight from the *Earth* that the determination of some elements of its orbit would be favorably certain, but that those of inclination and nodes would be less exact.

In estimating the light of the comet that of Dec. 1 is regarded as unity, and if the computers are right, at nearest approach, during the last of April and the first of May the comet will be a brilliant object, more than four hundred times as bright as it appeared at the time of discovery. It will then be circumpolar and hence the light of the *Moon* will be less troublesome.

During the month of April it has moved from between the small stars 12 and 14 of *Andromeda* to θ and ρ in a path curved slightly to the north; on the 22nd it was a little to the south and west of β *Andromedæ*, thence it crossed the corner of *Pisces* and the *Triangle*, and on the 26th it will be northeast of α *Arietis*, the 27th southeast of ν; the 28th south by west of δ, and on the last day of April to the south and west of λ *Tauri*. For the month of May its course will be still to the south and east; on the third, it passes a little east of *Rigel* of *Orion*; on the 6th southeast of *Sirius;* on the 10th it passes very near ϵ *Canis Majoris*, a second magnitude star, and so on, somewhat rapidly in south declination and beyond the reach of northern observers. Its most noticeable features will be its great changes in brightness between April 20 and May 5, and its rapid motion among the stars. On account of this last named fact it will afford a neat exercise for the amateur computer and observer to take naked eye observations of the comet about the time above mentioned, and attempt therefrom to compute the parabolic elements of its orbit.

The second comet was discovered by E. E. BARNARD, Nashville, Tennessee, Dec. 3, 1885. When first seen, it was exceedingly faint, with a small star-like nucleus in the preceding part of the nebulosity. Its motion then was nearly west, and on the same night, it was seen to pass almost centrally over a small star, which shone through the nebulosity without probably any diminution of luster. Its position was near the western boundary of the constellation of *Orion*, and nearly five degrees north declination.

The elements of the orbit of this comet were computed by CHANDLER and WENDELL, HEPPERGER, KRUEGER, H. OPPENHEIM and others. Those by Dr. HEPPERGER are given below:

$$T = 1886 \text{ May } 3.3179 \text{ Berlin M. T.}$$

$$\left.\begin{array}{rl} \omega = & 119^\circ\ 37'\ 41.''1 \\ \Omega = & 68\ \ \ 19\ \ \ 34.\ 9 \\ i = & 84\ \ \ 23\ \ \ 49.\ 9 \end{array}\right\} 1886.0$$

$$\log. q = 9.680413$$

Dr. HEPPERGER also computed from observations made Dec. 5, 10 and 15, elliptical elements for this comet, giving for the logarithms of a and e, respectively, 1.336444 and 9.990626, the remaining elements coming out substantially as those above given. The light of BARNARD's comet, Dec. 5 is taken as unity. It will increase rapidly during the month of April and May 15, it will be brightest, appearing two hundred and sixty-five times as brilliant as it was on the second day after discovery.

During the month of April this comet has made a comparatively short path, moving pretty nearly northwest from α of the *Triangle* into the constellation of *Andromeda*, and on the 30th of April it will be between the stars γ and τ by Dr. OPPENHEIM's ephemeris, which thus far follows the path closely. About this time the comet will change its course from north to south, and on the 10th of May it will be north and west of β in the *Triangle* and its motion thereafter will be rapid to the southeast.

The same may be said regarding the uncertainty of the elements of the orbit of comet Barnard as was said of Fabry and for the same reasons. E. WEISS in the *Astronomische Nachrichten* has claimed that these two comets will be conspicuous objects at the same time, and that about May 1 they will be quite near each other. It is also said that Comet Fabry passes its line of nodes May 8, which line the *Earth* passes April 27, and that the comet crosses the ecliptic April 25. It is therefore *possible* that the comet may be projected on the *Sun's* disc April

26 or 27. For reasons already given respecting the uncertainty of the position of the line of nodes there is only the merest *possibility* of such a transit, nor is it probable that persons in considerable north latitude will be favored in seeing these comets at their best because of unfavorable altitudes except in early morning hours during a few days.

The Comet Fabry was visible to the naked eye certainly as early as April 8. Mr. BARNARD, of Nashville, saw it on that day. He reports that "it presented a beautiful sight in the telescope, the head and tail being clearly defined. The nucleus was bright and star-like and slightly yellowish. The tail was long, narrow and very gradually brighter along the axis.

THE PRINCIPAL COMET METEOR STREAMS.

S. J. CORRIGAN, NAUTICAL OFFICE, WASHINGTON.

For The Messenger.

A computation of the elements of the orbits of four prominent meteoric comet streams, viz: the *Lyrids*, *Perseids, Leonids* and *Andromedes*, observations of which were given by Mr. DENNING in the April MESSENGER, discloses the following facts relative thereto. The elements have been derived from the *true* radiants according to the method given by me in the April number, and were also computed from the *apparent* radiants by the method published in the February MESSENGER. The eccentricity of each meteoric orbit was assumed to be the same as that of the associated comet, and the proper modifications were therefore introduced in the computation, but, since the eccentricities are nearly unity, these modifications do not cause the elements to differ materially from what they would be if the orbit were exactly a parabola. The greatest difference is in the case of the *Andromedes* or BIELA meteors, the eccentricity of BIELA's comet being considerably less than unity. I have also computed the position of the *apparent* comet radiants from the elliptic elements of the cometary orbits, and they agree very closely with the positions of the meteoric radiants observed by Mr. DENNING on the dates of maximum.

In the following tabulation the dates of observation and the *apparent* positions, in right ascension and declination, of the radiants of the meteors and also of their associated comets, as observed, are given first. Then follow the *true* positions of the radiants as obtained by computation and then the elements and the velocities of the meteors and comets relative to the *Earth*. All are referred to the mean equinox of 1885.0

Lyrids.	April 18	April 19	April 20	Comet(1)1861.
	R. A. Dec.	R. A. Dec.	R. A. Dec.	R. A. Dec.
Pos. of app. radiant	260°.0+33°.5	267.°0+33.°0	274.°0+33.°5	270.°9+33°.5
" " true "	210 .5+55 .7	222. 9+58. 1	233. 3+61. 0	227. 6+59 .8
Long. of perihelion	255 42	248 54	240 34	243 42
" " node	29 05	30 04	31 03	30 16
Inclination	71 21	77 29	81 29	79 46
Perihelion distance	0.8478	0.8944	0.9402	0.9270
Motion	Direct	Direct	Direct	Direct
Velocity per second relative to Earth	28 miles	29 miles	30 miles	30 miles

The above elements suffice to show the close relationship of the *Lyrids* to comet (1) 1861. The elements of that portion of the stream which appears between April 19 and 20 to correspond very closely to the cometary elements, the meteor and comet radiants being within one degree of each other. The meteors of April 18 show a considerable deviation, the possible cause of which will be suggested farther on.

Perseids	July 26	Aug. 10	Aug. 19	Comet (III) 1862
	R. A. Dec.	R. A. Dec.	R. A. Dec.	R. A. Dec.
Pos.of app. radiant	27°.0+55°.0	45°.0+57.°0	68°.0+57°.0	43°.8+57.°2
" " true "	359 .1+81 .3	35 .2+83. 8	114 .2+78°.5	30 .2+83. 8
Long.of perihelion	333 41	346 03	371 35	345 00
" " node	124 04	138 26	147 05	137 46
Inclination	70 04	65 49	62 53	66 26
Perihelion distance	0.9491	0.9555	0.8664	0.9626
Motion	Retrograde	Retrograde	Retrograde	Retrograde
Velocityper second relative to Earth	36 miles	37 miles	37 miles	37 miles

From the above we see that the radiant of the meteors of August 10, the date of maximum is only about one half a degree distant from the cometary radiant, and the elements show a very good agreement with those of the comet.

The radiant of July 26 is about four degrees and that of August 19 about nine degrees from the cometary radiant. The difference between the true radiants is much less than that between the apparent.

Leonids	Nov. 13	Nov. 14	Nov. 16	Comet(I) 1866
	R. A. Dec.	R. A. Dec.	R. A. Dec.	R. A. Dec.
Pos. of app. radiant	148°.0+23°.0	149°.0+21.°0	150°.0+22°.0	150°.4+22°.8
" " true "	150 .8+28 .9	151 .5+26. 3	151 .8+28 .5	153 .9+29 .4
Long.of perihelion	54 08	55 33	52 18	60 45
" " node	231 50	232 49	234 50	231 42
Inclination	15 43	13 39	15 49	17 18
Perhelion distance	0.9884	0.9882	0.9876	0.9766
Motion	Retrograde	Retrograde	Retrograde	Retrograde
Velocityper second relative to Earth	44 miles	44 miles	44 miles	44 miles

The radiant of the *Leonids* lies within about two degrees from the cometary radiant, and the elements, while differing slightly, yet agree sufficiently closely to demonstrate the relationship.

Andromedes	November 27		Biela's Comet	
	R. A.	Dec.	R. A.	Dec.
Position of app. radiant	23°.7	+44°.3	24°.0	+43°.2
" " true "	352 .0	+ 9 .3	349 .9	+ 7 .7
Longitude of perihelion	108 16		109 40	
" " node	245 57		246 29	
Inclination	13 08		12 33	
Perihelion distance	0.8578		0.8606	
Motion	Direct		Direct	
Velocity per second relative to Earth	12 miles		12 miles	

The agreement between the radiants and elements of the *Andromedes* and of the Biela comet is closer than that between any of the other three showers here discussed.

Having before us the above facts derived from observation and computation, we are led to the conclusion that the meteors of each stream do not move in perfectly parallel lines, because, if they did, the *true* radiant would have the same position at all times. The deviations are within reasonable limits, and are probably caused, mainly, by the perturbing force of the *Earth*.

The members of the original streams may have moved in parallel lines, but passing so close to the *Earth*, the perturbations due to that body, must have thrown them into slightly different orbits, and in the course of many revolutions of the meteors, this effect would be very marked.

By perturbation the position of the radiant, and therefore the elements derived thereform would be changed.

Another possible cause of the deviation is suggested by the very great linear velocity of many of the streams. For example, the *Leonids* move relatively to the *Earth* at the rate of forty-four miles per second. Would it be at all surprising if these bodies, most of them probably of very small mass, should upon striking the denser portion of the atmosphere with this great velocity, be deflected and indicate, by their altered course, a radiant slightly different from that which they would otherwise give ?

It would seem that perturbation (mainly by the *Earth*), and the deflection above referred to, would be *entirely* sufficient to account for all the differences, which evidently exist, between the radiants and also the elements, and that the relationship which these streams seem to bear to the associated comets, is a real one.

I would also propound the following queries: Is there any good reason why we should consider as moving in orbits where eccentricities are nearly unity, only those meteors whose orbital elements show them to be connected with known comets? May not all meteors, as distinct aggregations of matter, have an origin much the same as that of the comets, so that like the latter they move around the *Sun* in very eccentric orbits? A collection and discussion of all observed radiants would probably give the answer.

April 17, 1886.

A PRACTICAL METHOD OF WORKING ROCK SALT SURFACES FOR OPTICAL PURPOSES.*

JNO. A. BRASHEAR, PITTSBURG.

Two years or more since Prof. LANGLEY asked me to undertake the work of polishing the rock salt trains so frequently called into use in his well-known researches in obscure heat rays. These surfaces, under the very best conditions, are ephemeral in their character, owing to the deliquescent nature of the material, and in order to get the best results from them, frequent repolishing and refiguring are absolutely necessary. I have been informed that the French opticians polish all rock salt surfaces upon broadcloth; and, indeed, almost all surfaces I have tested show them to have been finished upon some yielding material, as the edges are almost always rounded, or as I would call it, over corrected. This is fatal to good results in any optical surface. Mr. GEORGE CLARK of ALVAN CLARK & SONS polished a prism for Prof. LANGLEY which turned out to be beautiful in polish and figure. His method was to use a pitch polisher with "diamantine" (a fine variety of Vienna lime) as the polishing material. A strong brine was used instead of water, in the ordinary way. Mr. CLARK informed me that the one great difficulty he met with was to wipe the prism surfaces *after the polishing was completed*, he using the arm or palm of the hand, in preference to anything else. On a few occasions I have succeeded in this way, but where success may be had once, failure may result twenty times, for if any moisture is left on the surface of the prism or lens, even for a moment of time, it is ruined.

Happily I have no trouble in this respect now, and as my method is easily carried out by any physicist who desires to work with rock salt surfaces, it gives me pleasure to explain it. For polishing a prism I make an ordinary pitch bed of about

* Read before the American Association for the Advancement of Science, Ann Arbor Meeting, August, 1885.

two and one-half or three times the area of the surface of the prism to be polished. While the pitch is still warm I press upon it any approximately flat surface, such as a piece of ordinary plate glass. The pitch bed is then cooled by a stream of water, and conical holes are then drilled in the pitch with on ordinary counter sink bit, say $\frac{1}{4}$ in. diameter, and at intervals of half an inch over the entire surface. This is done to relieve the atmospheric pressure in the final work. The upper surface of the pitch is now very slightly warmed and a true plane surface (usually a glass one, prepared by grinding and polishing *three* surfaces in the ordinary way), previously wetted is pressed upon it until the pitch surface becomes an approximately true plane itself. Fortunately moderately hard pitch retains its figure quite persistently through short periods and small changes of temperature, and it always pays to spend a little time in the preparation of the pitch bed.

The polisher being now ready, a very small quantity of rouge and water is taken upon a fine sponge and equally distributed over its surface. The previously ground and fined salt surface (this work is done the same as in glass working) is now placed upon the polisher and motion *instantly* set up in diametral strokes. I usually walk around the polisher while working a surface. It is well to note that the motion *must be constant*, for a moment's rest is fatal to good results, for the reason that the surface is quickly eaten away, and irregularly so, owing to the holes that are in the pitch bed. Now comes the most important part of this method. After a few minutes' work the moisture will begin to evaporate quite rapidly. No new application of water is to be made, but a careful watch must be kept upon the pitch bed and as the last vestige of moisture disappears the prism is to be slipped off the polisher in a perfectly horizontal direction, and if the work has been well done, a clean, bright and *dry* surface is the result. The surface is now tested by the well known method of interference from a perfect glass test plate.

If an error of concavity presents itself the process of polishing is gone over again, using *short* diametral strokes. If the error is one of convexity, the polishing strokes are to be made along the chords, extending over the edge of the polisher. The essential feature of this method is the fact that the surface is *wiped dry* in the final strokes, thus getting rid of the one great difficulty of pitch polishing, a method undoubtedly far superior to that of polishing on broadcloth. If in the final strokes the surface is not quite cleaned I usually breathe upon the pitch bed, and thus by condensation place enough moisture upon it to give a few more strokes, finishing just the same as before. In ten minutes I have polished prisms of rock salt in this manner that have not only shown the D line double, but Prof. LANGLEY has informed me that his assistant, Mr. KEELER (J. E.), has seen the nickel line clearly between the D lines, as well as every line that can be seen by the use of a good flint glass prism, although the dispersion is not so great. This speaks for the superiority of the surfaces over those polished on broadcloth.

In polishing prisms I prefer to work them on top of the polisher as they can be easily held, but as it is difficult to hold lenses or planes in this way, without injuring the surfaces, I usually support them in a block of soft wood, turned so as to touch only at their edges, and work the polisher over them. Though it takes considerable practice to succeed at first, the results are so good, that it well repays the few hours' work it requires to master the few difficulties it presents.

NEW MINOR PLANETS.—Dr. PALISA at Vienna discovered a new minor planet on March 31.5214, Gr. M. T. R. A. 14*h* 0*m* 34.6*s*. Dec. −1° 17′ 17″. Daily motion in R. A. −48*s*, in Dec. N. 1′. 13th magnitude. Others on April 2.4905, Gr. M. T. R. A. 14*h* 0*m* 4.7*s*. Dec. −5° 31′ 24″. Daily motion in R. A. −48*s*, in Dec. 0. 13th magnitude. And April 3.4473, Gr. M. T. R. A. 12*h* 24*m* 44.9*s*. Dec. −0° 40′ 11″. Daily motion in R. A. −40*s* in Dec. N. 9′. 12th magnitude. Also another on April 5.5532, Gr. M. T. R. A. 14*h* 1*m* 53.3*s*. Dec. −1° 29′ 5″. Daily motion in R. A. −44*s*, in Dec. N. 3′. 13th magnitude.

EDITORIAL NOTES.

There are still in hand a few more copies of GALLE's Catalogue of Comets from 1860 to 1884 as translated from the German, by W. C. WINLOCK. Single copies fifty cents.

A scholarly mathematican and computer highly appreciates the articles of Mr. S. J. CORRIGAN on the computation of meteor orbits. A prominent English astronomer also gives him a handsome compliment.

SMALL EQUATORIAL FOR LICK OBSERVATORY.—Messrs. WARNER and SWASEY, Cleveland, Ohio, have recently shipped to the Lick Observatory a 6-inch equatorial provided with all their latest improvements, also one of their chronographs of new design.

COMET-METEOR RADIANTS.—Below will be found the radiant points and distances of the five new comets of last year. The present list is a continuation of my previous one given in the SIDEREAL MLSSENGER, 1885 p. 153. The first column contains the current number; the second gives the designation of the comet by the recent method in the order of perihelion passage of the year; the third, the discover; the fourth, the day of the *Earth's* passage through plane of comet's orbit; the fifth designates the nearest node; the sixth, the distance of this node from the *Earth's* orbit in the order $R-r$, the *Earth's* distance from the *Sun* being taken as unity, the seventh and last column gives the radiant for the day in question.

No.	Designation of Comet.	Discoverer.	Earth's Passage.	Designation of node.	Earth's dist. from node.	Com.-met. rad. R. A.	Com.-met. rad. Dec.
1	1885 II	Barnard	June 23	Descending	−1.51	325°.8	+55°.0
2	1885 III	Brooks	April 14	Ascending	+0.12	184 .5	−73 .9
3	1885 V	Brooks	June 13	"	−0.18	201 .4	−87 .0
4	1886	Fabry	April 26	Descending	+0.11	322 .6	+36 .9
5	1886	Barnard	May 29	"	+0.36	350 .8	+49 .0

O. C. WENDELL.

HARVARD COLLEGE OBSERVATORY, 1886, April 17.

LARGE TELESCOPE FOR SMITH COLLEGE.—From private letter we learn that Smith College, at Northampton, Mass., has given the order for an equatorial of eleven inches aperture, and a steel dome of twenty-one feet in diameter to Messrs. WARNER & SWASEY, of Cleveland, Ohio. It is expected that the Observatory will be completed and the telescope in place before the close of the present school year.

SKETCHING THE FABRY AND BARNARD COMETS.—One or two suggestions for those desiring to make drawings of the tails of comets Barnard and Fabry may perhaps be of service. For those who have access to a catalogue of naked eye stars it will be well to plot the positions of all the stars in the neighborhood of the comet's tail before making the observation, and then drawing the outline of the tail among these stars. By this means a more accurate drawing can be made, and the original observation published without a second drawing and consequent touching up. A good way to prepare these maps is to use common computing paper ruled into squares of about one-fifth inch. By making one of these squares equal 30′ a very good sized drawing will result. If quite a liberal distance is plotted on each side of the tail the same map may be transfered to a number of sheets by pricking through the stars into sheets placed below the map. A field or opera glass will be found of great help in making detailed drawings, stars as faint as 7.5 magnitude may then be plotted. The following catalogues are recommended for getting places of the stars: Uranometria Nova, Uranometrie Generale, found in the Annales de l'Observatoire Royal de Bruxelles, Tome I, HEIS's Catalogue or Uranometria Argentina.

Observations for magnitude of the various parts of the tail may be made when dawn is appearing (not so well in the evening twilight) by observing what parts disappear simultaneously with a neighboring star. The time of the disappearance should be noted, and care taken to have the star of about the same altitude as the observed part of the tail. In the same way an approximate determination of the brightness of the nucleus may be made. The following ephemerides give the approximate position and time of rising or setting during the most favorable time for observation:

BARNARD.

Date	R. A.	Dec.	Rises
May 3	1h 38m	+40° 24′	1h 50m A. M.
7	1 43	39 09	1 50 " "
11	1 53	36 12	2 00 " "
15	2 11	30 50	2 40 " "
19	2 40	21 53	3 30 " "
	FABRY.		Sets
May 1	4h 13m	+ 3° 33′	7h 50m
3	5 1	− 7 44	
5	5 42	−16 43	7 50
7	6 16	−23 6	
9	6 43	−27 31	7 50

Those unable to provide maps of the above regions will be supplied by addressing Leander McCormick Observatory, University of Virginia. F. P. LEAVENWORTH.

NEW NEBULOUS STAR.—On March 3 I found with the 6-inch COOK equatorial a star of 9½ or 10 magnitude, with a faint nebulosity surrounding it.

Its place from two ring micrometer comparisons with No. 1659 of GRANT's Glasgow Catalogue is

$$\left.\begin{aligned} \alpha &= 6h\ 40m\ 58.0s \\ \delta &= +1^\circ\ 26'\ 27'' \end{aligned}\right\} 1886.0$$

I strongly suspect that it is not a stellar point but an extremely small nebula with faint nebulosity surrounding. At best with the 6-inch it did not appear like any of the neighboring stars. A short distance (4′ or 5′) preceding this and very slightly north is a faint double-star that I suspect is enveloped in nebulosity. The nebulous star has been seen on several different occasions and always appeared the same. E. E. BARNARD

VANDERBILT OBSERVATORY, April 13, 1886.

DARK TRANSITS OF JUPITER.—In answer to Mr. WILSON'S interesting note about III in SIDEREAL MESSENGER for April p. 125, I would state that the satellite very frequently transits as a black spot. I have observed it thus on the following dates: August 2, 1879; December 30, 1880; February 12, 1883, when it appeared as a small very black spot, smaller than its shadow generally is. See SIDEREAL MESSENGER, March 1883, p. 31; May 9, 1885, small, round, black on north edge of equatorial band; see SIDEREAL MESSENGER, July 1885, p. 158. I have several other records of similar black transits of the satellites among my notes that I cannot at the moment find. There are now probably a sufficient number of recorded black transits of this moon to give data for the investigation of the cause of the phenomenon. I have several times witnessed black transits of the IV satellite. In 1880, I saw quite a number of brown transits of I, but I have never seen II transit otherwise than bright.

Red Spot.—I have observed this object several times this year; it seems to be clearly defined and not difficult of observation, and sustains identically the form of previous years. The southern part of the equatorial belt curve southward following red spot as it has frequently done in former years, and very noticably last year. Since my first observation of the red spot I have been struck with the remarkable fact that it exerts a repellant force against the equatorial belt, never permitting a closer approach to it than probably about one-half the width of red spot.

Peculiar dark spots at the equator.—I have several times lately noticed a feature that has become very striking on April 1. There are several spurs or projections from the inner edge of the southern part of equatorial band. Examining the planet on the above date with a power of about 90 on the 6-inch, I noticed what I took to be the shadow of one of the satellites, this at 11*h* 25*m* Nashville M. T. was central in transit at the equator, upon applying a power of 200 I found that which from its small size and blackness I had mistaken for a shadow, was really one of the projections seen before, but how much darker. Following this some distance was a similar object, whilst on the northern edge of equatorial belt was a feebly luminous spot. At 12*h* 45*m* three of these dark projections were visible ranged along the inner edge of belt and *just* south of equator, I noticed that from the summit of each there extended in a following direction a dusky streak for a short distance and looking like smoke. I was strongly impressed with the resemblance to what might be called a silhouette view of three volcanic peaks ranged in a line and vomiting smoke which a stray wind was carrying eastward! I have always noticed a tendency of any projections from the inner sides of the great equatorial belt system to curve backwards as they approached the equator, as if there were a more rapid motion of the edges of the belt system than along the equator. E. E. BARNARD.

VANDERBILT OBSERVATORY, Nashville, Tenn., April 5, 1886.

WEATHER TELEGRAPHIC SIGNALS IN NORTH AMERICA.—The foregoing is the title of an interesting paper recently written in German by Professor J. HAGEN, College of the Sacred Heart, Prairie Du Chien, Wisconsin. The points discussed are—

1. The history of the weather service in North America.
2. The organization of the service.
   (1). Pertaining to observers.
   (2). Pertaining to stations.
3. Work of the service.
   (1). That done at stations.
   (2). That done at the central office.

O CETI.—E. F. SAWYER, Cambridgeport, Mass., reports that the maximum of *o Ceti* occurred January 19, 1886. It was a faint one equalling a fifth magnitude. This is very unusual for its range of variation at different maxima is commonly between the fourth magnitude and the second. The *Gesellschaft* announced the maximum to come in January 7 for 1886. The mean period is about three hundred and thirty-three days.

POSITION ANGLES OF THE TAIL OF COMET FABRY.—The following are the measured position angles of the tail of FABRY's comet made with the 6-inch COOK refractor of this observatory:

Date	Nashville M.T.	Position angle	Remarks.
1886			
April 7	4h 17.m4	315°.75	3 obs., tail straight slender, well-defined,
" 12	4 6. 8	314 .70	4 obs., tail straight, broader than formerly,
" 13	4 9. 1	318 .20	3 obs., tail straight, broader, not well defined.

The comet on the above mornings has been an easy object to the naked eye, but not at all conspicuous. In the telescope the nucleus was bright and surrounded by a considerable glow. On the 13th the sky was poor, and the tail did not appear so bright. On each occasion, the axis of tail has been gradually brighter than its edges. E. E. BARNARD.

VANDERBILT OBSERVATORY, Nashville, Tenn., April 12, 1886.

ELEMENTS OF COMET BARNARD:—The following elements are also by OPPENHEIM in A. N. No. 2714:

1886	R. A. h. m. s.	Dec. ° ′	Log. r.	Log. Δ.	Brightness.
May 2	38 8	+40 28.4	9.6796	9.9556	118
3	38 33	40 19.5		9.9401	
4	39 14	40 5.9	9.6804	9.9238	136
5	40 14	39 47.4		9.9069	
6	41 34	39 23.5	9.6858	9.8894	155
7	43 16	38 53.6		9.8711	
8	45 23	38 17.2	9.6955	9.8522	176
9	1 47 57	+37 33.8		9.8327	
10	1 50 59	+36 42.5	9.7087	9.8125	199
11	54 31	35 42.6		9.7917	
12	1 58 36	34 33.4	9.7248	9.7704	225
13	2 3 15	33 13.8		9.7487	
14	8 29	31 42.6	9.7429	9.7266	253
15	14 20	29 58.4		9.7042	
16	20 49	28 0.3	9.7624	9.6818	284
17	27 56	25 46.9		9.6594	
18	35 41	23 16.9	9.7828	9.6374	318
19	44 5	20 29.1		9.6164	
20	2 53 8	17 23.0	9.8035	9.5964	349
21	3 2 48	13 58.5		9.5781	
22	13 3	10 16.3	9.8242	9.5619	371
23	23 51	6 18.4		9.5485	
24	35 8	+ 2 7.9	9.8448	9.5383	377
25	46 52	− 4 10.8		9.5318	
26	3 58 59	− 6 32.5	9.8648	9.5291	359

ELEMENTS OF COMET FABRY.—The following elements are by OPPENHEIM in A. N. No. 2715:

1886.	R. A. h m s	Dec. ° ′	Log. r.	Log. Δ.	Bright-ness.
May 1	4 12 43	+ 3 33.4	9.9218	9.2984	457
2	4 37 42	− 2 16.8			
3	5 1 12	7 43,6	9.9351	9.3266	378
4	22 51	12 32.9			
5	5 42 31	16 42.6	9.9484	9.3810	277
6	6 0 11	20 11.9			
7	15 57	23 6.1	9.9617	9.4455	193
8	30 1	25 31.1			
9	42 32	27 30.8	9.9748	9.5100	135
10	6 53 42	29 10.5			
11	7 3 40	30 34.7	9.9877	9.5705	97
12	12 35	31 45.1			
13	20 37	32 45.5	0.0004	9.6260	70
14	27 52	33 37.1			
15	34 22	34 21.8	0.0130	9.6763	53
16	40 30	35 1.9			
17	46 0	35 35.2	0.0253	9.7220	40
18	51 3	36 5.4			
19	7 55 43	39 32.2	0.0873	9.7636	32
20	8 0 3	36 56.3			
21	4 5	37 18.1	0.0491	9.8017	25
22	7 51	37 38.0			
23	8 11 23	−37 56.1	0.0606	9.8367	20

MORSE'S LANDMARKS IN ASTRONOMY.—Mr. E. P. MORSE, of Batavia, New York has prepared a neat 9-inch star map which is printed on white card board, arranged with colored cords for marking the day, the meridian, the zenith, etc. The map shows the Milky Way, the constellalions in faint outline and prominent stars in true positions, the ecliptic, daily motion of the *Sun*, and other useful elementary data. It is so easily under stood that it ought to be a thing of use and pleasure in the hands of a child a dozen years old, because with it he may locate any prominent star, or to tell the time of night by the stars. Price 25 cents.

BOOK NOTICES.

A Popular History of Astronomy During the Nineteenth Century by AGNES M. CLERKE. Publishers, Messrs. ADAM and CHARLES BLACK, Edinburg, Scotland, 1885, 8vo, pp. 468.

This book is a genuine surprise because of its merit and its timely appearance, and because it was not written by a man;

for the years are few since the time that a woman either could or would have written a book on astronomy for popular reading in Europe or America, because the *savants* would have thought such an undertaking strangely unorthodox according to any scientific creed.

But ideas have changed somewhat since the time of CAROLINE HERSCHEL and MARIA MITCHEL (now of Vassar College Observatory) and the doors of Science open more easily and naturally to merit and skill, in any person, than they were wont to in earlier days.

To write a history of astronomy to follow such an author as GRANT, which shall clearly present its marvellous growth, in all the varied and intense specializations of work, in the nineteenth century, is indeed a task that few astronomers in the world would not hesitate to undertake.

In the midst of such difficulties Miss CLERKE has gathered the materials of this book and written it admirably. The theme is divided into two parts, the first treating of the progress of astronomy during the first half of the nineteenth century, and the second is a critical review of the recent progress of the science. Under the first head, the work of Sir WILLIAM HERSCHEL appears justly as the foundation of Sidereal Astronomy, on which the noted BESSEL begins to build exact astronomy in Germany. The skill of FRAUNHOFER is a useful adjunct at this time, and STRUVE's double-star researches and Sir JOHN HERSCHEL's explorations of the heavens are some of the characteristics of fifty years of progress in astronomy. Under the same head, are also presented the progress of knowledge regarding the *Sun*, planetary discoveries, comets, and instrumental advances.

About two-thirds of the book is devoted to the recent progress of astronomy, commencing with the foundation of astronomical physics, as seen in the discovery of the sun-spot period, magnetic disturbances and the elementary principles of spectrum analysis, the theory of the constitution of the *Sun*, solar photography, planetary influences. Then follows specialized study in recent solar eclipses, the spectroscopic study of the the *Sun*, the temperature of the *Sun*, its distance, planets and satellites, theories of planetary revolution, recent oomets, stars and nebulæ, and methods of research.

From a careful reading of this book, it would seem from the form of expression, now and then chosen, that the authoress has not been a practical observer, and yet we can but admire the skill with which she freely and independently discusses impending problems of the science. We do not say that we fully endorse all positions taken as quite eatisfactory; for example, the claims regarding the discovery of *Neptune*, the theory of the solar corona, spectroscopic work, the personal equation, etc., but all these points and others in mind, are minor matters, which will neither seriously disturb or mislead any body. The fresh, apt and terse way, in which the good things of every page are said to overshadow the weak ones that they are scarcely noticeable.

We have read this book with delight, and in commending it to the readers of the MESSENGER we bespeak for it unusual favor in America.

A Catalogue of Suspected Variable Stars. With Notes and Observations. By J. E. GORE, M. R. I. A., F. R. A. S.

This catalogue of suspected variable stars was presented as a paper before the Royal Irish Academy in 1884, and reprinted from its proceedings. It contains 158 pages of closely printed matter with a frontispiece double-page plate showing the distribution of known and suspected variable stars, the known being red dots, while the suspected are black ones. The catalogue proper is arranged in six columns, on the page, first, the number of the star, second, its name; third and fourth, R. A. and Declination for 1880; fifth, supposed change of magnitude, and sixth, authority. Whole number of stars is 773, taken in order of right ascension. The notes accompanying are unusually full and apparently prepared with care and great labor.

The Catalogue is a valuable and needed contribution to this new branch of astronomy.

The new Minor Planets, recently discovered by DR. PALISA, are numbered respectively 254, 255, 256, 257.

The Sidereal Messenger

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

VOL. 5. No. 6. JUNE, 1886. WHOLE No. 46.

DESCRIPTION OF A PRINTING CHRONOGRAPH.

PROF. G. W. HOUGH, DIRECTOR OF DEARBORN OBSERVATORY.

About the year 1848, the idea of recording astronomical observations, by the use of galvanic electricity, was put in successful operation by different individuals. Since that time chronographs of various forms have been constructed for recording in a legible manner, on a moving sheet of paper, the time of any phenomenon observed. The great superiority, in point of accuracy and saving of labor over the old eye and ear method, formerly used, soon led to the general adoption of the new plan.

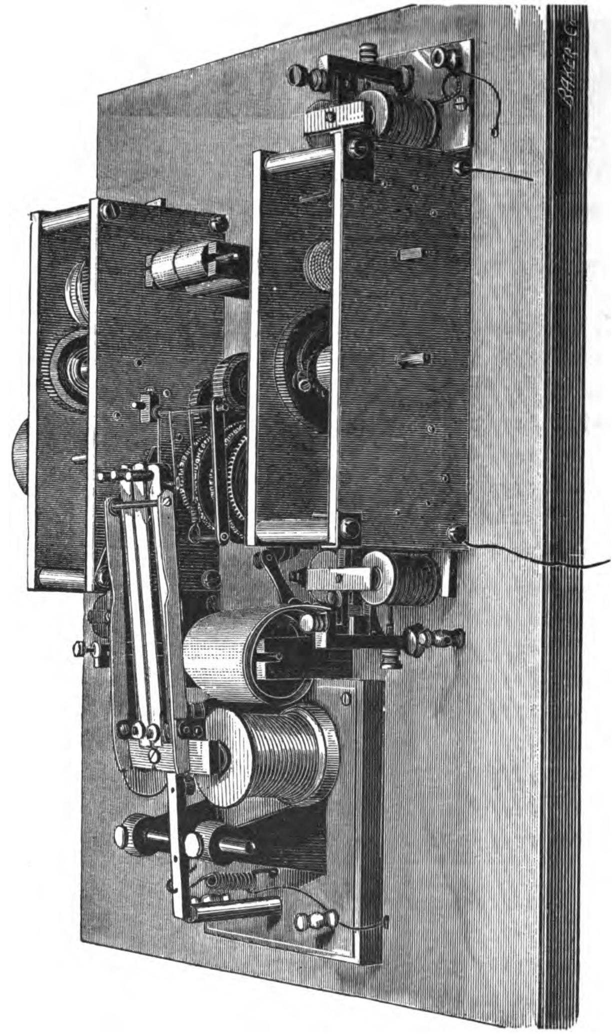
The idea that type-wheels might be substituted for the moving paper, and a printed record made, was long ago entertained by astronomers, and various plans were devised for accomplishing this purpose.

In the year 1865, in a paper read before the Albany Institute, I gave an outline of a plan for a printing chronograph, radically different from any that had been proposed. It was based on the principle of using separate systems of mechanism for the fast running type-wheel, and those recording the integer minutes and seconds. These two trains to be simultaneously controlled by the sidereal clock, and to be entirely independent of each other.

In the year 1871 I completed a printing chronograph based on this method.

This machine was in constant use at the Dudley observatory for three years, demonstrating the practicability of such an apparatus.

In this first machine the blow for printing was done by a hammer, elevated by a heavy train of clock-work, which made the instrument somewhat unwieldy. The type-wheels were constructed



PROF. G. W. HOUGH'S PRINTING CHRONOGRAPH.

by soldering electrotype strips, on the rim of a brass disc, and required to be renewed once a year or oftener. In other respects the machine was entirely satisfactory.

About a year ago, I put in operation at the Dearborn observatory the printing chronograph about to be described. Since the machine was first set up, the mechanism has been modified in various ways in order to bring the instrument in as compact and convenient a form as possible.

The accompaying wood-cut will aid in making a description of the machine intelligible. The relative size of the different parts may be inferred from the statement that all the mechanism rests on a table eighteen inches by twenty-four inches.

First, the movement in the rear, consists of a system of clock-work, carrying a type-wheel with fifty numbers on its rim, revolving once every second; one, two, or parts of two numbers being always printed, so that hundredths of seconds may be indicated.

This train is primarily regulated to move uniformly by the Frauenhaufer friction balls, and secondarily by an electro-magnet acting on the fast moving type-wheel and controlled by the sidereal clock. This train is entirely independent, and can be stopped at pleasure, without interfering with the other type-wheels.

Second, the movement in front consists of four shafts for carrying the type-wheels indicating the minutes and seconds. The motion of this train is also governed by an electro-magnet, controlled by the sidereal clock, operating an escapement in a manner analogous to the action of an ordinary clock; every motion of the escapement indicating integer seconds, advancing the type one number. There are three type-wheels, indicating minutes, seconds and hundredths of seconds. The integer seconds are advanced at every oscillation of the standard pendulum; and the minute, at the end of each complete revolution of the seconds' wheel.

The type were cut on solid cast-brass discs, and will probably wear as long as other parts of the mechanism.

Third, in the right hand end of the front movement there are three shafts, for moving the paper fillet, on which the record is made.

The large electro-magnet operating the printing hammer is seen on the left, directly under the hammer-arms is the spool of paper. When the machine is ready for use the end of the paper is drawn over the tops of the type-wheels, and passed between the brass rollers between the two movements.

The train for moving the paper is unlocked by an electro-magnet whenever an impression is made, or it may also be unlocked independently by a duplicate observing key so as to leave a blank space of any desired amount between the records for different stars or groups of wires.

The paper fillet is two inches in width, and the spool will hold about forty feet — sufficient for 1200 observations, including the spacing for different objects.

The type are inked by means of small rollers covered with cloth, resting against their rim, and revolving with the wheel by friction. These rollers require inking every two or three days. The inking rollers, however, may be dispensed with and impression ribbon used instead, but it is not nearly so handy, and besides requires a heavier blow to get a good impression.

The blow for making the impression is struck by means of the electro-magnets of one ohm resistance. The hammer-arms are flexible. When the armature is pressed down without striking a blow, the hammers stand about one-half inch above the type. The impression is therefore made from the spring of the arms and not by a direct blow.

By this device, which is regarded of the greatest importance, the motion of the type-wheel is not disturbed an appreciable amount. None of the type-wheels are stopped in the act of printing.

If the record is made while the type-wheel indicating integer seconds is in the act of escaping, two numbers, or one number and part of another, is printed, so there is no ambiguity; this condition, of course, only occurs when the hundredths of seconds' wheel indicates 0.96 to 0.02 seconds. If two integer seconds are printed when, for example, the hundredths read 0.98 the smaller number is the correct one.

The battery for operating the printing magnet consists of three storage cells, charged in series, by means of eight gravity elements. The charging battery is kept permanently connected with the storage cells. By means of this compound battery, there is always sufficient current to operate the recording and printing chronographs, at the same time— as well as an electric bell — in all eight pairs of electro magnets.

The storage cells each consists of two lead plates, four by six inches, coated with red lead, and hung vertically in a glass jar, containing dilute sulphuric acid. The lead plates may be kept in constant use for one year without renewal.

Aside from the printing magnet, the electrical power required is essentially the same as for a recording chronograph.

The printing magnet might be operated with three Grove cells or their equivalent.

The machine is readily set to indicate the time given by the clock's face.

The hundredths-of-seconds wheel needs no adjustment as it is permanently set to print zero, when the connection is made by the clock pendulum.

The integer seconds are set with the clock by rapidly operating the escapement by hand; and the minute wheel may be moved in either direction.

It requires about two minutes to get ready for observing, including the preparation of the inking rollers.

In observing some stars with our first machine, it was found advantageous to set the type to print directly the nearest integer seconds of mean right ascension so that the final reduction was always a small quantity.

During the construction of the present machine, a great many experiments were made to ascertain the probable error due to our method of control. For this purpose the standard mean time signal clock was arranged to operate the printing magnet once each minute. By this means the comparison between the sidereal and M. T. clocks was made for every part of the second. The difference between two successive records and 0.164 second gave the errors of any impression.

By employing an ordinary train (similar to that used in a cheap clock) for driving the hundredths-of-seconds' wheel, the "mean" error was about ±0.03 second, and the maximum possible error ±0.08. This train was so imperfect that it was necessary to make it gain 0.20 second in every second in order to carry it over the hard places. The train now used, is ordinary gear, accurately cut but not polished. The "mean" error is found to be ±0.015 second with a possible maximum error ±0.05 second.

In order to secure the best possible results, the train for driving the hundredths-of-seconds' type-wheel should be as accurately constructed as that used for an astronomical clock, then the "mean" error would be less than ±0.01 second and the maximum possible error would not exceed ±0.03 second.

The theory of control, for securing hundredths of seconds, is as follows: A train of clock-work is regulated, by any suitable device to run with approximately uniform velocity, but always a little fast; the final control is then secured by an electro-magnet, checking its velocity once every second. The whole train may be checked, or only the type-wheel shaft, the latter being driven by friction.

By employing the first method the probable error of any impression is a little less than for the latter.

When the whole train is regulated, however, and it is stopped by design, it may require several seconds for the type-wheel to come in coincidence with the sidereal clock, whereas when the type-wheel shaft is driven by friction only, the coincidence will be secured in one or two seconds.

The train for carrying the integer minutes and seconds' type, will run about ten hours, without winding, requiring a weight of seven pounds, single cord. The train for running the paper fillet requires about two pounds weight, single cord. The train for hundredths of seconds will run one hour and forty minutes and requires a weight of fourteen pounds, single cord.

The saving of time and labor by the use of a printing chronograph is very considerable.

In an observatory when systematic meridian work is done, the saving in labor for a single year, would probably amount to more than the cost of the machine.

THE STATIONARY METEOR SHOWERS.

W. F. DENNING, BRISTOL, ENGLAND.

For The Messenger.

Before proceeding to quote facts bearing on the stationary radiation of meteors, I wish to refer to the interesting remarks, of Mr. S. J. CORRIGAN in the MESSENGER for April, 1886.

The mathematical treatment of the question by your able correspondent does not effectually dispose of the difficulty or clear up the mystery involving it. If, as assumed, parabolic orbits are truly representative of the meteors forming these alleged stationary radiants, then such meteors (encountering the *Earth* on widely different dates) must necessarily exhibit, as he proves, a very great dissimilarity of orbit and can have no physical correlations. For the date (= node) is of equal importance with the radiant and parabolie meteors emanating from the same apparent focus on the star sphere at different epochs, possess no affinity other than a mere coincidence in their observed directions. If parabolic motion is really applicable to the bulk of visible meteors, then the idea of stationary radiation is not tenable for a moment. But the general adoption of a parabola in computations of meteoric orbits is based on an assumption. There are large discordances and errors in estimating the *durations* of meteor flights and the form of orbit, which is inferred from this, is also open to very grave doubt.

In the instance of the special showers from near ε *Persei*, R. A. 61.°8, Dec. 36.°8+, quoted by Mr. CORRIGAN as a case in point, the observations of the meteors of 1872, August 10, and 1869, November 6, are very uncertain as to this important feature of duration. The time of flight for the former was roughly estimated by one observer only as 0.5 second, but in the latter case there is still great reason for doubt. Prof. HERSCHEL adopted 5 seconds as the probable observed velocity from a mean of two observers who gave 4 and 6 seconds respectively; but there is strong evidence this is much overrated. Mr. J. CHAPMAN at Broadstairs in Kent observed the fireball and alludes to "its very rapid motion," adding, "the whole scarcely occupied 2 seconds." Mr. T. HUMPHREY, at Hawkhurst, remarks: "I particularly noticed the extreme rapidity of the meteor's flight. My own description of the meteor as seen at Bristol was that "it glided swiftly down the sky" and "its duration could not have exceeded 2 seconds." I remember this fireball well. It descended with great suddenness, flashing out at the end point with marvellous brilliancy and projecting a *vivid* streak near η *Serpentis* for fully fifteen minutes. From these and other accounts its visible duration of flight must have been nearer *one* than *five* seconds. Were the latter accurate the meteor would have fallen *very slowly*, whereas several of the observers concur in their expressions as to its extreme swiftness. The length of course in the atmosphere traversed by this body being about 175 miles, its real velocity was probably more like 100 miles per second, than the 26 miles per second which a parabolic orbit gives. These facts destroy the weight of the comparisons made by Mr. CORRIGAN on the basis of a parabola, the observed rate of motion being quite inconsistent with that form of orbit. It is most unfortunate that the durations of meteors cannot be estimated (unless in exceptional instances) within small limits of error, and that no plan seems available to insure greater accuracy.

I will now proceed to state some facts bearing on stationary radiants. When, ten years ago, I began habitually recording meteors, I found a number of showers in lingering activity for several months. Further observations only confirmed the idea and multiplied the cases of such persistency. I then made a special effort to trace whether the radiant points of each of these continuous showers remained absolutely stationary, or whether, the successive displays showed displacement such as must naturally occur in systems grouped together by mere chance. I ultimately found that such displacements as were apparent merely resulted from unavoidable errors of observation and that allowing for these, the places of radiation become fixed points in the firmament. Certain regions were vacant of showers,while other points again and again became the well defined centers of convergence. Not satisfied with my prior results and realizing the serious theoretical impediments to their adoption, I instituted another series of observations, but utterly failed to shake my former convictions. My paper, printed in the *Monthly Notices* for December 1884, contained the more prominent facts observed in relation to the stationary showers and since that was written I have again practically tested the question. From 1334 meteors (omitting *Perseids* of August 10 and *Andromedes* of November 27) which I observed with the utmost care during the last 9 months of 1885 I found additional corroboration of the long-enduring streams. It is unnecessary for me to quote many details here, but I adduce a few conspicuous examples of these presumably stationary showers with the hope that they will form the materials for rigorous criticism and discussion and that some light may be thrown on the question.

Since my results were published in December 1884, I have carefully sifted and in part revised my observations. I have also added others and derived the radiant points either from the records of a single night, or from very limited periods as Colonel TUPMAN once stated, that fixed radiation would disappear under such treatment. The sequel proves however that it becomes more strikingly evident. For the present I only summarize five series of positions relying solely upon my own observations.

I. NEAR MU PERSEI.

EPOCH.	RADIANT. R. A.	RADIANT. Dec.	VELOCITY.
1878 July 26, 27 and 30	59°	+47°	slowish.
1877 August 12	60	+50	swift, streaks.
1877 August 16	61	+48	swift, streaks.
1879 August 22	61	+50	swift, streaks.
1885 September 5	61	+49	swift.
1877 September 7	61	+48	swift.
1877 September 15	61	+48	swift.
1879 September 21	61	+48	swift.
1884 September 22	59	+49	very swift.
1877 October 8	61	+47	very swift.
1877 October 17	62	+48	swift.
1877 November 4	61	+49	swift.
1879 November 14	59	+48	swift.
1885 November 30	60	+49	very swift.

In January 2, 1886, I observed several *very swift* meteors from 62° +47°, but clouds came over before I could secure sufficient paths to accept the radiant with perfect safety. The remarkable facts in connection with this recurring shower are the nearly identical positions of its radiant and the great and sustained velocity of the meteors. Parabolic elements will not satisfy the very swift motions observed at the end of November and also probably in Jauuary.

II. NEAR EPSILON PERSEI.

EPOCH.	RADIANT. R. A.	RADIANT. Dec.	VELOCITY.
1879 August 21, 22, 23 and 25	62°	+35°	very swift, streaks.
1884 August 25	62	+37	swift, streaks.
1885 September 3	62	+37	swift, streaks.
1877 } 1885 } September 5	60	+35	swift, streaks.
1880 September 6	61	+36	swift, streaks.
1877 September 7	60	+38	swift, streaks.
1885 September 8, 9 and 10	62	+36	swift, streaks.
1877 September 15 and 16	61	+36	swift, streaks.
1885 September 17	62	+38	swift, streaks.
1879 September 20 and 21	61	+38	swift, streaks.

I have not seen this radiant well-defined in October though both in November and December it apparently resumes a marked activity. On November 4, 1877 it formed a conspicuous shower.

During the month from August 21 to September 21 the display is a notable one, and furnishes many brilliant meteors of the swift streak-bearing class similarly to the *Perseids* of August 10.

III. NEAR BETA TRIANGULI.

EPOCH.	RADIANT. R. A.	Dec.	VELOCITY.
1878 July 27	28°	+36°	swift, streaks.
1879 July 29	30	+37	swift, streaks..
1877 August 4	30	+37	swift.
1884 August 25	30	+36½	swift, streaks.
1879 September 15	30	+36	slowish.
1879 September 21	30	+36	slowish, long paths.
1877 October 8	30	+36	swift, short paths.
1876 October 15	31	+37	swift.
1877 November 9	29	+37	slowish.
1885 December 4	31	+37	very slow, trains.

Here we see the same coincidences of position, but there is a tendency in the later showers to yield slower meteors. In July and August they are swift and often generate streaks, but the meteors from this radiant early in December are very slow and evolve trains of sparks. It is almost certain that different systems give rise (in this instance) to the recurring radiant, though how is it possible to explain their close agreements of position?

IV. NEAR GAMMA PEGASI.

EPOCH.	RADIANT. R. A.	Dec.	VELOCITY.
1885 July 13	6°	+11	very swift, streaks.
1878 July 31	7	+11	very swift, streaks.
1885 August 20	5	+12	slowish.
1879 August 22	5	+17	slow (radiant estimated.)
1884 August 25	5	+10	slow, bright and short.
1885 September 15	5	+11½	slow.
1884 September 22	7	+10	slow, short.

This radiant in July furnishes very swift meteors, but during the two ensuing months I have invariably registered them as slow. The place of radiation is, however, well-defined and closely accordant. Position on August 22, 1879, evidently 6° too far north.

V. NEAR ALPHA ARIETIS.

EPOCH.	RADIANT. R. A.	Dec.	VELOCITY.
1878 July 30	31°	+18°	swift, streaks.
1877 August 12	31	+18	swift, streaks.
1879 September 21	31	+19	slow, trains.
1885 October 7	31	+18	slow, bright.
1874 October 18	34	+18	swift, bright.
1877 November 7	30	+16	swift.

In this case the observed velocities are variable though the radiant reappears from nearly the same point during several months.

Speaking generally of these five showers I may say I have observed them on many other dates to those indicated, but the paths secured were too far to give certain radiants. With every increase of observations the same points became determinable, on additional nights, so that the epochs quoted are to be considered as representing those only whereon they have already been noticed to the best advantage. I believe that with greatly extended observation these showers will be discovered to be continuous, though sometimes affected by curious lulls and occasionally by conspicuous outbursts.

I have recorded several thousands of meteors in the region of *Perseus* and surrounding constellations and two of the best permanent radiants are near μ and ϵ *Persei*. Again and again I see meteors falling from the points 60.°5 +48.°4 and 61.°3 +36.°8, which are the average places of the showers I and II in the foregoing summary. I have never discovered a single radiant lying about midway between the two. In regard to the system marked III it is strange the meteors always come from the same point, 2° north of β *Trianguli*. There are no showers closely southeast or west of that star. The same persistency is found in the two remaining instances (IV and V) where the paths invariably converge upon points 5° southeast of γ *Pegasi* and 5° south of α *Arietis*, respectively, and never from the region near.

In selecting these positions as examples, I have purposely given several which supply meteors apparently moving slower as the radiant recedes from the apex of the *Earth's* way, though such meteors are calculated to uphold the theory of parabolic motion. I might readily have quoted only those instances in which the radiants yield very swift meteors at every successive display, but I have no desire to prejudice the question by giving undue prominence to materials which are not fairly representative of the true state of things. I have also omitted for the present the positions of showers deduced by me from the observations of continental astronomers, because a man can only place implicit confidence on what he has seen with his own eyes. As to the radiant near ε *Persei* I have only quoted my observations from August 21 to September 21 and my intention is to thoroughly investigate the display during that period, for if it can be conclusively proved that the radiant point is continuous and stationary for thirty-one days, there is no reason why it may not present the same aspect during a much longer interval. To re-examine the whole matter would require an immense amount of assiduous labor; it becomes therefore necessary to narrow it down by selecting certain well-defined instances for close and critical study.

I contend there is some important meaning in this observed clustering together of radiant points. If existing ideas fail to explain it some others must be adopted that will; for theoretical objections cannot absolutely and finally negative a demonstrated fact of observation. In the present instance I do not assume the evidence amounts to demonstration, but believe a fair case has been made out for future investigation. The question ought to be thoroughly examined observationally. Hitherto the opposition has been solely geometrical. No one, so far as I have learned, has watched the sky for a single hour to test the validity and accuracy of the results brought forward. Yet it is only by patient scrutiny of the heavens that the matter can be settled, because everything depends upon the degree of reliance to be placed on recent observations. The mathematical difficulties in the way of accepting stationary radiant points are ample, and it would appear insurmountable. They have been clearly expounded on several occasions by those well qualified to speak with authority. But, notwithstanding this apparent antagonism of observation and theory, the observed facts have not been controverted and still possess considerable significance. They will doubtless be elucidated by future observers who will obtain more complete and exact materials than any hitherto recorded. If fixed radiation is a false effect, further observations are capable of showing it in that character, but if it is a real feature then the most elaborate arguments, or refined mathematical objections, cannot obliterate it from the sky.

ON PERSONAL ERRORS IN DOUBLE-STAR OBSERVATIONS.

H. C. WILSON, CINCINNATI OBSERVATORY.

For the Messenger.

The measurement of the position angle and distance of the components of a double-star is, apparently, a very simple operation, yet it requires great care and practice to render this simple operation free from the effects of systematic errors. Neglect of the proper precautions to detect and avoid such errors has doubtless rendered the measures of the majority of double-star observers almost entirely worthless as data for computing the orbits of binaries. Accidental errors and mistakes are of little consequence, for their effects may be easily eliminated by the method of least squares, but where the errors follow regular laws this method is of no use.

Instrumental errors may be eliminated by proper methods of observing. The general rule applying to such may be stated as follows; in each measure move the parts of the instrument employed alternately in opposite directions, so that an error in one direction shall be balanced by an equal error in the opposite direction. To illustrate this rule let us refer to the diagrams, figure 1 and figure 2. In figure 1 let the parallel lines *a b* represent the threads or wires of a filar micrometer when placed in the true direction of the lines joining the centers of the stars. Now suppose the micrometer to be turned out of this position several degrees in either direction, say toward 90°, and to be brought back slowly. The wires will appear to be parallel to the stars too soon, and the reading of the micrometer will be taken at *a′ b′*. Similarly, if the wires be brought up in the opposite direction, the reading will be taken *a″ b″*. The position angle *a′ b′* will be too large and *a″ b″* will be too small.

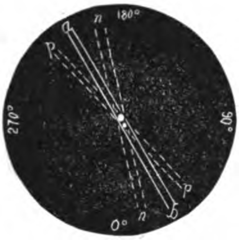


Fig. 1.

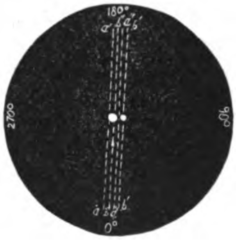


Fig. 2.

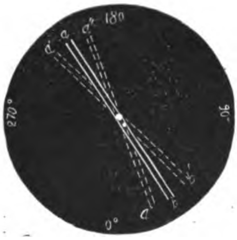


Fig. 3.

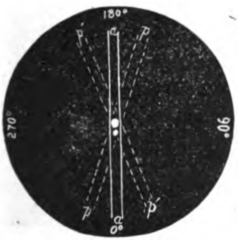


Fig. 4.

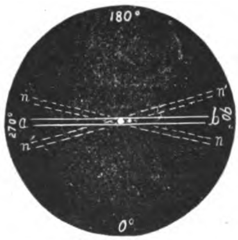


Fig. 5.

The mean of the two will be nearly correct. If an observer is in the habit of turning the micrometer in only one direction his position angles will always be too great or too small. The deviation will be systematic, varying with the distance between the stars and perhaps also with the angle.

In the measurement of distance an error in the bisection *a′ b′*

(fig. 2) when the wires are brought toward each other will be offset by an equal error of the opposite sign when the bisection is made by separating the wires, *a″ b″*. The usual method is to measure the double distance by moving one of the micrometer wires past the other, making a bisection in the same direction on each side. At the Cincinnati observatory the practice has been to measure two double distances with opposite motion of the screws.

It is not so easy to dispose of errors which are purely personal or optical in their nature, for their causes and the laws which govern them are unknown. The existence of such errors admits of no doubt, for if we compare the measures made by the most eminent observers we shall find striking differences even where the stars exhibit no signs of change. The renowned English astronomer DAWES, soon after he began to measure double-stars in 1830, discovered a tendency in his own eye to "obtain a different result in position when the line joining the centres of the stars was nearly parallel to the line joining the centres of the eyes, from that which was obtained when these lines were nearly perpendicular to each other; and a still more decided difference was found to prevail when those lines formed a very oblique angle." He sought to overcome the difficulty by attaching a prism to the eyepiece between it and the eye. By this means the stars could be placed at any desired angle. He confined himself however to the vertical and horizontal positions. It has been objected to this method that the use of the prism would cause loss of light and impaired definition and might thereby introduce serious errors of a different sort; but DAWES, after using it for forty years, regarded the objections as unfounded. I am not aware, however, of any other observer who has made regular use of the prism.

The great double-star observers, W. STRUVE and DEMBOWSKI, also recognized the possibility of such errors in their measures. They always observed with the head vertical. W. STRUVE, by means of observations of artificial double-stars convinced himself that his constant errors were insignificant. O. STRUVE, the son of the last named astronomer, has given in the Pulkowa Observations, Vol. IX, a most complete investigation of his own large systematic errors,as derived from a great number of observations of artificial doubles. He has also investigated the deviations of several other observers by comparison of their observations with his own corrected results. He confirms his father's conclusion in regard to the angles, but shows that his father's distances were subject to large deviations. The same was found to be true concerning the measures of DEMBOWSKI. No observer was found to be entirely free from systematic errors.

The results obtained by the method of artificial doubles have not, however, been received with entire confidence by other astronomers. The chief objection to the method is that the circumstances under which terrestial and celestial observations are made are very different; especially the circumstance that in the case of an artificial double the telescope is at rest and the stars may be bisected separately, while in observing actual doubles it is necessary to keep the eye upon both stars at the same time, because of irregularity in the motion of the telescope.

DEMBOWSKI, a short time before his death, proposed to test his personal errors by observing a number of circumpolar doubles at different distances from the meridian. He prepared a list of twenty-four stars, having no sensible motion, which he proposed to observe, on an average, five times each in each of the twenty-four hours of star time. Thus each star would be observed throughout the whole 360° of angle with the vertical. This method is undoubtedly the best which has been proposed, but involves such an amount of additional labor, especially where the regular work of the observer is in the opposite part of the sky and the dome is difficult to manage, that very few would be able to use it. According to a statement by Dr. DOBERCK (*The Observatory*, Vol. II, page 217) the astronomers, STRUVE, DUNER, HALL and WINNECKE were to join DEMBOWSKI in his investigation. Whether any of them has carried out the plan to any extent I have not been able to learn.

At Cincinnati the observers under Professor STONE's direction always inclined the head so that the line joining the eyes should be either normal or parallel to the line joining the centers of the stars. Professor STONE has given a careful investigation of the results obtained by this method in the introduction to No. 5 of the Publications of the Cincinnati Observatory. This method probably eliminates one cause of error, viz.: the oblique angle between the stars and the line joining the eyes, but introduces another, quite as serious, depending upon the inclination of the head. At the same time it furnishes the means of determining the amount of the deviation, produced by this cause, directly from the observations. This is true at least concerning the angles. In regard to the distances I am not so sure.

Suppose the line joining the centers of the stars to make an angle of about 45° with the vertical as in fig. 3. The true direction of the wires when placed parallel to the line joining the stars will be *a b*. For the normal measure of position angle, the head must be inclined 45° to the left. To do this requires an effort and causes an unequal strain upon the muscles of the neck which is perhaps communicated to the muscles that control the eye. The result is the eyes seem to be normal to the stars too soon and the wires will be set at *n n*. For the parallel measure the head is inclined 45° to the right and a similar effect is produced but in the opposite direction. As the inclination of the head is the same in both cases the amount of the deviation should be the same in each direction and the mean of the two measures should give the true angle. Again, suppose the angle with the vertical to be 0° as in fig. 4. For the normal measure the head is in the natural position, and there seems to be no reason why the measured direction should not coincide with the true direction *ab*, if the wires be brought up alternately from both sides. In the parallel measure, however, one can easily see that a very large deviation may be produced by the great inclination of the head, and that the deviation will be plus (pp), or minus ($p'p'$), according as the head is turned to the right or left. If readings are taken with the head inclined in both directions the difference will give twice the error.

(*To be Continued.*)

OBSERVATIONS AT WILLET'S POINT.

ALICE MAXWELL LAMB, WASHBURN OBSERVATORY.

The results of the astronomical observations taken in 1885 at the field observatory at Willet's Point are announced in the Printed Orders No. 3, dated February 15, 1886. The observations for latitude with the Wurdemann and Lingke instruments were continued during 1885, as in former years, with the following results:

Wurdemann (371 observations on 81 pairs)...........	Lat. 40°	47′	21.″35
Lingke (193 observations on 61 pairs).................	Lat. 40	47	21. 75
Grand mean giving observations and instruments equal weight	Lat. 40	47	21. 49

The following table gives the results for the various years:

Transferred from old observatory...................	Lat. 40°	47′	21.″70
In 1880 (326 observations on 84 pairs)...............	Lat. 40	47	21. 59
In 1881 (591 " " 104 ")...............	Lat. 40	47	21. 47
In 1882 (235 " " 60 ")...............	Lat. 40	47	21. 37
In 1883 (497 " " 118 ")...............	Lat. 40	47	21. 15
In 1884 (523 " " 89 ")...............	Lat. 40	47	20. 75
In 1885 (564 " " 85 ")...............	Lat. 40	47	21. 49

As will be seen, the sequence of the results of the years, 1880–4 which seemed to indicate a systematic change of latitude, is interrupted by the result for 1885, this result being practically the same as that for 1881.

Out of curiosity, and at the suggestion of Professor HOLDEN, I have combined the 1885 observations of the well determined pairs of stars (those designated as AA and AA, AA and A, AA and B, A and A, or A and B) and found the mean of the results of the observations of such stars for each instrument. The mean results thus obtained are as follows:

Wurdemann (163 observations on 38 pairs)............Lat. 40° 47′ 22."00
Lingke (80 observations on 30 pairs)..................Lat. 40 47 21. 51

No one pair of stars was observed consecutively in each of the years 1880–1885, and it is thus impossible to completely summarize the results by pairs as well as by instruments and years. The same pairs were observed, however, to some extent at least, in the years 1880–1884. The following tables show the relation between the results of observations of well determined stars in the different years. The results for the first five years were taken from the SIDEREAL MESSENGER for July, 1885,

TABLE I.

Summary of Observations of Well Determined Stars with the Wurdemann Instrument in the Years 1880, 1881, 1882, 1883, 1884, 1885.

Year.	Seconds of Latitude.	Residuals.
1880	21.37 [14]	−0."29
1881	21.77 [20]	+0. 11
1882	21.64 [28]	−0. 02
1883	21.37 [34]	−0. 29
1884	19.76 [22]	−1. 90
1885	22.00 [163]	+0. 34
Weighted mean of the above results.............		.........21. 66

TABLE II.

Summary of Observations of Well Determined Stars with the Lingke Instrument in the Years 1881, 1883, 1884, 1885.

Year.	Seconds of Latitude.	Residuals.
1881	21.31 [25]	+0."03
1883	21.29 [71]	+0. 01
1884	20.99 [65]	−0. 29
1885	21.51 [80]	+0. 23
Weighted mean of the above results.............		.........21. 28

The evidence of the tables seems to be rather against a systematic change of latitude at Willet's Point, but the results of future years will be awaited with interest.

April 26, 1886.

EDITORIAL NOTES.

So many valuable communications are already in hand that a number of the MESSENGER will be published for July.

Carleton College Observatory has recently received a new spectroscope made by Messrs. FAUTH & Co., of Washington, D. C. It has a Rowland grating, ruled by BRASHEAR and is adapted to the CLARKE Equatorial.

The Vanderbilt University Observatory, Nashville, Tennessee, has secured one of WARNER & SWASEY's fine chronographs after their new pattern.

COMET 1882 II.—From the observations of the Great Comet of 1882, given on page 198 of the "Washington Observations for 1882" (just issued) it appears that the constant correction required to the transit circle north polar distances which were published in Appendix I for 1880 (page 34) amounts to $+1.''7$. This is the correction "$\Delta\varphi + \Delta z$" referred to in the appendix mentioned, and applies to the 1882 observations only. W. C. W.

COMET DISCOVERIES.—The exact date of the discovery of Mr. BROOK's two comets of this year (as announced in *Science Observer Circular* 66) is rendered uncertain, in the transmission (apparently) of the news from Rochester to the Harvard College Observatory. A similar trouble occurred last year, and it seems to be a source of needless inconvenience to those who are trying to keep a list of new comets. The actual date of discovery should be specifically stated in the telegram. W. C. W.

COMET BARNARD.—This comet was observed here on the morning of May 17. It was low in the smoke of the city, and the moon was full, but the comet was pretty bright in the telescope. The tail was faintly suspected, pointing slightly north of following. There was an ill-defined hazy nucleus.

E. E. BARNARD.

VANDERBILT UNIVERSITY OBSERVATORY, May 18.

OBSERVATIONS OF THE COMPANION OF SIRIUS. At the request of Professor YOUNG I send you the measures of the companion of *Sirius*, which have been made at Princeton during the past three years. All except "*i*" were made by Professor YOUNG, "*i*" was made by Mr. MCNEILL. Observations "*e*" and "*f*" were made with the 9½-inch glass. All the others were made with the 23-inch. The magnifying power used was 460 in most cases, 790 was used once, and 300 several times. During the present year the companion has been quite a difficult object except when the seeing was good, and there have been fewer good nights than usual.

	Date.	Position Angle.	Number.	Distance.	Number.
a	1883.105	39.°0	3	9.″41	3
b	1884.245	37. 4	4	8. 88	4
c	1884.267	35. 7	6	8. 75	12
d	1884.280	38. 0	5	8. 92	10
e	1884.286	35. 1	5		
f	1884.286	35. 3	5	8. 26	6
Mean position angle 1884.273, 36.°30.					
Mean distance 1884.270, 8.″70.					
g	1884.929	34. 9	4	[8. 62]	4
h	1884.929			7. 97	4
i	1884.929			8. 01	4
k	1884.932	35. 1	4	8. 19	8
l	1885.031	33. 6	10	8. 07	8
m	1885.201	33. 9	6	8. 01	8
n	1885.225	33. 8	5	8. 11	8
o	1885.231	33. 5	6	8. 22	8
p	1885.234	33. 6	6	8. 14	8
Mean position angle 1885.112, 34.°06.					
Mean distance 1885.089, 8.″09.					
q	1886.036	30. 7	5	7. 77	8
r	1886.039	30. 7	6	7. 46	10
s	1886.042	27. 4	3		
t	1886.072	30. 3	6	7. 54	8
Mean position angle 1886.047, 29.°77.					
Mean distance 1886.049, 7.″59.					

MALCOLM MCNEILL,
PRINCETON, N. J., May 11, 1886. Asst. Prof. Astronomy.

THE RED-SPOT ON JUPITER.—In the April number of the *Observatory*, Mr. DENNING calls attention to the fact that the red-spot is now connected with a belt on the south side, and expresses a hope that Mr. PRITCHETT and myself will be able to see it.

Some two years since I incurred criticism from Mr. DENNING, for asserting, that it was entirely erroneous, that the red-spot had become "merged into a belt."

Subsequently, in connection with this subject, the relative seeing qualities of large and small telescopes, was pretty thoroughly discussed by prominent astronomers. It seems hardly worth while to continue the discussion, but perhaps a few remarks may not be out of place.

During the month of April of the present year, the belt to the south, approached very close to the red-spot on *Jupiter*, so that with a low power or indifferent seeing, one might imagine that the spot was joined to the belt, but when the seeing was favorable, with a power of 300 or upwards, it was seen to be separated by a narrow line of light, so that the outline of the spot was sharp and well-defined. In other words, it did not touch the spot at any point. In this connection Mr. DENNING speaks of using powers of 200 and 300. I think most observers will agree with me that this is not sufficient optical power to settle any disputed point.

In my work on *Jupiter* I never use so low a power as 200, because it is not sufficient to show detail. When the seeing is so bad that 300 cannot be used, I consider the observations of no value.

In the January number of *Monthly Notices* Mr. DENNING has given sketches of the red-spot, for different years. On February 6, 1884, he has a belt hooked on the following end of the red spot, and on February 25, 1885, he has a belt hooked on the preceding end of the spot. At the present time I presume the junction would be on the whole south side of the spot.

From 1879 to the present time, I have never observed any actual connection of the spot with the belts in its proximity.

In 1884, I stated that the spot was never "merged into a belt," and might have added that it was always separated by a visible space. I was under the impression that in this statement I had clearly intimated, that small telescopes did not possess sufficient optical power to show the separation. In view of this fact it is rather refreshing to hear the owners of small telescopes assert that the Chicago telescope failed to show what was readily seen with the smaller ones.

They might with equal propriety assert that the inner satellite of *Uranus*, or numerous double-stars do not exist, because they are unable to see them.

In the study of planetary markings, light and separating power are just as essential as in double-star work.

In the recent discussion on telescopes, the assertion was made again and again, that large apertures give too much light for planetary observation.

My experience with various telescopes, having apertures of four inches and upwards, leads me to the contrary opinion that we do not have light enough, especially when high magnifying powers are used. I have frequently reduced the aperture of the Chicago telescope, when observing *Jupiter*, and always found I could see more and better with the full aperture.

Some recent writers appear to be under the impression that a 6 to 10-inch object glass is the best telescope. Possibly this idea was correct half a century ago, but it is not true now. There has been just as much improvement, in recent years, in the optical performance of telescopes as in any other department of instrumental astronomy. G. W. HOUGH.

JUPITER.—*Black Transit of Satellite IV.* The fourth satellite of *Jupiter* was observed in black transit here with the 6-inch on May 8th. It was first noticed as a black spot at 9*h* 20*m*, Nashville M. T. Some little time previous to this it had been looked for on the disc, but could not be seen either as a white or dark spot. 9*h* 25*m* IV still black and about in conjunction, small, seeing poor. 9*h* 32*m* still black and past conjunction. 9*h* 43*m* IV is very black and rather small and round when best seen. The satellite was not followed after this last observation. E. E. BARNARD.

COMETS *a* AND *b* 1886 (BROOKS).—On the evening of April 27, 1886, while sweeping the northern heavens with the 9-inch reflector, I discovered a nebulous object near the star *Kappa Cassiopeia*, which I immediately decided must be a comet. Only a short time was required to detect motion, which proved to be nearly southeast; and telegraphic announcement of the discovery was made to Dr. SWIFT within two hours, who ordered it immediately cabled to Europe. The comet is large, nearly round and with slight central condensation.

Again, on the Saturday morning following, or May 1, while sweeping the eastern heavens, it was my privilege to discover another comet. It was situated in the great square of *Pegasus*, or in approximate R. A. 23 hours; declination north 21 degrees; with a northerly motion.

BROOKS' COMET NO. 2, 1886. TELESCOPIC VIEW (ERECTED) MAY 7th, 1886. POWER 100 DIAMETERS.

It has a small, but bright star-like head, and a conspicuous tail, presenting a fine telescopic appearance. It very much resembles DONATI'S great comet of 1858 when telescopic. I send herewith a drawing of its appearance on the morning of May 7, my latest observation. WILLIAM R. BROOKS.

RED HOUSE OBSERVATORY, PHELPS, N. Y., May 9, 1886.

COMET *a* 1886 (BROOKS).—The following elements and ephemeris of Comet *a*, were computed by H. V. EGBERT, assistant at Dudley Observatory, and published in *Science Observer*, Nos. 67 and 68:

ELEMENTS. (Comet *a* 1886.)

$T =$ June 7.79, Greenwich M. T.

$\pi - \Omega = 199° \; 30'$
$\Omega = 193 \;\; 35$ } Mean Equinox 1886.0
$i = 87 \;\; 53$

$q = 0.2849$ Motion direct.

These elements represent the places used, as follows:

$\Delta \lambda \cos \beta$	$+0.'03$	$-0.'05$	$-0.''05$
$\Delta \beta$	$+ .10$	$-0. 13$	$-0. 02$

EPHEMERIS.

Greenwich 12 h. 1886.	R. A. h m s	Dec. ° ′	Light.
May 27	3 15 10	+36 00	6.6
June 24	6 52	− 4 56	4.7
July 2	7 55	− 9 24	2.2
July 10	8 49	−11 50	1.2

Light on April 29 taken as unity.

This new comet was discovered by Professor BROOKS, April 28, in *Cassiopeia*. Mr. BARNARD, of Nashville, observed it the same day, finding it "gradually a very little brighter at the center" of the nebulosity, and, in general, having the usual appearance of small telescopic comets. Its path has been southeast through *Cassiopeia*, and the 27th of May it will be among the small stars of *Pegasus*, about five degrees southeast of β, if Mr. EGBERTS ephemeris is followed. This is the day of its greatest brightness. The time of observation will be short because of its unfavorable position.

CORRRCTIONS IN S. M. No. 45.—On page 157, of S. M. for May, in the Nashville mean time of the observations of the position angle of the tail of FABRY's comet, for 4*h*, etc., read 16*h*, etc., which will make the astronomical mean time agree with the dates of the month as given in column first. I had inadvertently omitted to *add* 12*h* to the reading of my watch in the observations. E. E. BARNARD.

COMET *b* 1886 (BROOKS).—The elements and ephemeris of Comet *b*, as computed by Professor FRISBY, Naval Observatory, Washington, D. C.:

ELEMENTS. (Comet *b*, 1886.)

T = May 4.540, Greenwich M. T.

$\pi - \Omega = 38° 45.'5$ ⎫
$\Omega = 287\ 57.\ 2$ ⎬ App. Equinox.
$i = 100\ 57.\ 4$ ⎭

log. q = 9.92551.

EPHEMERIS.

Gr. Midnight.	R. A.	Dec.	Log. r.	Log. Δ	Light.
	h m s	° ′			
May 30	3 32 58	71 9.5	9.9866	0.0905	.49
June 3	4 41 53	71 31.8	0.0032	0.1193	.40
7	5 39 24	70 35.1	0.0204	0.1478	.32
11	6 23 20	69 15.0	0.0380	0.1783	.26
15	6 58 55	66 54.1	0.0557	0.2015	.21
19	7 27 41	64 28.3	0.0734	0.2275	.17
23	7 39 51	62 58.9	0.0909	0.2486	.14
27	7 59 37	60 49.5	0.1081	0.2704	.12
July 1	8 12 33	59 4.3	0.1250	0.2910	.11
5	8 23 24	+57 23.6	0.1414	0.3096	0.10

Light May 2=1

"On May 1, the comet as observed at Cambridge had a nucleus about as bright as an 8½ mag. star with a tail from six to eight minutes of arc in length."

The second new comet of this year, was also discovered by Mr. BROOKS May 1, in the constellation of *Pegasus*. May 2 and the following morning it was seen by Mr. BARNARD who says, "it was a beautiful object, a perfect minature of a great comet. The head was very narrow and bright, and the tail was about one-fourth of a degree long and spread out towards the end. The comet's motion was very rapid to the northeast."

Professor Boss, of Dudley Observatory, also computed the elements of the orbit of this comet which agree closely with those given above. This is noteworthy, because there are special difficulties in computing an orbit so related to the ecliptic.

The comet will continue to grow fainter during this month.

o CETI AND *χ* CYGNI.—In confirmation of a note, relative to the latest maximum of *o Ceti*, by Mr. E. F. SAWYER (S. M. 45, p. 156) I send you the following statement from a private letter of Prof. SCHOENFELD. "The star *o Ceti* was last winter hardly one and one-half or two steps brighter than in 1868, and remained fainter than in 1867." If we consider that the deviation between ARGELANDER'S elements of the maxima and the best observations may amount to twenty-five days, the close agreement of Mr. SAWYER'S observation with the ephemeris is remarkable.

The epoch of maximum of *χ Cygni*, as given in SCHOENFELD'S II Catalogue, viz.: 0.311, has been suspected of being a misprint, especially as the I Catalogue puts the epoch on August 25, 1863. However, Prof. SCHOENFELD informs me, that epoch in his II Catalogue means really 1800, March 11. In fact, his intention was to have the epoch near the middle of all the observations, not only for this star, but for all the rest, except *o Ceti*. I. G. H.

THE WARNER ASTRONOMICAL PRIZES.—It is a gratifying fact that very many astronomical discoveries, and some of great importance, have been made during the past few years. I think this is due in part to the impetus given by competition for the honors and prizes awarded to discoverers, and in order that this interest may to that extent be continued and sustained, I offer *one hundred dollars* for each and every discovery of a new comet made in any part of the world from March 1, 1886, to March 1, 1887, subject to the following conditions:

1. It may be discovered either by the naked eye or telescope, but it must be unexpected, except as to the comet of 1815, which is expected to reappear this year or next.

2. The discoverer, if residing in the United States, Canada or Mexico, must send a *prepaid telegram immediately* to Dr. LEWIS SWIFT, Director of Warner Observatory, Rochester, N. Y., giving the time of the discovery, the position and direction of

motion with sufficient exactness, if possible, to enable at least one other observer to find it.

3. This intelligence *must not be communicated to any other party or parties*, either by letter, telegraph or otherwise, until such time as a *telegraphic acknowledgemcnt has been received by the discoverer from Dr. Swift.* Great care should be observed regarding this condition, as it is essential to the proper transmission of the discovery, with the name of the discoverer, to the various parts of the world, which will be immediately made by Dr. SWIFT.

Three disinterested scientists will be selected to settle any dispute that may arise regarding comet discoveries. H. H. WARNER.

ROCHESTER, N. Y., March 1 1886.

OBSERVATIONS OF BARNARD'S COMET.—

April 19 7:50 P. M. Last sight of the comet in evening.

April 22 4:20 A. M. First sight in morning.

May 3 3:30 A. M. Comet brighter, shows no tail, no stellar nucleus.

May 5 3:30 A. M. Looks like another comet, nucleus stellar, equals 5.5 mag., with tail one degree long and slightly concave on the preceding side.

May 9 3:45 A. M. Comet has larger nucleus as if a disc 5 magnitude; can just be seen with the naked eye; tail two degrees long, and slightly concave on the preceding side.

May 11. Not so brilliant at nucleus; tail traceable only one degree; very little curved. J. R. H.

OBSERVATIONS OF FABRY'S COMET.—

1886 April 1 4 A. M. (75°M. T.). Clear after a week of clouds. Comet Fabry is very bright; has a tail one degree long, is straight and brighter along the preceding edge. Just visible to the naked eye. Its color very white.

April 2 4 A. M. Nucleus probably brighter, and certainly seen by the naked eye. Tail one and one-half degrees long, with preceding edge best diffused.

April 8 4: 10 A. M. Tail generally broader and seems to taper toward the end; preceding edge clearly defined. Color less white than April 1.

April 22 4 A. M. Comet still has stellar nucleus equal to 5 magnitude; tail broad and traceable thirty minutes. Considerable coma, apparently increased in amount towards the *Sun*. Similar appearance seen April 20. J. R. H.

COMET BARNARD.—To observers in northern latitudes, as predicted last month, the comets Fabry and Barnard have not been as conspicuous objects as the computers promised. Their apparent paths were near that of the *Sun*, and their height above the horizon at night unfavorably small.

Under date of May 13, Mr. BARNARD writes of his comet as follows:

The comet discovered here on December 3, 1885, has been an interesting object in the early mornings of late. On May 8th (A. M.) it could be seen as a hazy ill-defined spot with the naked eye. Unfortunately the comet in the morning has been just over the smoky city and consequently has always been seen at a disadvantage; a nucleus shone in the head, but it was not stellar, the image unsteady however, which may have caused the ill-defined appearance. The tail was long and bright, stretching for a considerable distance out of the field of view; it was brighter along the following side, and broader than at former observations.

May 13 (A. M.) The comet seen through heavy smoke over city; it was dimly visible to the unaided eye, the very low altitude and the thickness of the sky prevented any good observation of it. In the 6-inch the comet was bright and a bright hazy nucleus was visible in the head. The tail was broader than formerly.

MEASURED POSITION ANGLES OF THE COMET'S TAIL.

May 7....	Nashville M. T.	15*h* 32.*m*9....	P. A. of Tail	317.°66....	3 obs.
" 12....	" "	15 25. 7....	" " " "	329. 91....	1 "

COMET BARNARD (a) 1885.—The remarks of Prof. SWIFT and of Mr. LEAVENWORTH lead me to give my last observations of this comet.

August 28, with Mr. EGBERT'S ephemeris I picked up the comet which was seen with some difficulty in the 6-inch. It was close south preceding a 9th-magnitude star.

August 31 positive of seeing it, but very faint, it was 8′ or 10′ north preceding a 10th mag. star. Seeing not specially good. After this date poor skies prevented further search for the comet.

Comet Barnard 1884. My last observations of this comet were 1884, November 5, 6, 7, 8, 9, 10, 11 and I feel sure that it could have been followed longer had good skies continued. It was very faint in the five inch on these dates. E. E. BARNARD.

VANDERBILT UNIVERSITY, April 5, 1886.

The following orders and subscriptions have not been previously acknowledged:—

Normal School, Ypsilanti, Mich. Jennie Leys, Los Angelos, California. John L. Bennett, Galena, Ills. (Vol. 4). Professor Charles A. Bacon, Director Smith Observatory, Beloit College, Wis. Professor T. C. George, Natural Sciences, University of the Pacific, San Jose, Cal. Librarian of Baldwin University and German Wallace College, Berea, Ohio. Jas. S. Lawson, U. S. C. and G. Survey, Box 2512, San Francisco.

The Star-Guide: A List of the Most Remarkable Celestial Objects Visible with Small Telescopes, with their Positions for Every Tenth Day in the Year, and Other Astronomical Information. By LATIMER CLARK, F. R. A. S. and HERBERT SADLER, F. R. A. S. Publishers, Messrs. MACMILLAN & Co., London, 1886, pp. 50.

Those students of astronomy who are acquainted with "WEBB'S Celestial Objects for Common Telescopes," will easily understand the purpose of this small book. It may be considered an introduction to such a work as that before named for amateurs having telescopes with apertures ranging from two to four inches.

When the student begins to observe, he does not know, if illustrated, what objects to select that are best suited to the size of his telescope that he may use his time and instrument most wisely. He ought neither to try difficult double-stars or faint nebulæ without experience, knowledge of the instrument used and self-confidence. This little book is intended as a self-help to aid the amateur in making a right start, and to guide him by the readiest path to independent work. It seems to us quite certain that a student with a small telescope and any interest in the multitude of beautiful objects of the nightly skies would not be long in awakening a quenchless ardor with such proper guidance early.

Following an introduction of ten pages, appears the list of most remarkable objects selected for amateur study. Under each month of the year are arranged about fifty objects in the order of right ascension, the first column giving the star's name; the second, the months limiting the time visible; next two, right ascension and declination; the next four, respectively, the mean time of transit at Greenwich on 1st, 11th, 21st, 28th days of the month; the next two, distance and position angle of double-stars; the next magnitudes; and the last column is for remarks. Arranged in a similar manner is a small table of circumpolar stars; a table of objects suitable for telescopes from four to seven inches aperture, numbering two hundred; and a table of twenty-four radiants of shooting stars. Then follows an interesting series of tables of test objects, containing from six to twelve each that are grouped for dividing tests, defining tests and space penetrating tests, in separate tables for telescopes of 2, 3½, 3, 3½, 4, 5, 6 and 7-inches aperture respectively. The next table gives the selenographical latitude and longitude of two hundred and twenty lunar craters and other objects, with the names of each arranged in alphabetical order, and references to WEBB's lunar map, by number and quadrant.

From what has been said of the contents of the "Star Guide" it will evidently commend itself to the attention of all amateurs as a very useful hand book and a time-saving aid in many obvious ways.

The Sidereal Messenger,

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider." — GALILEO *Sidereus Nuncius*, 1610.

VOL. 5, NO. 7. JULY, 1886. WHOLE NO. 47.

PULKOWA DOUBLE-STAR WORK.

[By the kindness of a friend, we have read a private letter written by OTTO STRUVE, some years ago to S. W. BURNHAM, of Chicago, concerning double-star studies. With pleasure and MR. BURNHAM'S reluctant consent, after making at first a positive refusal, we give selections from the pen of Pulkowa's scholarly astronomer.—ED.]

First of all, accept my most sincere thanks for your letter, and the assurance that it will afford me great pleasure to correspond with you upon the subject of Double-Stars,—a subject which has constantly occupied my attention, with short interruptions, since my youth, now more than forty years, and most intimately accompanied the growth of my scientific life. To have fellow laborers in this field, greatly enhances my pleasure, especially when they take hold of the subject as earnestly and eagerly as you and Baron DEMBOWSKI. Our efforts, just because they are not identical in their directions, complement each other happily, and then there can be no mistake that in such ways, by united strength, happy results are brought to light.

From the various writings published by me, you will have recognized in general the character of my efforts in this department—the investigation of the motions of the northern hemishere in single systems. Still more evident will this appear, when the whole series of observations which I began to print at the end of last year, shall lie before you, published in full. But in order to render possible, even now, a deeper insight into this work, and, as the printing progresses, to gratify the wish expressed in your letter for the communication of new measures, allow me now to send you the accompanying twenty proof sheets of that work. I will, if agreeable to you, continue sending them at proper intervals. To explain: I have divided the publication into four sections, the first of which embraces the W. STRUVE stars; the second the O. STRUVE stars; the third the double-stars, which have been discovered by other astronomers (J. HERSCHEL, BURNHAM, DAVIES, ALVAN CLARK); the fourth, doubles of the fifth and sixth classes of HERSCHEL, and other stars with great proper motion. Finally, during the preparation for the press, I shall supply the most recent measures as a supplement to all four of the preceding sections. The publication is divided into two volumes (Volumes IX and X of the Pulkowa Observations) and, as an introduction to the first part, will contain in addition to the historical portion, the investigations concerning personal and instrumental errors, while the introduction of the second part will contain the comparison of the relative motions with the absolute ones, which may have been especially determined for the purpose with the meridian instrument here. Unfortunately, the work has suffered many interruptions, and they still threaten it even now, since I am able to devote to it only a comparatively small portion of my time, on account of other duties—director for twenty years of the Observatory, and for thirty-five years Scientific Conductor of the extended geodetic and geographical labors in the Russian realm.

I cannot but acknowledge the validity of the grounds which have induced you to include in your forthcoming General Catalogue each and every object which has been designated as a double-star by any astronomer, those cases naturally excepted where the observer himself has afterwards pointed out an object which he had introduced erroneously. Through this completeness, and still more through the care which you have exercised in the identification of the objects hitherto uncertain, and in the fixing of the positions, your work will undoubtedly have a very high scientific merit; and it gives me pleasure to extend to you, in advance, thanks for it. According to my idea, completeness in reference to what is designated by any one anywhere as a double-star, is of less importance than a knowledge as complete as possible of what the sky presents only within limits rigidly fixed in reference to distance and brightness. Perhaps you might even yet have the desire to elaborate your work in the given direction, and therefore I will take the liberty of laying before you my views in reference to it. As a starting point we lay down the proposition : double-stars are such stellar pairs as move about one another in orbits under the special condition of mutual attraction of the visible components. Thus we possess already in the researches of my father (Cat. Novus, Mens. Mic, and especially Pos. Med.) frequent evidence to confirm our judgment in regard to the limits, which, according to the laws of probability, and corresponding to our present proofs of gravity, should be adopted for a double-star catalogue, in this more limited sense.

Such a double-star catalogue is a real need in order to give relative limits to those who wish to engage in micrometrical measurements, and to diminish the waste of energy. It would furnish directly a more secure foundation, now almost entirely wanting, for rendering computations according to the theory of probabilities valuable, and leading to wider and positive results. In this case, however, care should be taken that the catalogue be so constructed that it should receive no modification for a long interval of time. A simple division of your present work into two parts, say into special double-stars, and such stellar pairs within four minutes distance, as have been noted and measured by different astronomers — or say in *Duplicæ, Lucidæ and Reliquæ*, would not in itself alone lead to the limits; since hitherto, definite limits in reference to brightness and distance have been accepted scarcely by any one observer. Thus first of all, a systematic revision of the heavens would have to be carried through, in order to obtain a uniform material. An important auxiliary for this, with reference to the brightness of the objects to be investigated, has now been furnished through the Bonn *Durchmusterung*. On the basis of your own work, you will probably find the statement true, that to magnitude 7.0 (according to W. STRUVE) and distance 16 seconds in the northern hemisphere, only a small percentage are still unnoted. Within these limits further accsessions through a new revision, could only be very few in number; although as the systems discovered by you (*e. g.* *β Delphini*) show that, even among the few objects hitherto unnoted, perhaps especially interesting systems might be discovered.

But I think it would be desirable to extend the limits, and perhaps to accept for the principal stars 8.0 (according to ARGELANDER) as the limit of magnitude; for the companion, without regard to magnitude, 32 seconds as the limit of distance, by which named distance the ratio of the physical to the optical double-stars, as experience teaches (*Poss. Med.* page CCXXXX) is at least in the case of the brighter companions very nearly 1 to 1. But beyond 32 seconds the ratio rapidly diminishes, while within that limit the number of optical doubles is proportional to the square of the distance, and soon it would increase to a figure well nigh immeasurable. Beyond these limits, it would be important to establish limits in respect to the magnitude of the companions. Exception should be made of these doubles for which, as *e. g. Regulus*, *40 Eridani*, etc., the physical connection, in spite of the faintest of the companions, is already assured, or at least very probable. For discovering such exceptional cases, which are indeed of great interest, such a Catalogue as the one you are now finishing would be certainly of great use. But the number of these exceptional cases is infinitesimally small, compared with the mass of those objects which could be registered, being only optically near one another.

My opinion, to sum up, is then as follows: a double-star cataloge in the specified restricted sense is a real desideratum, but it should be based upon a systematic revision. What limits should be retained for this naturally stands open for further discussion. In the first place, it would be necessary to find the forces for such a work, which, even within the limits of 8.0

magnitude for the primary, and reaching from the North pole to 30 degrees south declination would require the setting the telescope upon, and careful examination of about 80,000 objects, and which therefore ought not to be laid upon a single observer. But if three or four observers would be willing to share in the work, then it could be far advanced in a couple of years. I have already thought of directing the refractor here upon this work, as soon as I finish my present publication, which perhaps will still require two years, and demand various supplementary investigations. But here we certainly would be limited entirely to the northern hemisphere. Now perhaps you yourself would like to take part in such mutual work, and I should think that one or two especially interested in this subject might be found in Germany or England. Be so kind as to give me your opinions upon these suggestions now thrown out.

The task which you have set yourself at in the completion of your General Catalogue, namely, of collecting as fully as possible, and with all concordance, whatever is designated anywhere as a double-star, and to clear up by personal observation all doubtful estimates therein, and to correct the chance errors which have occured, is truly no easy thing; and I wonder at the energy which has enabled you to advance through the work in a few years. Twenty-five years ago I undertook to investigate only those stars in J. HERSCHEL which were not already included under the W. STRUVE, or O. STRUVE stars, but which according to the given description, might be reckoned as far as possible among double-stars in the restricted sense, as also those casually noted as double by BESSEL and ARGELANDER in their zone-observations, in all six hundred and fifty celestial objects, and I remember that this work cost me much time and fatigue. And what an infinitesimally small fraction has that work of mine been, in comparision with that which you have accomplished in comparatively so short a time!

Besides this, you have undertaken the work of enriching your catalogue with a description as exact as possible of the pairs, and statement of their relative positions, as well as with reference to all measurements, whereby the labor of later workers in orbits will be much lessened. In this part of the work, it will not be entirely agreeable to you to learn that my work, which will contain by rough estimate some 10,000 observations, generally made under good atmospheric conditions, will be only partially accessible to you before the printing of your catalogue.

In the fourth section you will also find a series of objects which are probably not mentioned in your catalogue, but possibly belong in it according to the plan of your work. In regard to these, however, I do not think they ought to be numbered with double-stars. I have for a long time connected by frequent careful micrometric measures about one hundred stars, distinguished by very great proper motions, with neighboring, and generally very faint stars, in order to investigate their connection for the purpose of determining their parallaxes. But to number such stellar pairs among double-stars would be to go far out of the way. Nor have I permitted myself for a similar reason to designate as new, distant companions of known doubles, although at the time I have connected them by measures.

The numbers O. STRUVE 540 to 549, in regard to which you desire more explicit information, I hastily collected only a short time ago, at the desire of Baron DEMBOWSKI, without being able to undertake in reference to them a careful comparison with other catalogues. I take the liberty of copying out of my record books the following details for your use. [These details omitted.]

As you have also consulted the *Bulletin* of the St. Petersburg Academy, no other publication occurs to me which has appeared here, that you have not yet referred to in your work. I will take the liberty however to add a copy of the catalogue *Novus*, and the *Positiones Mediæ* to our next package forwarded through the Smithsonian Institution. The Catalogue of 1843 is unfortunately entirely out of print. Perhaps I might also procure for you a copy of the volumes of the Dorpat Observations, which contain MADLER'S Double-Star Measures, if you do not yet possess them. MADLER'S measures have indeed only a very subordinate value, still they belong to the history of this subject.

I thank you for sending your paper upon the so-called HERSCHEL'S General Catalogue. Although as you correctly remark, this publication is worse than useless, I could not omit its notice in the *Viertiljahrsschrift* on account of HERSCHEL'S name.

Recently, together with the further editing of my observations, I have been specially occupied with investigations on the orbit of 61 *Cygni*. During the last decade, both components have shown a decided diminution of their motion in a straight line. Under a supposition of a uniform motion in a circular orbit, this would give a period of revolution of abont six hundred and fifty years.

I must beg your pardon for writing in German, my mother tongue, although in earlier years I corresponded regularly in English with my English friends, and do this even yet with some of them, *e. g.*, my old and honored friend, Sir GEORGE AIRY. But I find that with an increasing age, correspondence in foreign languages becomes a continually increasing labor, especially, if, as with me, duties multiply, and do not permit proper time and care to be given to each letter. In reference to reading foreign languages, I find, however, it will make no difference if your answers follow in English.

Till to-day your letter has laid in the portfolio devoted to unanswered communications, and I rejoice that I can now take it out, since I hope that the present letter, which has already grown very long, will give you clear evidence of how highly I value your labors, and at least free myself from the reproach of indolence in writing to you. With the highest esteem, yours with true devotion, OTTO STRUVE.

Among the interesting papers in a late issue of *Nature* (June 3) are those on *Sunspots and Prices of Indian Food Grains* by Frederick Chambers, of Bombay, and the *Physical Appearances of Mars in 1886* by W. F. Denning, of Bristol, England. This double number is unusually good.

DIFFRACTION.

By HENRY M. PARKHURST.

After making many observations with different forms of photometers, founded upon the principle of the reduction of the aperture near the eye-piece, I at one time suspended them for several years, chiefly in consequence of my inability to explain the contraction of my scale as compared with that of observers using the principle of polarization. During the last three years I have been observing variable stars, sometimes by comparison and at other times photometrically, and in the latter observations have again met the same difficulty. This became especially glaring in the attempt, by means of a new logarithmic cap with a much narrower opening than I had before used, to connect the stars of the Harvard Photometry with my comparison stars. The brighter stars would disappear with an aperture 50 per cent greater than they should have done with the accepted ratio of 2.512.

The photometric results of Prof. Langley, in determining the reduction of light in its transmission through wire grating (*American Journal of Science and Arts*, Sept., 1885,) suggested the query whether diffraction was not the source of my difficulty, since the logarithmic curves for the brighter stars approach each other very closely, in the case of the last cap above referred to, within 1-30th of an inch. I was unable to learn that there was any mathematical way to ascertain the amount of loss of light by diffraction in a cap of given dimensions, and attacked the problem in the following way.

I reasoned that the light cut off in passing a straight edge, for instance, the side of a large, square cap, would equal a certain definite width, x, so that with such a cap the effective light would correspond with an aperture $2x$ smaller, without diffraction. In order to determine x, we must know approximately the law of the extinction. I assumed for trial three different laws, involving the first, second and third powers of the distance from the diffracting edge. The first power in my formula indicated uniform extinction over the whole width x affected. The second power indicated an increase in approaching the edge proportionate to the distance from the limit of effect y; and the third power increasing in proportion to the square of the distance. Neither of these was a plausible theory, but I hoped that for distances greater than 1-30th of an inch one of them would give satisfactory results, and I could not devise any theories of equally easy computation which would answer that purpose.

Covering the open space at the end of the curve, to increase the effect and to allow of the observation of a much wider range of brightness, I made three series of observations, two with the above cap and the third with the next narrowest cap, and computed the apertures at which the different stars disappeared. Then assuming different values of x and y, and the three different powers, I satisfied the observations as well as I could. The result was that whichever power was used the value of x came out .04 inch as the least that would be admissible, and that a change of the power made no appreciable practical difference with the logarithmic caps that I employed. It varied largely, but with the second and third powers the proportion of the diffraction beyond the distance .08 inch was so small that the errors of observation made it doubtful, even with the narrowest cap, which need no longer be used. As the practical result, I have enlarged the openings of my logarithmic caps by adding .04 inch all around the margin. It remains to be seen whether in actual, long continued use it will be found necessary to increase the value of x, which is the only question necessary to be considered in ordinary photometric work.

Although, from the peculiar shape of my apertures, the question of diffraction is especially important in my apparatus, all other modes of determining magnitudes by measurement of aperture are subject to the same errors, especially when those measured apertures are small. Assuming 9.2 mag. for a circular aperture of one inch diameter, clear of diffraction, there should be an allowance on account of diffraction for the different magnitudes as follows: 14 mag., —.02; 12 mag., —.05; 10 mag., —.12; 9 mag., —.18; 8 mag. —.28; 7 mag., —.44; 6 mag., —.65; 5 mag., —.93. From this it appears that the actual magnitudes corresponding to the last two apertures would be 4.07 and 5.35; an actual difference of 1.28 being contracted to a measured difference of 1.00.

It is manifest that this error is not confined to the brighter stars, when fainter stars are measured by means of small apertures; for if, by cat's eyes, an iris diaphragm, or any similar plan, the actual aperture used is less than an inch, the error of the scale becomes noticeable, no matter how faint the stars which are measured. For instance, by a comparison of the observations with Photometer I, in the third report of the Committee on Stellar Magnitudes, with the observations with the meridian photometer and with the wedge, it will be found that in the average the scale is contracted half a magnitude for each star of the 24 stars. Diffraction would produce a contraction of the scale; but it would require a reference to the original observations to ascertain the degree of correspondence in the amount with that indicated by my own observations. It will be noticed that the large discrepancies between the wedge and Photometer I, occur with the brightest stars observed; whereas it would seem that the brighter stars must have been observed with a larger aperture, making the diffraction the least. Probably this is to be explained by the fact that the observations were differential, and that the whole series with Photometer I was increased beyond what it should have been, by a constant amount; so that the subtraction of that amount would make the observations of the bright stars consistent, and throw the discrepancy upon the faint stars where the effect of diffraction would be greatest.

The Lick Trustees have decided to purchase from Messrs. Feil and Mantois a 36-inch crown disk, which was made by them at the same time with the crown disk of the objective now in the hands of the Clarks. The Clarks "have received the order to figure this disk as a third (photographic) lens for the large objective."

A SHORT METHOD FOR COMPUTING OCCULTATIONS.

CHAS. L. WOODSIDE.

FOR THE MESSENGER.

The more general observation of occultations of stars by the moon by observers in all parts of the earth is, it seems to me, very much to be desired; for occultations, accurately observed, furnish information to the investigator of the moon's motion of a character nowhere else to be obtained. Comparatively few occultations are observed, however, owing principally to the large amount of time and labor necessarily consumed in the computations, all of which is lost should the sky be obscured during the occultation. The method here presented will, in a great measure, I think, avoid this difficulty, for so little time (not more than fifteen minutes) is consumed in computing an occultation by this method that the computation need not be made until just before the occultation takes place if the sky is clear, but if cloudy we need not compute at all, thus saving our time and labor. Furthermore, the computations are very easily made, neither the times of immersion and emersion or of apparent conjunction having to be assumed and the entire data being taken from the *American Ephemeris and Nautical Almanac*, and one table easily prepared beforehand for the particular latitude; it is so simple that a school boy can obtain results equally as accurate as can be obtained by a mathematician by the usual methods, and the entire computation can be gone over and proved in less than *two* minutes.

I originally intended to give but a brief notice of the method for practical observers, but have concluded to describe it at length for the benefit of such amateurs as may be interested in but not familiar with the subject.

The method is partly graphic, the diagram being drawn with reference to a certain scale, from the data above mentioned. This scale is called the "Latitude Scale," the number of inches equal to ten (10) divisions being found by multiplying the cosine of the geocentric latitude of the place of observation by the geocentric radius of the earth at the place, and dividing unity (1) by the amount so found. This scale is invariable for all computations involving the latitude of the place for which it is constructed, and the quantities O, Y, x', y' and the moon's semi-diameter express the number of divisions of this scale to be taken in making the diagrams.

The occultation is to be projected on a plane passing through the earth's centre, perpendicular to a straight line joining the earth's centre and the star. On this plane we project the earth's central meridian and the parallel of latitude corresponding to that of the observer, (as seen from the star) in the form of an ellipse, the semi-major axis of which is always ten (10) inches long for all latitudes and is perpendicular to the meridian line; the semi-minor axis of which is of a length equal in inches to the sine of the star's declination multiplied by ten, and is coincident with the meridian line. This ellipse represents the apparent diurnal path of the observer, and, the visible pole being placed at the top of the diagram, the semi-ellipse visible from the star will be *above* the major axis when the latitude and star's declination are of an opposite name and *below* it when they are of the same name. The place of the centre of the ellipse on the plane of projection is at a distance from the earth's centre equal to the quantity O, which quantity is found by multiplying together the sine of the geocentric latitude, the geocentric radius of the earth, the cosine of the star's declination and 100. This quantity is to be measured on the meridian line, north from the earth's centre if the latitude is north and south if the latitude is south.

The moon's path on the plane of projection is represented by a straight line, the direction of which is found by means of the co-ordinates x' and y', the former being measured on a line parallel to the major axis of the ellipse and the latter being measured north if prefixed by the sign +, and south if prefixed by the sign — (as indicated in the *Ephemeris*) on a line joining the easterly extremity of x' and perpendicular to it. The place of the moon's centre on the plane of projection at geocentric conjunction in right ascension is at a distance from the earth's centre equal to the quantity Y, which is found by multiplying the quantity *Y*, as given in the *Ephemeris*, by 100. This quantity is also to be measured on the meridian line, north from the earth's centre if prefixed by the sign +, and south if prefixed by the sign —, as indicated in the *Ephemeris*. The co-ordinates x' and y' represent the moon's hourly motions in right ascention and declination respectively, and are found by multiplying the quantities x' and y' as given in the *Ephemeris* by 100. The moon's semi-diameter is always equal to 27.23 divisions of the Latitude Scale for all latitudes and occultations.

The ellipse (which for convenience we will designate as the star's path) is to be divided into intervals of five minutes of time by drawing ordinates to abscissæ of lengths equal in inches to the sines of 1¼° multiplied by ten, 2½° multiplied by ten, 3¾° multiplied by ten, etc., up to 90° multiplied by ten, all measured perpendicularly from the minor axis. This dividing of the ellipse is for the purpose of showing at once the place of the star for any moment of hour angle and is the same for all occultations. The moon's path is also to be divided into hours and minutes, the extent of the moon's motion in one hour being exactly equal to the hypothenuse of the right angled triangle formed by the co-ordinates x' and y'.

The moon's and star's paths having been laid out, it will be evident that, given the local hour angle of the star at the time of the moon's geocentric conjunction in right ascension, we know at once the exact places of the star and the moon's centre at that moment; for the place of the former will be at the hour and minute on the ellipse indicated by the hour angle and the place of the latter will, of course, be at the meridian line. Knowing this, and knowing also the extent of the moon's motion in one hour, we can easily find its place for any other time by dividing its path into hours and minutes, reckoning from the meridian line and the time of the hour angle; and the moon's path is therefore to be divided throughout its whole extent for that purpose.

Now as the moon and star move along in their respective paths, there will be two places where the moon's centre and the star will be separated by an extent equal to the moon's semi-diameter, at the first of which will occur the immersion and at the second the emersion. Now, knowing the local mean, standard or sidereal time at which the moon's centre was at the meridian line (at geocentric conjunction in right ascension) and also knowing as before, the extent of its motion in one hour, we can easily find the time at which its centre was at any other place on its path by again dividing its path into hours and minutes of the same scale as before, reckoning from the meridian line and the time of geocentric conjunction; and its path is again to be divided throughout its whole extent for that purpose. Therefore, the places of the moon's centre relative to this second division of the moon's path will correctly indicate the local mean, standard or sidereal time (whichever it is desired to find) at which the immersion and emersion will take place. Circles may be drawn to represent the moon and the north points and vertices marked. The north point is in a direction from the moon's centre parallel to the meridian line; the vertex is in a direction from the moon's centre parallel to a line joining the earth's centre and the star. The angles which the points of immersion and emersion make with the north point and vertex may now be easily measured.

Now, in order that the diagrams may be drawn with the greatest facility, the computer must supply himself with the following things:

First, the "Latitude Scale." This may be made with pen and ink on the edge of a piece of card, but as the scale is invariable for the place, the divisions had better be cut on wood or metal. The number of inches equal to ten divisions of the scale is to be computed as previously directed.

Second, an ellipsograph. This instrument may be purchased at any mathematical instrument store, or one made for the purpose. The one I use consists essentially of two bars or tracks of ¼ in. square brass placed at a right angle and screwed to a triangular piece of sheet brass. On each of these tracks slides a carrier, which carries a bar at one extremity of which is fastened an ordinary writing pen. This does the work very quickly and accurately.

Third, a card, on which are drawn the ordinates to the ellipses corresponding to five-minute intervals of time. These ordinates have abscissæ of length equal in inches to the sines of $1\frac{1}{4}°$ multiplied by ten; $2\frac{1}{2}°$ multiplied by ten, etc., up to 90° multiplied by ten. Thus, $5^m = 0.218$ in., $10^m = 0.436$ in., $15^m = 0.654$ in., etc., all measured from the minor axis. The diagram paper being laid on this, the ordinates will be seen through it and may thus be easily marked on the ellipse. Only a small portion of the ellipse is required in practice.

Fourth, as the extent of the moon's hourly motion differs at different times, a scale of equal parts for dividing this extent into minutes of time will be required. This "hourly scale" is also to be drawn on card, 52 divisions of the latitude scale across the top and 64 divisions across the bottom—top and bottom divided into six equal parts and one of those parts into ten, and connected by straight lines.

Fifth, the moon's semi-diameter scale, being simply a piece of wood or metal, diamond shaped, the length of which is exactly equal to 27.23 divisions of the latitude scale.

Sixth, a table giving the quantity O and the length of the semi-minor axis for every ten minutes of declination up to 28°.

Seventh, compasses, pen and ink (or pencil if preferred), paper, a T square, a rule divided into tenths of inches, a straight edge about twenty inches long and a protractor for measuring the angles.

To illustrate the working of this method, let us compute the circumstances of the occultation of 37 *Sextantis*, 1886, April 14, for Harvard College Observatory, Cambridge, Mass., the position of which is:

Latitude geographic, ...	$= +42° \ 22'.8$
Longitude from Washington, ...	$= - \ 0^h \ 23.7^m$
Difference of time, Standard (75th meridian) and Washington, ...	$= - \ 0^h \ 8.2^m$

and the co-ordinates for which are:

$$\log \rho \sin \varphi' = 9.82641$$
$$\log \rho \cos \varphi' = 9.86915$$

Latitude Scale, 10 divisions = 1.3516 inches.

Turning then to the *American Ephemeris*, page 425, we take out and compute the star's local hour angle and standard time of geocentric conjunction thus:

Wash. Hour Angle	$= +1^h\ 7.9^m$
Diff. longitude	$= -0\ 23.7$
*Local Hour Angle	$= +1\ 31.6$

Wash. M. T. of Conj.	$= 10^h\ 15.3^m$
Diff. time	$= 0\ \ 8.2$
Standard Time of Conj.	$= 10\ \ 23.5$

Also, we take out from our table for finding O and the semi-minor axis,

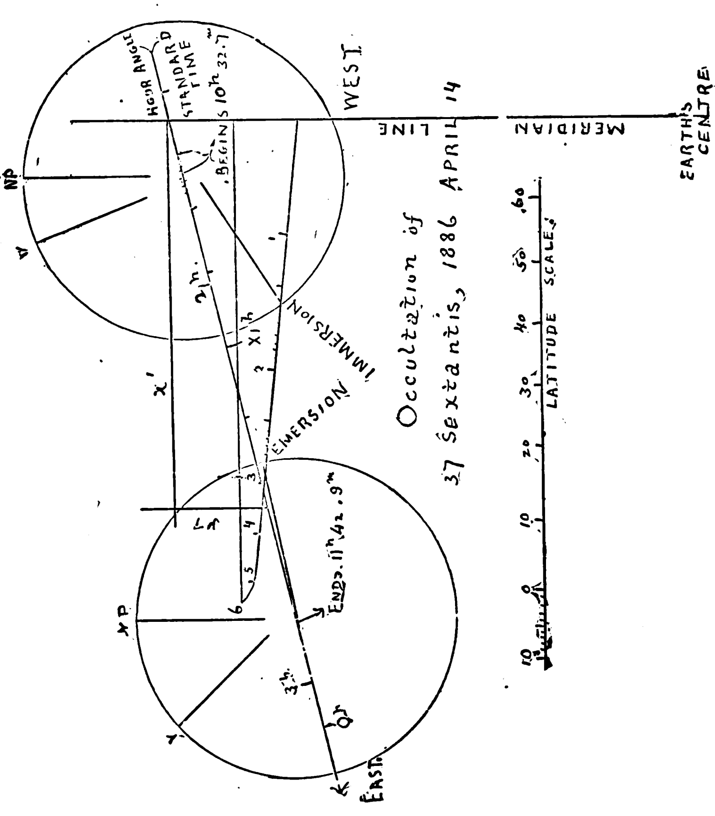
$$O = 66.55 \text{ divisions.}$$
$$m = 1.21 \text{ inches.}$$

and from the *Ephemeris*, mentally multiplied by 100,

$$Y = +76.25 \text{ divisions.}$$
$$x' = 57.90 \quad \text{"}$$
$$y' = -17.49 \quad \text{"}$$

and we are now prepared to construct the diagram represented in Fig. 1, at one-fourth the real size. Commence by drawing the meridian line and major axis, so placing them that when the ellipse is drawn the place on it corresponding to the star's hour angle will be at or near the centre of the paper. Now draw the ellipse (or that portion of it required—usually about two hours) and mark the five minute intervals of time on it. Then with the latitude scale measure O south (as the latitude is north) on the meridian line to find the earth's centre and from this point measure Y north (as that quantity is +) to find the place of the moon's centre at geocentric conjunction in right ascension. Next measure and draw the co-ordi-

* Hour angles must always be considered positive, *i. e.*, *past* the meridian.



OCCULTATIONS OF 37 SEXTANTIS, 1886, APRIL 14.

nates x' and y', and draw the moon's path ; measure on a slip of paper the extent of the moon's motion in one hour, and, by the aid of the " hourly scale " divide it into ten- and one-minute intervals. Now, placing the star's hour angle at the meridian line, by the aid of this scale divide the moon's path on one side into intervals of ten minutes ; then take the moon's semi-diameter scale and find the approximate places of the moon's center at immersion and emersion. The ten minute intervals within which the moon's centre will lie are then to be divided into minutes and the exact places of the moon's center at immersion and emersion found. Then, placing the "standard" time of geocentric conjunction at the meridian line, again divide the moon's path (on the other side) as before, and we have at once the "standard" time at which the immersion and emersion will take place. Circles may now be drawn to represent the moon if desired, the north points and vertices found and the angles measured and the computation is complete, giving the following results, Eastern standard (75th meridian time):

Immersion, at 10*h* 32.7*m* at 124° from the north point and 96° from the vertex.

Emersion, at 11*h* 42.9*m*, at 285° from the north point and 245° from the vertex.

Duration of occultation, 1*h* 10.2*m*.

At the observatory the immersion was observed by Prof. Searle with the 6¼ in. Clacy refractor at 10*h* 32*m* 17.2*s*. The emersion was not seen.

If all occultations visible at a place are to be computed, it will be found very convenient to go over the "Elements" in the *Ephemeris* and select those fulfilling the conditions of visibility, and mark on the margin of the page opposite the particular occultation the quantities O and m. Then, when constructing the diagrams, all the quantities may be taken directly from the *Ephemeris*, and measured at once. I have said that not over fifteen minutes was consumed in computing an occultation by this method, but I very frequently compute one in *ten minutes*, and I think that anyone, having acquired that familiarity with the process which comes with practice, can do the same.

ON PERSONAL ERRORS IN DOUDLE-STAR OBSERVATIONS.

H. C. WILSON, CINCINNATI OBSERVATORY.

(Continued from page 179.)

FOR THE MESSENGER.

Similarly it may be shown that at 90° (fig. 5, page 175) the parallel measure will presumably coincide with the true angle, while the normal measure will deviate in the directions *nn* and *n' n'* according as the head is inclined to the right or left. It will be seen that the errors of the normal measures increase with the angle from the vertical, while those of the parallel measures increase with the angle from the horizontal; and that both change signs with the quadrants. The corrections to be applied may be determined from the differences between the two classes of measures of the same stars.

The effect of the inclination of the head upon the measures of distance is not so apparent. In my own case, the difference between normal and parallel measures ($n-p$), is negative near the vertical and positive near the horizontal position, while it passes through zero near 45°. This would seem to indicate that with me the inclination of the head produces a tendency to *exaggerate* distances, while it makes no difference whether the eyes are normal or parallel to the stars.

It may be of interest to give here the results of an investigation of my personal errors during the period from 1882 to 1886. For this investigation I selected those stars which I had observed with both positions of the eyes on the same night, in order to eliminate the effects of bias peculiar to certain nights. Most of the observations were made with a magnifying power of 450. In the preliminary investigation I used only the measures made with that power. Afterward measures made with other powers were included, the differences having been first multiplied by the square root of the ratio of the magnifying power to 450. The difference $n-p$ for each pair of measures of position angle, then gave an equation of the form,

$$e=a+bw+cw^2+\text{etc.},$$

in which w represents the reciprocal of the distance between the stars, and *a*, *b*, and *c* are coefficients to be determined and which depend upon the angle with the vertical, the method of observing, and the peculiarities of the observer. Dividing the equations into groups depending upon the angle with the vertical and solving by the method of least squares, the following set of equations was obtained:

V	$n-p$	No.
0°	....	....
25	$e = -0°.7 - 3°.4\ w$	35
45	$= -0\ .4 - 4\ .5\ w$	36
65	$= -0\ .3 - 3\ .3\ w$	26
90	....	....
115	$= +0\ .3 + 4\ .2\ w$	35
135	$= +0\ .0 + 4\ .7\ w$	33
155	$= +1\ .0 + 2\ .1\ w$	23

The groups near 0° and 90° were omitted because I had neglected to note the direction in which my head had been turned for each measure. The signs in those groups were therefore discordant and I did not feel at liberty to change them arbitrarily to make them agree. It will be seen that the signs are all negative in the first quadrant and positive in the second, and that the coefficients do not differ more than can be accounted for by accidental errors of observation. Indeed, if we take the means of the three equations in each quadrant we shall find that they are numerically identical. It is probable that the difference (n—p) is constant for any given distance and the corrections n and p will therefore be complementary to each other. I preferred, however, to retain the coefficients as they stand in the above equations and to form from them, by interpolation, a table of corrections, assuming that the error should be equally divided at 45°, and that it should belong wholly to the parallel measures at 0°, and to the normal measures at 90°. After the preliminary corrections had been applied, the arithmetical means of all the observations of each star were taken and from these means the individual, uncorrected observations were subtracted. The resulting differences arranged in groups according to angle and distance are given in the following tables:

	15° n	p	No.	45° n	p	No.	75° n	p	No.
0″—2″	+ 0°.3	— 3°.8	8	+ 1°.2	— 2°.2	18	+ 4°.3	— 0°.7	4
2 — 8	+ 0 .2	— 1 .6	16	+ 0 .9	— 0 .9	20	+ 1 .4	— 0 .4	15
8 — 32	+ 0 .2	— 0 .8	12	+ 0 .5	— 0 .5	13	+ 0 .9	— 0 .1	6

	105° n	p	No.	135° n	p	No.	165° n	p	No.
0″— 2″	— 4°.2	+ 0°.8	10	— 2°.0	+ 1°.6	15	— 0°.4	+ 3°.6	11
2 — 8	— 1 .4	+ 0 .4	15	— 0 .6	+ 0 .3	25	— 0 .4	+ 1 .6	16
8 — 32	— 0 .6	+ 0 .2	5	— 0 .3	+ 0 .2	16	— 0 .2	+ 0 .7	6

The corrections seem to be practically the same in both quadrants, only in the reverse order; also, the corrections to normal are the same as those to parallel in the reverse order. They may therefore be combined, without regard to sign, in groups which depend upon the angle of inclination of the head, and if the mean distances of the three groups be assumed 1″ 5″ and 16″, we shall have

	15°	45°	75°
1″	± 0°.5	± 1°.7	± 4°.0
5	± 0 .3	± 0 .7	± 1 .5
16	± 0 .2	± 0 .4	± 0 .8

The sign + applies when the head is turned to the left, and sign — when the head is turned to the right. In these groups the corrections are approximately proportional, directly to the angle, and inversely to the square root of the distance. They may therefore be represented with a sufficient degree of accuracy by the general formula

$$c = a\,I\,\sqrt{w}$$

in which I represents the angle of inclination of the head and a is the only coefficient to be determined. Applying this formula to all of the observed differences, I obtained the following values of a for the three groups:

15°	$a=+0.040$
45	$a=+0.038$
75	$a=+0.043$
Mean	$a=+0.040$

The agreement between these values is quite satisfactory and a may be assumed constant.

The above corrections may be perhaps a little more accurately represented by the formula

$$c=a+b\ w+ \text{etc.},$$

but the coefficients a and b will vary with the angle. The equations for the three groups will be

$$15^\circ \quad c = +\ 0^\circ.2 + 0^\circ.4\ w$$
$$45 \quad c = +\ 0.3 + 1.5\ w$$
$$75 \quad c = +\ 0.6 + 3.4\ w$$

The corrections computed by the two formulæ are nearly identical up to 75°; and observations made with the head inclined more than 75° should be rejected. I prefer therefore to use the first form.

The comparison of the measures of distance gave the following results:

NORMAL—PARALLEL.

	0°	No.	45°	No.	90°	No.	135°	No.
0″— 2″	—0″.07	7	—0″.03	13	+0″.08	2	—0″.01	13
2 — 8	—0 .05	12	0 .00	21	+0 .10	14	—0 .03	26
8 — 32	—0 .15	5	+0 .01	12	+0 .06	2	+0 .03	7
Mean.	—0 .09	24	0 .00	46	+0 .09	18	0 .00	46

These differences do not appear to vary with the distance but do not show considerable change with the angle. The fact that the parallel measures are the greater at 0° and that the normal measures are the greater, by the same amount, at 90°, *i. e.*, the measures in which the head is inclined most are largest, would seem to indicate that the inclination of the head produces a tendency to exaggerate distances, while the fact that the measures are equal at 45° and 135°, where the inclination is equal in either direction, would seem to show that no effect is produced upon the distances by the different relative positions of the eyes and stars. It is probable that the measures would be improved by the application of a system of corrections something like the following:

	n	*p*
°	″	″
0	0.00	—0.09
45	—0.04	—0.04
90	—0.09	0.00
135	—0.04	—0.04
180	0.00	—0.09

The effect of neglecting these corrections would, however, only produce a constant error in the distances of about + 0″.04. I concluded therefore not to apply any corrections to my observations of distance.

In order to test my personal equation by comparison with other observers, I collected all the available measures of the doubles in my working list, rejecting in the comparison all binaries and doubtful measures. The results of the comparison between my corrected measures and those of W. STRUVE, DEMBOWSKI, BURNHAM and the previous Cincinnati observers, are given in the following tables, arranged in groups according to angle and distance:

COMPARISON OF POSITION ANGLES.

	W.—Str.	No.	W.—Dem.	No.	W.—Bu.	No.	W.—C. O.	No.
0°	—0°.1	23	+0°.4	20	+0°.7	5	+0°.6	46
45	+0 .8	10	—0 .9	11	—1 .3	10	+1 .1	44
90	+0 .6	12	—0 .5	13	+1 .0	9	+0 .7	43
135	+0 .7	12	+0 .8	16	+1 .1	9	+1 .3	45
Mean.	+0 .5		0 .0		+0 .4		+0 .9	

	W.—Str.	No.	W.—Dem.	No.	W.—Bu.	No.	W.—C. O.	No.
1″—2″	+0°.6	6	+0°.6	12	+0°.5	8	+1°.8	38
2 —4	—0 .1	17	+0 .1	17	—0 .4	10	+0 .7	42
4 —8	+1 .1	11	—0 .4	12	+0 .3	6	+0 .8	39
8 —16	+0 .1	16	0 .0	14	—0 .1	8	+0 .7	38
16 —32	+0 .3	7	+0 .1	5	......	..	+0 .8	21
Mean.	+0 .4		+0 .1		+0 .1		+0 .9	

COMPARISON OF DISTANCES.

	W.—Str.	No.	W.—Dem.	No.	W.—Bu.	No.	W.—C. O.	No.
0°	+0″.11	23	+0″.18	20	+0″.07	5	+0″.05	46
45	+0 .19	10	+0 .15	11	+0 .21	10	+0 .07	44
90	+0 .19	12	+0 .25	13	+0 .16	9	+0 .07	43
135	+0 .16	12	+0 .19	16	+0 .19	9	+0 .03	45
Mean.	+0 .16		+0 .19		+0 .16		+0 .05	

	W.—Str.	No.	W.—Dem.	No.	W.—Bu.	No.	W.—C. O.	No.
1″—2″	+0″.02	6	+0″.09	12	+0″.22	8	+0″.08	38
2 —4	+0 .09	17	+0 .14	17	+0 .07	10	+0 .03	42
4 —8	+0 .30	11	+0 .33	12	+0 .10	6	+0 .09	39
8 —16	+0 .25	16	+0 .30	14	+0 .39	8	+0 .10	38
16 —32	—0 .05	7	—0 .02	5	....	..	—0 .05	21
Mean.	+0 .12		+0 .17		(+0 .19)		+0 .05	

Professor STONE found, by comparison with the corrected measures of W. STRUVE, that the position angles in Publication No. 5, require a constant correction of about + 0°.6 (Introduction, page xix). This will explain, in part at least, the nearly constant difference between my measures and those of the previous Cincinnati observers as indicated by the column *w—c. o.* It appears then from the first two tables that my systematic errors in the measurement of position angles have been satisfactorily eliminated.

In the last two tables, on the other hand, all the comparisons conspire to show that my measures of distance, except for large distances, are too great. It is interesting to compare the differences in the last table with the following corrections to the distances of Str., Dem. and C. O., as derived by comparison with O. STRUVE'S results (see Pulkowa Observations Vol. IX, page 131, and Pub. Cin. Obs. No. 5, page xxiii).

	Str.	Dem.	C. O.
1″.6	0″.00	+0″.02	+0″.08
2 .9	+0 .14	+0 .14	+0 .20
5 .6	+0 .22	+0 .22	+0 .22
12 .0	+0 .19	+0 .20	+0 .06
23 .9	+0 .08	+0 .06	—0 .16
	+0 .13	+0 .13	+0 .08

When these corrections are applied my deviations almost entirely disappear. If, then, O. STRUVE'S results are reliable, I may conclude that my measures of distance as well as of angle are nearly free from systematic error.

Mt. Lookout, April 15, 1886.

EDITORIAL NOTES.

The next number of the MESSENGER will be published for September, as August will be one of our vacation months.

The meeting of the American Association for the Advancement of Science for 1886 will be held in Buffalo, N. Y., beginning August 18. Accommodations at the large high school building of that city have been secured, and adequate local arrangements are assured, and a large meeting is anticipated. For particular information address the local Secretary, Dr. Julius POHLMAN, Buffalo, N. Y.

DISCOVERY OF COMET BROOKS NO. 3, 1886.—On Saturday evening, May 22, 1886, I discovered a new comet in the head of *Virgo*, its approximate position being R. A. 11*h* 45*m* and Decl. +10°. Although in a nebulous region, I at once suspected its cometary character, and prompt telegraphic notification was made to Dr. SWIFT of the Warner Observatory. The next evening I was enabled to confirm the discovery by a second observation, as also did Dr. SWIFT the same evening, both observations being made with difficulty through thick haze.

The comet is large, nearly round, and not a difficult object in a fair sized telescope. An observation obtained last evening gave its estimated position, R. A. 11*h* 58*m* 30*s* and Decl. +6° 01′.

WILLIAM R. BROOKS.

PHELPS, N. Y., May 29, 1886.

From the Albany positions of May 25, 28, and 31, Mr. H. V.

EGBERT has computed the following elements, which are published by permission of the Director of the Dudley Observatory.

ELEMENTS.

$T = 1886$, May 28.76, Greenwich M. T.

$$\left.\begin{array}{rl} \pi - \Omega = & 170^\circ\ 13' \\ \Omega = & 46\ \ 03 \\ i = & 16\ \ 59 \end{array}\right\} \text{Mean Eq. 1886.0.}$$

$q = 1.5122$

Light May 25=1.0.

The comet is about one and one-half minutes of arc in diameter and faint, with an ill defined nucleus in the n p part.—*Science Circular, No. 70.*

The elements of this comet have also been computed by Dr. H. OPPENHEIM, varying but little from those given by Mr. EGBERT. We are not aware that an ephemeris of this comet has been computed by any one beyond June.

OBSERVATION OF COMET *c* (BROOKS) 1886.—Ring micrometer observation of Comet *c*, made at Vanderbilt University Observatory, as follows:

Nashville mean time, 1886, May 24, 8*h* 46*m* 48*s*.
Apparent right ascension, 11*h* 52*m* 43.82*s*.
Apparent declination, +8° 20′ 26.2″.
From four comparisons with Yarnall 5021,
Comet preceded star by 2*m* 28.52*s*.
Comet south of star 12′ 27 7″.
Mean place of star for 1886, .0.
Right ascension 11*h* 55*m* 11.05*s*.
Reduction to apparent R. A. +1.29*s*.
Declination, 8° 33′ 1.0″.
Reduction to App. Decl.—6.5*s*.

E. E. BARNARD.

THE DOUBLE STARS 30 AND 41 GEMINORUM.—The wide unequal pair 30 *Geminorum*, the discovery of which is attributed to Mr. EDGECOMB in 1878, appears to have been first noted by Lamont in 1836. The only measures I know of are:

Lamont, 185.1° : 32.00″ : 1836.24
β, 184.1 : 28.05 : 1879.06

The difference is probably due to the proper motion of the large star. The neighboring star, ξ (31) Geminorum, has also a distant *comes* according to the Munich observer. ξ has an annual proper motion of —0.0087 seconds and —0.195″ (Auwers). In his note on 41 Geminorum (*O Σ* 162) in the 47th volume of the "Memoirs" of the R. A. S., Mr. Burnham remarks that the measures of Maedler and his own "would seem to indicate considerable change if the early distance is correct," (of also *Memoirs* R. A. S., vol. xliv) and he gives the following results:

Maedler, 164.9° : 13.5″ : 1843.22
β, 154.9 : 21.16 : 1879.15

This eminent observer has, however, apparently overlooked Maedler's note on this object appended to his single observation, recorded in the 11th volume of the Dorpat Observations, page 53, "distanz geschatz." Taking all the circumstances into consideration, it would perhaps be premature to suggest any real change in the angle. DEMBOWSKI only appears to have looked for this object once, and notes "1865.97, veduta nessuna compagna." It was rejected from the revised catalogue of O. STRUVE because the distance was over 16″, and the magnitudes of the companion less than 8—9.

HERBERT SADLER.

LARGE PROPER MOTION IN A SMALL STAR NEAR 70 OPHIUCHI.—In the "English Mechanic" for July 14th, 1882, I drew attention to the very large proper motion of a star near 70 Ophiuchi (Σ 2272), and again in the pages of the same periodical for July 10th, 1885. I believe that the proper motion in question is by far the largest hitherto known to occur in the case of so small a star, for Professor HALL rates it about 13 mag., though as Se. called it 11 mag. in Σ's scale, the Washington observer may have estimated it rather too faintly. It seems to have been first noticed by the late Admiral SMYTH, as a little star about 5.5 seconds of time south preceding 70; but the only measures I know of are as follows:

Secchi,	215.08°: 87.514″.	1856.627
Hall,	197.84 : 71.384.	1878.842

The annual proper motion of 70 Ophiuchi is about 1.13″ in the direction of 169.5°, and that of this small star 1.28″ in about 82°, or larger than that of 70 Ophiuchi itself, and far larger than any hitherto known to belong to so faint a single star (for such the distance of this faint *comes* from the bright pair entitles it to be called); as FLAMMARION'S ascription of a large proper motion to a small star between 36 Ophiuchi and 30 Scorpii is obviously untenable, and indeed rests wholly on the presumed accuracy of a diagram by Admiral SMYTH. The *measures* of that observer are not usually considered to be very reliable now-a-days; his diagrams resemble nothing in the heavens above, or in the earth beneath. In view of the very large deviations of the motion of the components of 70 Ophiuchi from the orbits constructed from the best observatories, deviations which are increasing with very great rapidity, and to which I drew attention in my note in the above mentioned paper of July 10th, 1885, it is desirable that this small star should not be neglected by those astronomers who measure the bright pair, though it may exceed the ordinary limits of distance. There is another small star in 49.59° : 87.209″ : 1878.84 (HALL) which was only observed in position angle by SECCHI (67.2°). The change is probably due to the proper motion of 70 Ophiuchi itself. HERBERT SADLER.

London, June 9th, 1886.

ORBIT OF COMET *b* 1886 (BROOKS).—From Prof. FRISBY'S observation of May 3d, and my own of May 1st and 6th, comprising an arc of some 10° in geocentric longitude and 8° in latitude, I have computed the following orbit of Comet *b* 1886

(BROOKS). The observations have been corrected for parallax and aberration, and the orbit carried to a second approximation, a third being unnecessary.

$T = 1886$, May 5.02796, Gr. M. T.

$$\left.\begin{array}{rl} \pi - \Omega = & 39^\circ\ 46'\ 12'' \\ \Omega = & 288\ \ 34\ \ \ 1 \\ i = & 101\ \ \ 1\ \ 39 \end{array}\right\} \text{Mean Eq. 1886.0.}$$

$\log q = 9.92562$.

Middle Place $(c-o)$

$$\Delta\lambda \cos\beta = -5''$$
$$\Delta\beta = +2$$

O. C. WENDELL.

Harvard College Observatory, June 10, 1886.

THE GREAT LICK EQATORIAL.—The contract for mounting the 36-inch objective has been awarded by the Lick Trustees to Warner & Swasey, of Cleveland, for $42,000. The telescope is to be fifty-seven feet long; the diameter of the tube is forty-two inches. The tube is suspended at the middle, and the point of suspension is to be thirty-seven feet above the floor of the dome. The axes on which the tube moves are supported by a heavy iron column 17x10 feet at its base. Provisions are made by which it is possible for the observer at the eye end of the telescope to command all the possible motions, and these same motions can also be controlled by an observer stationed on a small balcony twenty feet above the floor. It is expected that in spite of the great size of the telescope itself and of its great weight, the mechanism will be so delicately adjusted as to require little physical force. Messrs. Warner & Swasey are to have this mounting completed in April, 1887, and sometime during the summer of 1887 the glass will be brought to Mount Hamilton and put in place. The cost of the entire apparatus is as follows: Cost of the dome, $56,850; cost of the mounting, $42,000; cost of the visual objective, $53,000; additional cost of the photographic objective, $13,000. Total, $164,850. Besides these sums several thousand dollars will be required to put the instrument into its final completed state.

NOTE ON REPOLISHING SURFACES OF ROCK-SALT.—In the Proceedings of the American Association for August 1885, Mr. J. A. BRASHEAR describes a method for producing optical surfaces of rock-salt which in his hands gives results leaving little to be desired in the way of accuracy of figure and brilliancy of polish. These surfaces, however, when exposed to the air, deteriorate more or less rapidly, according to the hygrometric conditions at the time, and soon become opaque and unfit for use. As the change in an ordinary dry state of the atmosphere is a gradual one, it is often a rather nice question to decide when it has advanced to such a point as to render the surfaces unfit for their work. The production of brilliant surfaces by Mr. BRASHEAR'S method requires, besides the necessary appliances, much experience in such manipulations, doubtless well worth acquiring, but not always in the possession of the experimenter, and thus the restoration of the original polish when dimmed will in general be beyond his power.

It very frequently happens, however, in investigations in radiant heat, where rock-salt finds its chief use in physical research, that the extreme accuracy of figure obtained by the above process is by no means necessary, whereas great transparency, *i. e.*, with good material, brilliancy of polish of the surfaces is always absolutely essential. Under these conditions it is convenient to have some rough and ready way of renewing the polish of the dimmed surface, even at the expense of its perfection of figure.

After considerable experimenting with different substances, I have found nothing which gives better results for this purpose than thick, soft Canton flannel. It should be spread out on a smooth flat surface like a table top, or, better, a marble slab, with the furry side up. Breathe evenly over the surface of the rock-salt prism or plate and rub it quickly with circular and then with straight strokes upon the flannel. As soon as it glides easily, without much friction, remove it and examine the surface, and if not bright repeat the operation, using a different part of the cloth. It is best to wear a pair of kid gloves, to avoid the condensation of moisture from the hands. A surface almost as bright as the original can be produced in this way, and the irregularities of figure caused by the rubbing are surprisingly small. A prism by Mr. BRASHEAR, which had been treated as many as eight times in this manner by the writer, still defined the Frauenhofer lines with considerable sharpness, and the refracting angle had been altered less than 1′. The surfaces, when examined with a test plane by means of interference bands in sodium light, showed curious irregularities and a general slight convexity of figure.

Lenses may be treated in the same manner, the cloth being held in the hand, unless a rounded surface of approximately the curvature of the lens is at command, but as they are usually thin they must be handled with great caution. It will of course be understood that nothing can be done in this way with surfaces originally bad, nor can much improvement be made in surfaces which have been badly corroded by exposure in too moist an atmosphere. The process applies only to surfaces of good figure which have become dimmed by exposure under ordinary conditions. After being repolished in this way as many times as experience shows is allowable, the surfaces must be treated by a more perfect process like Mr. BRASHEAR'S in order to restore their original accuracy of figure.

J. E. KEELER.

DISCOVERY DATES OF BROOKS' COMETS *a*, *b*, *c* 1886.—The correct dates of discovery of the Brooks Comets *a*, *b*, *c* 1886, are as follows:

Comet *a*, on the evening of April 27.

Comet *b*, on the morning of May 1.

Comet *c*, on the evening of May 22, civil reckoning.

On page 186 of the June MESSENGER the discovery of Comet *a* was given wrongly as April 28.

A New Minor Planet, No. 258 magnitude 11, was discovered by Dr. LUTHER, at Dusseldorf, May 7.

OCCULTATIONS OF STARS IN THE HYADES, OBSERVED AT THE DAVIDSON OBSERVATORY,

SAN FRANCISCO, CAL., FEB'Y 12TH, 1886.

$\varphi = +37° \ 47' \ 24.1''$

$\lambda = 8^h \ 09^m \ 42.52^s$ W. of Gr.

No.	Star.	Dis. or Reap.	Ob-server.	Instruments, Etc.	Time Noted by Chronom.	Corr'n to Chron.	TRUE LOCAL TIME. Mean.	TRUE LOCAL TIME. Sidereal.	Remarks, Etc.
							February	12, 1886.	
				in.	h. m. s.	m. s.	h. m. s.	h. m. s.	
1	Theta (2nd) Tauri	Dis ..	D......	6.4 Equat., 90 diams. Sid.* 3479 ..	2 29 49.2	+0 01.50	4 57 51.34	2 29 50.70	Good. Daylight.
2	75 Tauri	" ..	"......	do. do. do..................	2 35 37.2	01.50	5 03 38.39	2 35 38.70	Faint and difficult.
3	Theta (2nd) Tauri	Reap.	"......	do. micr. eyepiece 240 diams.....	2 58 38±	01.52	....	....	See note (a) below.
4	Theta (1st) Tauri.	" ..	"......	do. do. do..................	3 17 52.3	01.54	5 45 46.61	3 17 53.84	Sharp. C. B. H. marking time, etc.
5	B. A. C. 1394.....	Dis ..	"......	do. eyepiece 40 diams...........	3 33 15.1	01.55	6 01 06.90	3 33 16.65	Good. do. do.
6	B. A. C. 1391.....	Reap.	"......	do. micr. eyepiece 240 diams.....	4 47 55.1	01.63	7 15 34.74	4 47 56.73	Possibly ½ sec. late. do.
7	D. M. +16°: 619...	Dis .	"......	do. power 150 diams.............	5 22 05.4	01.66	7 49 39.47	5 22 07.06	Very faint, but good. D. marks time.
8	B. A. C. 1406.....	" ..	"......	do. do. do..................	5 24 04.9	01.66	7 51 38.65	5 24 06.56	Very good.
9	D. M. +16°: 618...	" ..	"......	do. do. do..................	5 27 01.5	01.67	7 54 34.77	5 27 03.17	Doubtful—faint.
10	B. A. C. 1406.....	Reap.	"......	do. micr. eyepiece 240 diams.....	6 44 48.5	01.76	9 12 09.12	6 44 50.26	Faint;—late one second ?
11	*a* Tauri..........	Dis ..	"......	do. do. do..................	6 50 48.2	+0 01.77	9 18 07.85	6 50 49.97	Good—instantaneous. See note (b).
12	*a* Tauri..........	" ..	C. B. H.	3in. Recon., 105 diams., M. T.* 231	9 29 30.8	−11 22.73	9 18 08.07	6 50 50.19	Good. "Dropped out of sight."
13	*a* Tauri..........	Reap.	G. D...	As before........................	8 03 21.2	+0 01.84	10 30 29.03	8 03 23.04	Good—fine ruby red appearance.
14	*a* Tauri..........	" ..	C. B. H.	As before........................	10 41 51.7	−11 22.72	10 30 28.98	8 03 22.98	Flashed out sharply at this instant.

NOTES.

No. 3 (*a*).—Actual reappearance missed; first seen at this time and estimated 8 or 10 seconds late.

No. 11 (*b*).—Did not have chronometer beat, but counted from inst. of disappearance. Original record of 48.3 seconds—perhaps better.—D.

A working list was prepared as follows: the apparent place of the moon was computed for each hour of G. M. T., and plotted on section paper, as were also all the stars in that locality. The path of the moon being established, the times and angles of disappearance and reappearance were read off approximately, etc. The average error of the prediction was —0.5*m*., maximum 4.2*min*.

OBSERVERS.—D. = Prof. George Davidson.
C. B. H. = Chas. B. Hill.

The Sidereal Messenger,

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider." —GALILEO *Sidereus Nuncius*, 1610.

VOL. 5, NO. 8. OCTOBER, 1886. WHOLE NO. 48.

THE MERIDIAN CIRCLE OF THE LICK OBSERVATORY.

GEO. C. COMSTOCK.*

For the Messenger.

Through the kindness of the Lick trustees I was invited to spend a portion of the past summer at Mt. Hamilton, and the meridian circle of the Lick observatory was placed at my disposal while there. The opportunity thus afforded was employed in making a preliminary study of the character and performance of the instrument, some portions of which may be of interest to readers of the SIDEREAL MESSENGER.

The summit of Mt. Hamilton, originally a sharp peak, has, by blasting and removing the *debris*, been transformed into a plateau barely large enough to furnish room for the observatory buildings and the offices connected with them. Upon the north-eastern verge of this plateau stands the meridian circle house so close to the edge that from the north end of the transit slit a stone may easily be tossed across the winding road that leads up the mountain far down into the deep canyon that forms its northern limit. At the southern edge of the plateau is mounted the azimuth mark or "mire" at a distance of less than one hundred feet from the meridian circle. West of the meridian circle house is the transit room connected with the former by a tower placed between the two buildings, and still beyond is the dome for the twelve inch

* Professor of Mathematics and Astronomy, Ohio State University.

equatorial, forming the northern end of the main building at whose southern extremity is the dome, not yet completed, for the great thirty-six inch telescope.

The meridian circle house is large and roomy and furnishes an admirable receptacle for the noble instrument which it shelters. The building consists of two independent walls, connected only by the window casings and separated by an air space of two feet. The outer wall is of light iron louvre work, the inner one is a mere shell of handsemely finished California redwood. Between the two walls is stretched a curtain of sail cloth to keep out the fogs which in the winter completely envelop the mountain. The instrument itself is still further protected by a sliding canopy which is pushed into an alcove at one side of the observing room when the instrument is in use.

The meridian circle was constructed by the Repsolds of Hamburg, with the exception of the objective of 6½ inches aperture which was made by Alvan Clark & Sons. Although mounted in 1883, it has not hitherto been found practicable to use the instrument for scientific work or even to investigate its constants. The instrument is of the modern type represented in Fig. 25 of Newcomb and Holden's Briefer Astronomy. Ten years ago there was not a meridian circle of this kind in America, but now the observatories at Williamstown, Madison and Northfield possess instruments by the same makers, similar in their essential parts to the Lick observatory circle but not provided with all of the accessories which are here introduced.

A distinguishing feature of the Repsold meridian circle is that the telescope and circles, instead of being supported by wyes and counterpoises fastened immediately to stone piers extending up to a level with the highest parts of the instrument, are carried upon open iron castings which rest upon piers of masonry or stone. These castings also support the microscopes which in the older forms of instruments were usually fastened immediately to the stone piers.

The theory of the old form of mounting was to obtain for the telescope a massive support which should be, as nearly as possible, immovable. The heavy piers were, however, found to become heated during the day, and at night when the instrument was in use, the brass and steel of the instrument having rapidly cooled off, were subject to a radiation of heat from the warmer piers which introduced errors of an irregular and anomalous character into the results of observation with the instrument. To escape the effects of this storage and radiation of heat the Repsolds, followed by some other makers, have substituted for the upper part of the pier the iron castings above mentioned so that every portion of the instrument, except a small part of the end of the telescope, is lifted above and away from the masonry. The wyes of the Lick observatory circle are fifteen inches above the tops of the piers, the piers are themselves wrapped in a non-conducting material and the whole enclosed in wooden jackets, thus largely reducing the dismal range of temperature of the piers as well as protecting the instrument from their radiation and allowing the air of the observing room to circulate freely about all parts of the instrument.

It must be confessed that an observer familiar only with the massive mounting of the older instruments feels instinctively that the iron castings of the Repsold instrument must furnish an unstable if not an insecure support for the telescope, but experience with such circles, both at home and abroad, has abundantly shown that such is not the case.

The meridian circle possesses two divided circles which are smaller and stiffer than those ordinarily made by other makers for an instrument as large as this. Each of these circles is divided to two minutes (2′) and is read by four micrometer microscopes. One of the circles is firmly clamped to the axis and remains always in the same position; the other turns freely about the axis and may be clamped in any position relative to the fixed circle, thus affording a means of eliminating the effect of division errors in the determination of a star's place by observing the star successively upon different parts of the circle, while with a fixed circle the star for a given position of the clamp is always observed upon the same divisions. The division lines upon the circles are purposely made very coarse, the width of each line being about 12″. This, in connection with an admirable and very ingenious system of illuminating the circles, makes the pointing of the micrometer microscopes upon the graduation very easy and rapid without at all impairing its accuracy. The probable error of a single micrometer pointing is about 0.11″, which compares very favorably with the corresponding quantity for larger circles with finer lines. The settings of the instrument may be made from either the north or south side of the piers by means of two telescopes of low magnifying power which point upon the same division of the fixed circle, thus avoiding the necessity for small setting circles. Both telescopes are enclosed in a single tube pointing north and south and viewing the fixed circle by means of prisms placed before their objectives. The field of view of these setting telescopes is about two degrees, and as every degree mark on the circle has its number engraved opposite it, there is always at least one number in the field of view, and the setting of the instrument is made by turning it until the proper division on the circle comes under a thread stretched in the focus of the setting telescope. One lamp placed on each side of the instrument in the prolongation of the rotation axis serves to illuminate the setting telescope, all of the microscopes, the microscope heads and the transit and micrometer threads at the eye end of the telescope.

The telescope is provided with two complete eye ends, with a suitable battery of eye pieces. One of these has the ordinary spider line transit threads and a printing declination micrometer. This eye end I have not used and can say nothing as to its performance. The other carries a ruled glass reticle mounted upon a micrometer by means of which the collimation can be measured and the reticle set so that the collimation constant shall be zero. The declination micrometer has the ordinary divided head which must be read by the observer after each bisection of a star. Both eye ends are provided with rapid motion screws in hour angle and declination, so that a large field is secured even with high power eyepieces.

The collimators of this instrument deserve special mention. They are telescopes with Clark objectives of 6½ inches aperture and are the equals in optical power of the meridian circle telescope. These large objectives are desirable for many reasons, among which may be mentioned the increased precision of the pointings of the collmiators upon each other and the utilizing of the whole objective of the meridian circle telescope in determinations of collimation and horizontal flexure. Recent experiments with the transit circle at Greenwich have shown the latter to be a matter of importance.

The meridian circle is provided with east and west collimators and a telescope in the rotation axis by which the figure of the pivots may be investigated. No investigation of this kind was possible in the time at my disposal.

The observations of a single month, made under unusual circumstances and with an unfamiliar instrument, cannot be relied upon to indicate the quality of the results to be expected from the instrument. I find from the data available that the probable error of a clock correction and an equator point from a single star are respectively $0.03s \sec \delta$ and $0.5''$. It is probable that these quantities can, under more favorable conditions, be considerably diminished.

The atmospheric conditions prevailing upon Mt. Hamilton attest the wisdom of its selection as the site of a great observatory. From July 24 to August 23 there was no night upon which meridian observations would have been impossible and but three upon which clouds would have appreciably interfered with observing. The average "seeing" during that period I should estimate at four on a scale of five.

The rapid progress which the Lick trustees are now making toward the completion of the observatory justify the expectation that within a year regular observations may be begun with this instrument. Eleven years have passed since James Lick executed the deed of trust by which he provided for the erection of the Lick observatory, and dissatisfaction has sometimes been expressed that its completion has been so long delayed, but the candid visitor to Mt. Hamilton who contemplates the magnitude of the work which has there been accomplished and the difficulties under which it has been carried forward, must concede that if haste has been made slowly it has been made wisely and that the scientific world is under a debt of gratitude not only to the founder of the Lick observatory but also to the gentlemen who have for so long disinterestedly given their time and their talents to the accomplishment of a work which now approaches its successful completion.

INSTRUMENTAL PHOTOMETRY.

By HENRY M. PARKHURST.

[Reply to the paper of S. C. Chandler, at the meeting of the A. A. A. S., Aug. 23, 1886.]

I was reminded of the pertinacity with which Hevelius adhered to plain sights, after the proposition was made to introduce telescopic sights. By his skill and experience he was able, either to equal the accuracy of the observations by the new method, subject probably at first to systematic errors of collimation, parallax, etc., from the lack of attention to such details, or so nearly to equal it that in the absence of accepted standards of comparison it could not easily be demonstrated that his observations would be improved by his adoption of telescopic sights.

It is not necessary, in order to prove the superiority of the instrumental photometry, that we should deny that after years of experience, mere comparisons can be as accurately made. It is enough to show that instruments can take the place of the skill derived from long experience. I well remember, at the second meeting of this Association, in 1849, when Prof. Sears C. Walker first exhibited to this section, Saxton's chronograph, his statement that a child in observing transits could equal the accuracy of trained observers with the eye-and-ear method. Training will no more make an observer than it will a poet. I do not think that any amount of training would ever make my estimations of brightness as reliable as those of Chandler, Sawyer, or the observers at Cordoba. But my instrumental method only requires me to judge of a single degree of brightness, and that is not difficult to learn.

We are now looking upon instrumental photometry in its infancy, and have a right to expect more from it hereafter. If steam can lift the lid of the tea-kettle, we may expect it to "drag the slow barge and drive the rapid car." If to-day, notwithstanding all the unknown sources of systematic error, an instrumental method will yield tolerable results, we may reasonably expect to develop from it a method which will yield good results.

Before the invention of the clock, it was practicable to obtain the right ascensions of the stars with some degree of accuracy, by observing them in sequences, estimating the intervals of time. I have sometimes accidentally applied that method in my photometry, forgetting to put my watch to my ear, and not discovering until after the extinction that I had been recording the time without its aid. Some one brings to the astronomer observing transits in sequences, a watch, with a crown wheel-scapement, running down in an hour. He tries it, and says he can do better without it; its rate changes too fast. But an unskilled observer takes that watch, ascertains how much its rate changes from minute to minute, and then, by winding it every half hour he can at once get more accurate results than would be possible without it; and furthermore, that watch may develop into the dead-beat scapement, or the compensation pendulun of the astronomical clock.

The method of sequences in photometry will yield useful results; but while there is no way to insure the equality of the scale in different parts, as there would be none in observing transits by estimation, there is the additional disadvantage that there is no way to connect the ends of the scale. It does not return into itself, as the star returns to the meridian at the end of twenty-four hours. So we find that Argelander, with all his experience, when he reaches the 8 mag. begins to crowd his scale, so that by the time he reaches 9.5 mag. he has really reached the 10.5 mag. upon the same scale he employs for the brighter stars. Mere estimations cannot correct themselves. For this purpose instrumental photometry is a necessity.

Another great advantage of instrumental photometry is its freedom from bias. When I compare a series of stars by estimation, I cannot compare the same series again on the same evening, or even months later, without danger of bias. But instrumental observations can be repeated immediately without possibility of bias.

What is most important is to discover the sources of systematic error. As I have a photometric method of my own, and as Mr. Chandler may yet subject my results to the same criticism he has applied to others, (and I wish he would,) let me say here that my observations of long period variables have generally been as bad as I could make them, and for this reason: In order to discover the sources of systematic error, and to test my apparatus under the greatest variety of conditions, I have made it a rule, in taking a second series of observations within a few days, to make the conditions as different as I could; and especially where I suspected an error, I have endeavored to exaggerate that error beyond anything which need to occur in practice. I have not yet reached the position in which I should be willing to undertake elaborate work, although I think the apparatus better adapted for accurate results, in certain departments of stellar photometry, when properly constructed and arranged, than any other.

Most of the instrumental methods have been subject to serious systematic errors. The method of diminishing the aperture, with which I commenced about thirty years ago, is subject to an error, exceeding a magnitude, from the brighter stars being extinguished in a darker field. Optically diminishing the aperture by a bar across the interior of the telescope, has the same effect. The amount of this error can be ascertained, and the correction applied; but I am not aware that it has ever been done.

Pritchard's wedge is subject to the same error from illumination, provided it is so constructed as to observe all the stars visible with the aperture employed.

My own method is not affected by any error from illumination; but there may be an error of diffraction with this photometer, as also with the method of extinguishing apertures, or with Photometer I at Harvard. I have assumed that the Nichol prisms gave a reliable standard, and have therefore corrected my scale to correspond.

Pritchard's wedge, as it is used, is not subject to the error of illumination, since it is constructed to be used in a black field. As it is not my purpose now to criticize but to defend instrumental methods, I will not take up your time with my objections to it.

It is my own opinion that the Harvard Photometry is subject to the inaccuracy to which Mr. Chandler has referred, and which may be hereafter rectified, either by the original observations, or by additional observations made for that purpose. It is not the fault of the meridian photometer; but if I am right it makes the results appear more discrepant than they really were.

I think it was when experimenting with my disc photometer, that the idea occurred to me that there ought to be a correction for atmospheric obscuration. I made a series of observations to determine the law and the amount of the correction, and formed a table which I submitted to Dr. Gould, who had not yet gone to Cordoba. Dr. Gould referred me to Seidel's table, of which I had never heard. Upon comparison I found that they were practically identical. But the atmospheric correction is not uniform. My conclusion was that we should apply a correction *ao*, *a* being a constant to be determined from the observations of the evening, and which may exceed 3 or be less that ½. This constant for the evening, *a*, not being employed at Cambridge, leads, in my opinion, to discrepancies which might be avoided, or at least diminished.

While therefore I do not believe we have yet reached perfection in the use of any photometric instruments, and while what is called photometry is not after all really measurement of light, but rather estimation of light assisted by instrumental means, yet I believe it is to instrumental photometry that we must look for our standards henceforth in all our work; and with these standards, the results of skilled observers, by mere estimation, may for a long time to come be as valuable and as reliable as those of observers by instrumental methods.

P. S.—When the above was written I had not access to the Harvard Photometry. I find that for northern stars, down to the southern tropic, the error resulting from the omission of the coefficient a, would be nearly inappreciable in comparison with errors of observation. It may require a laborious investigation to determine how far the want of uniformity in the atmospheric absorption affects the results for other southern stars observed in a northern latitude.

ELECTRIC PHENOMENA IN THE SOLAR SYSTEM.

By JACOB ENNIS.

The article with the above title by Professor HEYWOOD in the March number of the MESSENGER, is interesting because it is the first attempt, after my own, to show that the aurora borealis and the tails of comets are driven off in their peculiar directions by an electric repulsion from the sun. My Memoir on these subjects was published by the Academy of Natural Sciences of Philadelphia in their Proceedings for the year 1878. Separately it is a pamphlet of twenty pages closely crowded with facts, and may be obtained gratuitously on application by mail to myself, at 216 Congress Street, Houston, Texas. It is entitled the Electric Constitution of Our Solar System. Prof. HEYWOOD does not show where the electricity in the sun, in the comets, and in our atmosphere comes from. Its origin is evaporation. A gill of saline water is changed into about thirty gallons of vapor highly electrified. The rain fall around our globe is at least on an average thirty-six inches a year. This shows the amount of saline water evaporated from the ocean. And the amount of the electric fluid rising daily in our atmosphere is great beyond our conception. Only a very small part of this fluid comes down as lightning. The chief mass of it rises up and is carried by aerial currents toward the poles. From there it is driven off, like the tail of a comet, away from the sun.

Sir John HERSCHEL, in his admirable "Outlines of Astronomy," Art. 570, proves undeniably that the tail of a comet springs from evaporation. The corona of the sun I have shown in my Memoir to be of the same nature as our auroral streamers, and as the cometic tails. Since then the coronal rays have been seen to extend outwardly ten millions of miles. In no known place in creation is there such abundant evaporation as in the sun. The red vapors called the chromosphere are constantly raging and flashing and shooting up to the height of from ten thousand to a hundred thousand miles. The amount of electricity to form the solar corona which this evaporation may liberate, is beyond our conception.

I am not aware of any collection of facts which proves, as Prof. HAYWOOD asserts, that the aurora borealis is most frequent in the winter. It is well established to be a daily occurrence and seen nightly in the auroral zone far to the north all around the globe. It goes round and round from east to west, in the shadowy cone of the night, affording beautiful illumination through certain regions in the base of that cone. Its occasional brilliant exhibitions seen down to latitude 40° and lower, appear to be caused by special electric repulsions from the corona of the sun. The force of that corona must vary wonderfully, and the variations in our aurora must correspond. At some solar eclipses the corona rises not more than a quarter of a million of miles high. At the total eclipse of 1878 it reached upwards, or outwards, some ten millions of miles; that is, twelve solar diameters. See Prof. S. P. LANGLEY'S report to the observatory at Washington, D. C.

The electric manifestations, the lightning and the thunder, are not the cause, but they are the effect, of the summer showers. Therefore, being meteorological and not astronomical, they need not be discussed here.

At the period of writing my Memoir I had been perplexed with several facts where the streamers darting away from the sun and from the comets, did not proceed straight out and in right lines, but obliquely and in curved lines. These seemed to show that they were not of the same nature as our aurora borealis, whose streamers rise vertically. But in an unusually great display of March 15th, 1885, as reported in the United States weather reviews for that month, page 71, the streamers were *inclined*. The passage reads as follows: "Spokane Falls, Washington Territory. A bright aurora appeared at 11:10 P. M. There were three streamers of light pink color, which rose and fell at short intervals; these streamers were not vertical, but were inclined toward the west." This is important, for it aids to identify the tails of comets and the corona of the sun with our aurora, which is well known to be an electric outburst, pointing, like them, away from the sun.

Only one author, as far as I am aware, has opposed my position that all these great phenomena are of the same nature. His objection is that the spectra of their light are all different. This is but a slight opposition, and easily overcome. Every one knows that the spectra of objects vary greatly with temperature, pressure, allotropic condition and other circumstances. In these ways it happens, according to the admissions of the same author, that some elements may have as many as four different spectra. Now the circumstances out of which these great electric brushes arise from the burning sun, from the distant and freezing comets, from our northern zone of the aurora, and from the tropical region of the zodiacal light, all differ essentially. We cannot conceive why these electric brushes should not carry off with themselves small particles of the vapors out of which they spring. And these vapors must all differ from one another, as our viewless watery vapor differs from the red vapors of the solar chromosphere. These illuminated particles carried away must vary the spectra. Our aurora borealis strongly varies its colors. Although generally white and colorless, yet sometimes, as just stated, it may be pink and at others it may be deep red, or green, or yellow, or purple. The something which changes its colors may, and likely must, change the spectra. But enough. The precious space of the MESSENGER must not be occupied by a repetition of the facts contained in my Memoir aforesaid.

THE "RED LIGHT."*

HENRY C. MAINE, ROCHESTER, N. Y.

The appearance of what are known as the red sunsets or red light, in the autumn of 1883, is regarded as one of the most remarkable meteorological events of modern times. The strange feature of the red light was its long duration after sunset, and a peculiar halo or corona about the sun by day. The light after sunset was usually of an orange red or a rose color, and reached far up toward the zenith in the form of an arch, with a bright spot at the highest point. There was also a bright spot and colored arch in the east, opposite the sunset point, as if produced by reflection. The horizon to the north and south was also lighted with red until a late hour, sometimes 9 o'clock. On a few occasions the light assumed the form of alternate sections of rose color, and blue sky, with auroral action in the colored streamers. One of the most interesting exhibitions of the kind was upon the 19th of September, 1885. At nearly every exhibition, when the rose color was prominent, auroral action could be detected. The phenomena of the sunsets changed rapidly, arch succeeding arch with changing colors as the sun went lower and lower. The halo by day had an ashen or salmon tint on the outer border, which shaded into the sky. The border was irregular, being extended in various directions at different times. (See photograph No. 2.)

The ordinary ring or halo about the sun has edges well defined, with more or less display of prismatic colors. (See photograph No. 3.)

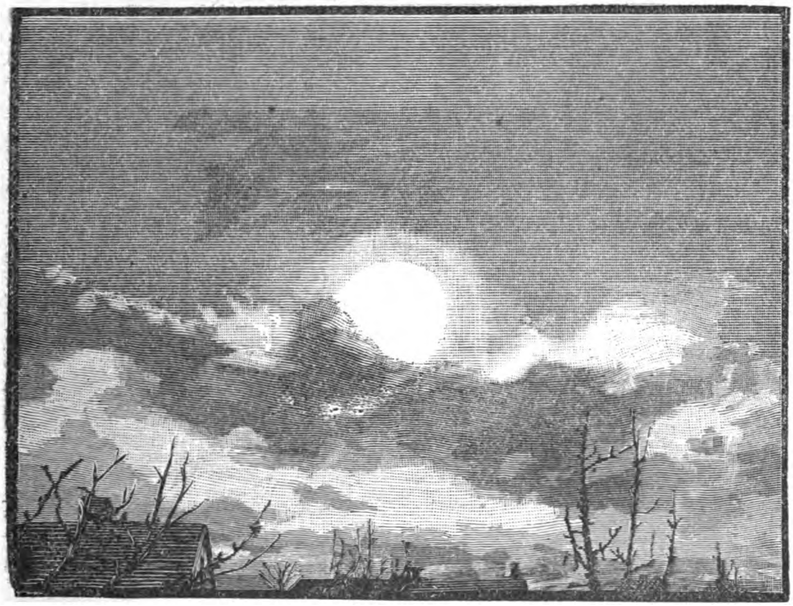
* The western sky was colored a bright roseate hue last evening and all around the horizon and up to the zenith the clouds were fringed with red, a repetition of the red sunsets of last summer. This is the first time the phenomenon has been seen in any degree of magnitude this season.—*Portland Morning Oregonian, July 4, 1885.*

The first step in determining the cause of the halo and unusual prolongation of sunset effects was to ascertain if they corresponded in time and intensity with other phenomena, and then determine the probability of physical connection. When the red light appeared, the sun was near its maximum of activity or spottedness, and the earth had been vexed with the most violent storms, and floods had been very destructive.

No. 1.—The Rosy Sunset of November 22, 1885, photographed by Henry C. Maine, showing the rosy arch and the brilliant light below it near the sun.

Having observed the sun daily, since the solar activity began to increase after the minimum of 1878-9, with the result of noting a correspondence in time of the most terrific storms on the earth with similar disturbances on the sun, observation was extended to the red light. A brief record of the most prominent sunset displays must suffice:

There was great solar disturbance at the time the green suns and red sunsets appeared in the equatorial belt, in the beginning of September, 1883. The green suns were seen at Panama on September 2, and at Trinidad on the same date. On the 1st of September twenty new solar spots appeared, and on that date there were seven groups and ninety-five spots one of which was visible to the naked eye. There were cyclones of great energy in the equatorial seas at the time, and the

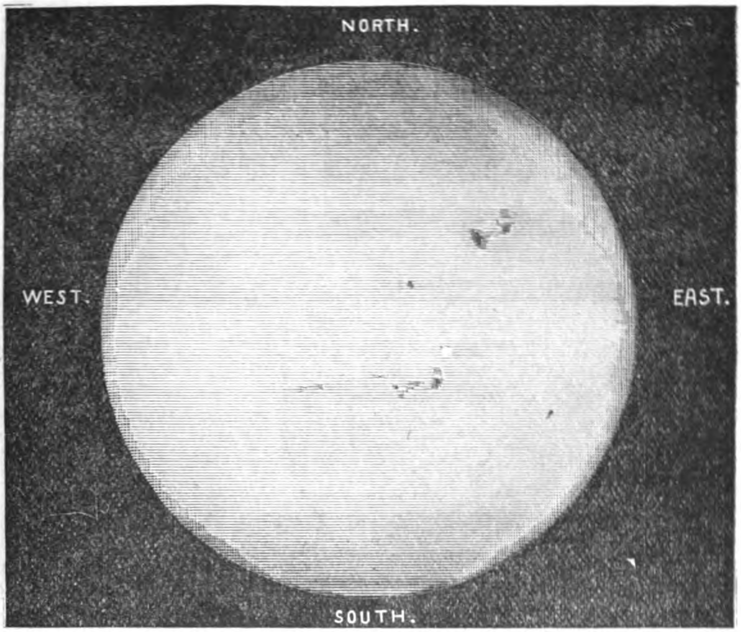


No. 2.—The Red Light Halo about the sun, photographed by Henry C. Maine, November 22, 1885. The vapors near the horizon are also lighted and of considerable actinic energy. A salmon color appeared in the faint outer haze surrounding the central brightness.

captain of a dismasted vessel was one of the first observers of the strange light in the sky. The red light appeared in Western New York on November 24, 1883, after a severe storm had passed over the great lakes. There was great solar disturbance at the time and the light was at a maximum on the 27th. On that day, the ashen halo, mentioned above, was very conspicuous. This persisted with slight changes for more than a year. On the 2d of December the red light was not seen in Rochester, and the sun was nearly clear of spots. A number of new spots appeared on the 6th, and on the 8th the red light re-appeared. It brightened until the 10th, when it was very brilliant. The red light faded as the sun storms disappeared

No. 3.—The Sun, June 18, 1885, photographed by Henry C. Maine.

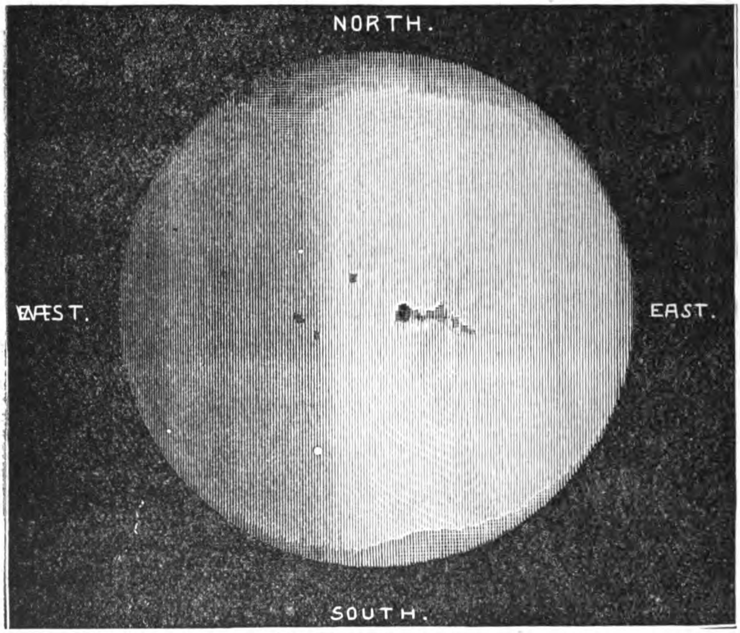
by the sun's rotation. December 21st a spot area of large extent appeared, followed by great meteorological disturbance, and the red light shone again, reaching great brilliancy on the 26th of December. This maximum was also noted by Dr. F. A. Forel, at Morges, Switzerland. The light waned until January 1st, when there was an ordinary sunset. On January 2d active sun storms appeared and on the 3rd, after an electric storm, which drove telephone operators from their instruments in some places, the red light re-appeared. After a great storm, the light was brilliant January 9th and morning of the 10th. On the 17th the light was brilliant, following new solar storms. On January 25th the light was very bright, following a great chain of sun storms. Hurricanes occurred in England on the 22d, and in France and England on the 26th. The red light then decreased in brightness. On the 11th of February active sun storms re-appeared ; tornadoes occured in the south on



No. 4.—Great Group of Sun Spots, June 18, 1885, photographed by Henry C. Maine.

the 13th and the red light was noted on the 14th. On the 19th two new sun storms came, the red light increased, and six southern states were swept by tornadoes. The sky was of a lurid red at midnight, probably from electric action upon vapors of the atmosphere. A new sun storm came February 24th, and the light continued brilliant, but faded in a few days. [The greatest brilliancy of red light, and severest terrestrial storms were noted when sun spots were between the eastern limb and the sun's meridian.]

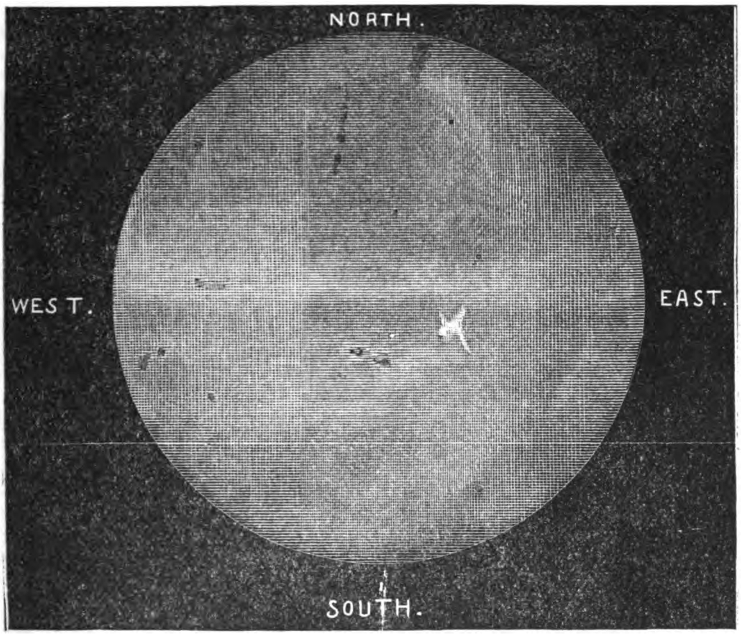
On March 2d, 5th and 6th, new sun storms appeared and the light shone brightly. A destructive general storm followed. More sun storms came on the 13th and 14th and the red light was at a maximum on the 17th. Then there was a descent toward a minimum. March 25th, a sun storm developed on the sun's



No. 5.—Great Actinic Energy about a Solar Storm or Sun Spot Group, June 20, 1885, at noon, photographed by Henry C. Maine.

disc; tornadoes swept seven states. The sun storm developed the largest group of spots seen up to that date. The red light shone with remarkable brilliancy on March 27th. April 1st a great chain of sun spots appeared; tornadoes followed in five states and on the 5th the red light was intense.

Thus the light fluctuated through the entire spring and summer of 1884. In the autumn of that year the skies were very brilliant at intervals, always corresponding with the intensity of solar action. In the late winter and spring of 1885, the sun storms began to diminish, the red light nearly disappeared and the peculiar halo about the sun was no longer conspicuous. Toward the middle of May there was a marked renewal of the solar storms, and by the first of June the spots were very numerous and large. During June the sun was the seat of con-



No. 6.—Hydrogen Cloud on Sun, June 12, 1885, at noon, photographed by Henry C. Maine.

vulsions of the most remarkable character (see photographs of June 20th and other dates,) accompanied by a long series of very destructive storms in all parts of the world. Early in July the red light re-appeared. On the 5th it was seen in Rochester, and in Oregon two days earlier. On the 31st of July the brilliancy of the red light reached a climax. The bright, rose colored spot above the sunset point again lighted objects like a second sunset, and appeared self-luminous.

The sunsets at this date were, as I observed, mostly of a rose color, which varied in intensity. They continued with varying brilliancy through August. The halo about the sun had re-appeared as a white corona, which increased in density until the salmon color on the outer border was noted again on the second of September as very conspicuous, as was also the red light. The halo still persists and was quite brilliant on the day of the annexed photograph, November 22, 1885. By reference to the records of the signal service, it is noted that the red light varied in intensity at different places on the same date, showing conclusively that local conditions must have had a part in producing the phenomena. The best observers reporting to the signal service noted the difference between the orange† and rosy sunsets. The red light continued during September with the usual fluctuations‡, being very brilliant on the 14th, and some days thereafter, following a great solar disturbance preceding the Washington Court House tornado.

These observations show that these phenomena, great storms on the sun, extended and severe meteorological disturbance on the earth, and the red sunsets, corresponded in time and intensity. The fluctuations of the red light also corresponded with the periods of change in solar agitation.§ Is there a fair presumption of a physical connection?

The persistence of the peculiar halo about the sun for more than a year, while the red sunsets were very unequal, sometimes disappearing altogether, indicates that there must be several factors to produce the sunset phenomena. Some of these factors were less changeable than the others. The halo

---

†Vevay, Indiana: Yellow or orange sunsets were observed on the 1st, 5th, 13th, 15th, 17th, 20th, 28th and 30th. Rosy sunsets were observed on the 3rd, 8th, 9th, 10th and 16th.—*Signal Service Monthly Weather Review for August, 1885.*

‡The color of the skies after sunset again deserves note. Many observers record especial coloring on dates from the 12th to the end of the month. The colors are variously described as orange, crimson and pink.—*Bulletin of New England Meteorological Society for September, 1885.*

§M. Faye says: "It is what may easily happen in the progress of a periodic phenomenon which passes rapidly and without fluctuation, from a minimum to the following maximum, but which passes slowly, by a series of secondary oscillations, from the maximum to the following minimum. This is, in effect, the well-known progress of solar spots.

showed but little change for a long period although it was noted that on most occasions the red light was brilliant at night, when the halo was most conspicuous. What was the condition of things which rendered the halo persistent while the sunsets changed, almost wholly disappearing at intervals?

A terrific volcanic eruption in the Straits of Sunda, Island of Java, on the 26th of August, 1883, has been regarded by many as the cause of the red sunsets. It has been held that the dust from the crater spread over the whole atmosphere of the globe at a great height, reflecting back the sunlight, after the sun had set, for a greater length of time than was usual. If the medium of reflection were dust suspended permanently in the atmosphere, and if the dust caused the solar halo, the presence of the halo about the sun by day ought to prove the presence of the dust, and the red sunsets, which are supposed to have been dependent on that dust, should therefore have been uniform during the time the halo was visible. But the sunsets were not uniform during that period as has already been shown. This does not, however, wholly exclude the dust as a possible factor. But it is difficult to conceive how dust could remain in suspension at so great a height for more than a year, then disappearing for a time and returning again last July and August. To explain the long suspension of the dust, those who adhere to the "dust theory" have assumed that it may be mingled with water vapor at a great height. Judging from observation, and the remarkable localization of the red sunsets on many occasions, as before noted, water vapor must be considered a very important factor in their display. The maintenance of water vapor at a height sufficient to reflect or refract the light of the sun after it is twenty degrees below the horizon, a distance which has been calculated by Mr. Serviss and others, requires unusual conditions. Where shall the conditions be sought? Do they exist in the earth itself or its atmosphere? Evidently they do not. Then they must be sought outside, and can be found nowhere except in the sun. The sun's intense activity during the past five years supplies all the conditions necessary to raise the vapor, by added heat and electrical action, to an abnormal height. But the same condition of the sun which would elevate the vapor to a great height, would also greatly increase the evaporation from the waters of the globe and give rise to excessive rainfall. As a matter of fact, such rainfalls have occurred and are now occurring.

Proceeding a little farther, it will appear that a condition of the sun which would produce the effects noted, must also have some appreciable effect upon the sun itself and its immediate surroundings or vaporous envelope. In an annexed photograph (No. 6) of the sun, June 12th, 1885, will be seen a luminous cloud of enormous dimensions, apparently floating high above the sun's surface, for it is brighter than the sun itself. This matter, (probably blazing hydrogen) if it does not pass out among the worlds of the solar system, goes to increase the nebulous matter about the sun. During the extended maximum of solar activity, (which has been stretched out two or three years beyond the ordinary limit,) this matter has passed out almost continually into the vapor envelope of the sun, as smoke and vapor rise in our atmosphere. But this sun vapor rises with much greater velocity from the sun, as the attraction of the sun is greater than that of the earth. The great increase of the eruptions of sun vapor during the present sunspot maximum, would enormously extend the vapor shell about the sun. If the earth is involved in an envelope of its own dust thrown to an unusual height by the Java volcano, as the "dust theorists" claim, how much more must we expect the sun to be involved in its own vapors, since the activity there exceeds by a million or more times the feeble efforts of a world cooled sufficiently to be inhabitable. The sun has the reputation of being a nebulous star. Tennyson says in "The Princess":

> "There sinks the nebulous star we call the sun,
> If that hypothesis of theirs be sound."

Nearly every astronomer who has observed the sun has observed the passage of vast, luminous vapor clouds, mostly hydrogen, into the sun's atmosphere, or away from the globe of the sun. Prof. Young saw such an event in 1871 and recorded it. The cloud rose to the height of two hundred thousand miles from the edge of the sun, at the rate of 167 miles a second, before it faded from view in the spectroscope. Prof. Young calculated that the first outburst of this vapor must have been at the rate of at least 300 miles each second. Louis Trouvelot, at Meudon, near Paris, saw a mass of luminous cloud move out from the sun on the 16th of August, 1885. The observers at New Zealand of the total eclipse of the sun, September 9, 1885, saw with the naked eye a red flame shoot out near the rift of the corona. So far as known, no such vapor cloud was ever photographed until last June, except during a total eclipse. Prof. Young said in his address before the American Association for the Advancement of Science, at Philadelphia, in 1884: "As regards the actual existence of an extensive gaseous envelope around the sun, it may be added that other appearances than those seen at an eclipse seem to demonstrate it beyond question—phenomena such as the original formation of clouds of incandescent hydrogen at high elevations and the forms and motions of the loftiest prominences.

Besides the reasons already stated for believing the sun's vaporous envelope is enormously extended during great solar activity, there is another which is most pursuasive, and which explains a puzzling matter in a reasonable way. That matter is the peculiar retardation of Encke's comet during certain of its perihelion passages, and absence of retardation at other passages. Prof. Simon Newcomb says in his Popular Astronomy: "Dr. von Asten found that between 1861 and 1865 there must have been a retarding action like that supposed by Encke. Carrying his work forward to 1875, he found that between 1871 and 1875 there was once more evidence of a retardation about two-thirds as great as that found by Encke. The absence of such an action between 1865 and 1871, therefore, seems quite exceptional and difficult of explanation."

It will be seen by reference to the past records of solar activity, that the years of retardation were years during or immediately following maximum solar disturbance. The comet was probably retarded then because the solar envelope was greatly extended; and the comet had to move through the vapors thus sent out into space by the eruptions below. When the solar activity in a measure subsided, towards the minimum period, the vapor thus thrown out condensed and returned to the sun, or was dissipated in space. So the comet would meet with less resistance upon another return. It was the opinion of Sir William Siemans that the matter thrown out from the sun's equatorial regions passed out beyond the earth's orbit and returned again by re-curving to the sun's poles. If this theory is true, more matter would pass out from the sun during maximum solar activity than at other times.

Bearing all these facts and theories in mind, is it not probable that the violent solar eruptions during the past five years have so loaded and extended the solar envelope that the nebulosity has become visible, and that the visibility began in the autumn of 1883? The effects of the solar eruptions upon our atmosphere might have been such as to aid in rendering the sun's envelope visible through vapor at an abnormal height. Such conditions explain the persistence of the solar halo, and its changes in form, while the sunset phenomena, which depended partly upon local atmospheric conditions, varied from day to day. The halo or corona about the sun itself may have been exaggerated to our view greatly beyond the actual limits of the solar envelope, by the condition of our atmosphere. Indeed, part of the display must be atmospheric. Suppose an extension sufficient to retard Encke's comet, which had a perihelion distance of about 30,000,000 miles, and it will not be far from the corona which persisted from November 24, 1883, for more than a year, and is still seen at intervals after great solar activity and meteorological disturbance on the earth. But the corona of the present maximum period must be much greater than the coronas which were encountered by the comet on the dates mentioned by Dr. von Asten.

Given this corona or envelope with sufficient density towards its outer edge to reflect the sunlight, and we have the rose colored arch, with its bright spot, which followed the sinking of the sun, with the brilliant reflection in the east; also the sunrise effects, which were quite as notable. Given this corona, and the character of this sunset would change from day to day through the changing condition of the vapor and possibly volcanic dust in our atmosphere. When the atmosphere was heavily laden with vapor and possibly dust from Krakatoa, the arch would be lost in the orange red glow of the gorgeous sunsets, as on November 27th, 1883, and later dates. When the dust had settled, if it was ever in our atmosphere, at the latitude of New York, the rosy arch would persist as it did and the corona would remain also by day. The arch lighted the dust and the watery vapor and the image of the arch was projected on our atmosphere; but when both dust and vapor were at a minimum, the arch alone was seen, with a faint rose color. This color is the one that might be expected from the character of the vapor, mostly hydrogen, in the sun's envelope or corona.

Prof. C. A. Young says in his work on the sun, page 207: "The observations of the eclipse of 1871 by Lockyer and others show that hydrogen in a feebly luminous condition is found all around the sun, and at a very great altitude—far above the ordinary range of prominences." This observation was near the sun spot maximum, and this accounts for the success of the observation, when luminous hydrogen was not observed at other eclipses.

The slightly varying brilliancy of the rosy arch, and of the halo by day is accounted for by the varying energy of the solar erruptions, the condition of the sun changing the condition of the envelope about it, and also affecting the earth's atmosphere. The auroral action of the red light is also dependent upon the solar condition.

With the corona receiving and reflecting the sunlight after the sun had set, it is not necessary to conceive that the water vapor was raised to so great a height as to reflect the sunlight after the sun was twenty degrees below the horizon. But the vapor must have been elevated considerably, as the condition of the sun and the excessive evaporation would warrant this. But such elevation to fit any theory must depend upon the sun and its increased activity. The duration of the red light after sundown was varied by the varying height and density of the water vapor or dust, which were dependent upon meterological conditions.

Prof. Balfour Stewart, the eminent director of the Kew Observatory, says that "the magnetical and meteorological processes of the earth are most pronounced when there are most sun spots." The intensifying of terrestrial meteorology has been so pronounced during the past five years that no argument is necessary here. The record of the tornadoes, cyclones and floods is a part of the history of those years, and is spread out everywhere in the daily press.

From all these considerations it would seem that there is a reasonable presumption of a physical connection between the unusual solar activity and the red light, and that the one is the principal cause of the other.

ADDENDA.—My attention has just been called to the following from the *Scientific American* of the 2d of January, 1886. I presume it had not before been published in this country; and appearing a month subsequently to the date of my essay, in which the same views of the corona were independently advanced, it should not interfere with my claim to original treatment. I trust that you will submit this note with accompanying extract as an addendum to the essay of "OBSERVER."

Prof. Tacchini, a great authority among scientists, gives a remarkable piece of information in a letter to *L'Astronomie.* He records that M. Faval asserts that on high mountains, when the sky is serene, the solar corona is so apparent that it strikes all observers. The mountaineers and dwellers among the Alps agree in affirming that the phenomena is something entirely new. Tacchini also gives an experience of his own on the subject. He made the ascent of Mt. Etna in July last. When near the volcano, at a height of over 10,000 feet, under a clear sky of a dark blue tint, he saw the sun surrounded by a white aureola, concentric with a magnificent corona of a coppery red. The corona was transformed near the horizon into an arc less defined and of much greater extent.—*Scientific American, Jan. 2, 1886.*

ORBIT OF THE BINARY STAR GAMMA CORONAE AUSTRALIS.

H. C. WILSON.

For the Messenger.

The double star γ *Coronae Australis* is one of the most interesting of southern binaries. The components are of about the 6th magnitude and almost exactly equal. The position of the star, R. A. 18*h*. 59*m*., Decl. —37° 18′, is unfortunately too far south for good observations in the northern hemisphere. Its duplicity was discovered in 1834 by Sir John Herschel at the Cape of Good Hope. Elements of its orbit have been published by Captain Jacob in 1855 (Mo. No. R. A. S., Vol. XV), Prof. Schiaparelli in 1875 (Astr. Nach. No. 2073), Mr. Downing in 1883 (Mo. No. R. A. S. Vol. XLIII), and Mr. Gore in 1886 (Mo. No. R. A. S. Vol. XLVI).

As an exercise, I have, in my spare moments during the last month, computed an approximate set of elements, using the graphical method given in "A Handbook of Double Stars," by Messrs. Crossley, Gledhill and Wilson, and including a number of observations of recent date, not yet published. The results are given side by side with those obtained by other computers:

ELEMENTS OF γ CORONAE AUSTRALIS.

Computer.	Jacob.	Schiaperelli.	Downing.	Gore.	Wilson.
	°	°	°	°	°
Position of Node	352.2	229 2	227.4	45.0	41.0
Inclination	53.6	111.4	69.3	47.4	50.5
Position of Periastron	256.2	304.5	284.0	141.0	139.0
Eccentricity	0.602	0.699	0.697	0.322	0.324
Period in years	100.80	55.58	54.98	81.78	78.80
Periastron passage	1863.08	1882.77	1883.20	1886.53	1887.40
	″	″	″	″	″
Semi axis major	2.55	2.40	2.44	1.88	1.85

The large differences between these elements show the uncertainty of orbits derived from an insufficient number of observations. Below are given all the observations upon which my elements depend, together with the differences between the observed and computed position angles and distances. It will be seen that the position angles are well represented, with the exception of those by Powell from 1859 to 1864, which seem to be affected by systematic error. The distances are not so well represented.

Epoch.	Observer.	Position Angles.	Distance.	Differences P. A.	*o—c* Distance.
		°	"	°	"
1834.47	Herschel	36.8	......	—0.6	......
35.55	"	36.5	......	+0.8	......
36.43	"	34.2	......	+0.4	......
37.43	"	32.4	2.66	+0.4	+0.37
47.32	Jacob	13.9	2.30	+0.5	+0.17
50.46	"	5.7	2.29	—0.9	—0.27
51.54	"	4.3	2.26	+0.3	+0.29
52.49	"	2.0	1.90	+0.3	—0.03
52.72	"	0.8	1.90	—0.2	—0.02
53.52	"	358.8	1.83	—0.1	—0.04
53.71	Powell	358.4	......	0.0	......
54.11	Jacob	356.6	1.80	—0.7	—0.04
54.78	Powell	355.4	......	—0.1	......
55.77	"	352.7	......	+0.1	......
56.44	Jacob	349.2	1.67	—1.4	—0.07
57.44	"	347.3	1.61	0.0	—0.08
58.20	"	343.3	1.53	—1.5	—0.12
59.72	Powell	338.0	......	—1.1	......
61.69	"	328.7	......	—2.5	......
62.27	"	325.2	......	—3.5	......
63.84	"	318.0	......	—3.6	......
75.65	Schiaparelli	257.4	1.45	+0.1	+0.11
76.65	Howe	253.1	1.67	+0.9	+0.31
77.43	Schiaparelli	248.4	1.49	+0.1	+0.12
77.61	Howe	245.7	1.37	—1.7	0.00
77.69	O. Stone	249.4	......	+2.3	......
78.49	"	242.4	1.22	—0.8	—0.16
78.49	Howe	242.9	1.47	—0.3	+0.09
79.70	Burnham	240.0	0.87	+2.9	—0.51
80.46	Russell	233.1	1.15	—0.3	—0.23
80.67	Hargrave	232.4	1.32	+0.1	—0.06
81.72	O. Stone	225.5	1.38	—1.5	+0.02
83.62	H. C. Wilson	217.8	1.62	+0.8	+0.32

The differences in the last two columns are almost identical with those obtained by Mr. Gore (Mo. No. R. A. S. Jan. 1886). I think we may conclude that the period is not far from eighty years. It is to be hoped that numerous observations of this star will be obtained during the next ten years, while the distance is small and the angular motion rapid.

MT. LOOKOUT, May 15, 1886.

EDITORIAL NOTES.

This issue of the MESSENGER regularly follows that of July. August and September were vacation months.

In the Section of Mathematics and Astronomy at the Buffalo meeting of the American Association for the Advancement of Science, the following papers were presented:

On the degree of accuracy which may be expected from chronograph records. Wm. A. Rogers.

On a method of determining the constants of Precession which is partially independent of the variations of the Proper Motion of the stars employed. Wm. A. Rogers.

Comparison of Boss' and Auwers' Declination-Standards. Henry Farquhar.

On some mechanical attachments (partly novel and partly not) for facilitating the astronomer's work with the equatorial. David P. Todd.

Change of Latitude of the Sayre Observatory. C. L. Doolittle.

Photographic determination of stellar position. B. A. Gould.

Some account of a new catalogue of the magnitude of southern stars. E. F. Sawyer.

A comparative estimate of methods and results in stellar photometry. S. C. Chandler.

Comparison of the places of the *Pleiades* as determined by Konigsberg and Yale College heliometers. W. L. Elkin.

A neglected correction in the use of Refraction tables. Cleveland Abbey.

Magnifying powers of telescopes. Henry M. Parkhurst.

Telescopic observations of meteor trains. E. E. Barnard.

On the use of Zenith telescopes for latitude. S. C. Chandler.

A new theory of Gravitation. John H. Kedzie.

Apparatus: An instrument to show at any time the direction of the earth in space, in its annual motion. John Haywood.

On a method of obtaining the mean apparent diameter of the sun. Samuel Marsden.

Some of these papers will appear in the MESSENGER later. The substance of some has already been given; all others are solicited.

OCCULTATION OF 4 GEMINORUM BY THE PLANET JUPITER.—In *Ast. Nach.* No. 2741, Mr. H. C. Wilson, of the Cincinnati Observatory, has given a list of occultations observed at Mt. Lookout in the year 1882-3-4. Among them is an occultation of 4 Geminorum by Jupiter on Nov. 7, 1882, and as occultations by a planet are rarely observed, I have thought it worth while to extract this observation and prepare the elements for its reduction.

The position of the planet is taken from the *American Ephemeris* for 1882, and the place of the star from Newcomb's *Standard Stars*.

But one phase was observed, the disappearance, which took at 12*h.* 2*m.* 20*s.*, Mt. Lookout mean time, corresponding to the Greenwich mean time, 17*h.* 40*m.* 1.4*s.* For this epoch the position of the star and planet are as follows:

JUPITER.

	α			δ		
Geocentric	6*h.*	3*m.*	25.95*s*	+23°	1′	7.6″
Parallax			+0.08			—0.7
Apparent	6	3	26.03	+23	1	6.9

4 GEMINORUM.

	α			δ		
Mean 1882.0	6*h.*	3*m.*	20.53*s.*	+23°	0′	57.4″
Reduction			+4.56			—6.1
Apparent	6	3	25.09	+23	0	51.3

From the above we have

$$\Delta\alpha = -0.94s.$$
$$\Delta\delta = -15.6$$

from which we find the position angle and distance of the star, referred to the center of the planet,

$$p = 224.48°$$
$$s = 21.86''$$

NEW YORK, N. Y., Sept. 14th, 1886. JOHN TATLOCK, JR.

ON THE NEBULA 4036 OF HERSCHEL'S GENERAL CATALOGUE.—In SIDEREAL MESSENGER (Vol. III, 1884, p. 189) I called attention to an error in the description of the nebula, G. C. 4037.

The position of this object as given in G. C. is also widely erroneous.

On June 29th and 30th four ring micrometer observations of the nebula were made with the 6 in.

The comparison star was Yarnall, 6205.

The mean of the four comparisons gave

Nebula precedes star by 3*m*. 14.68*s*.

Nebula south of star 9′ 1.4″

Applying these corrections to the position of the star we have for the place of the nebula:

$$\left.\begin{array}{l} \alpha = \;\; 14h.\;\; 56m.\;\; 58.43s. \\ \delta = -32^\circ \;\; 37' \;\; 8.1'' \end{array}\right\} 1886.0$$

The description with 6 in. is

S; B; R; vvmbM; probably a stellar nucleus.

Observations corrected for refraction.

Vanderbilt University Observatory, Nashville.

E. E. BARNARD.

MAGNIFYING POWER OF TELESCOPES.—The question of the magnifying power of a telescope, when used to form an image of the sun of a specified diameter upon a screen, was recently submitted to various persons, with a great variety of answers. The problem may be said to be indeterminate, but it is no more so than the magnifying power of a microscope. It requires an assumption of the distance of the eye from the image; and it seems proper to make the same assumption that is made with microscopes, 10 inches. This gives the

Rule—Divide the diameter of the image by the sun's apparent diameter in arc with a radius of 10 inches; or for practical purposes it will be sufficient to multiply the diameter in inches of the image upon the screen by 10.

HENRY M. PARKHURST.

RING MICROMETER OBSERVATIONS OF COMETS FABRY AND BARNARD, MADE AT THE LEHIGH UNIVERSITY OBSERVATORY.

COMET FABRY.

Date.	Mean Time.	$\Delta\alpha$	$\Delta\delta$	Comparisons.	Apparent α	Log. $(p \times \Delta)$	Apparent δ	Log. $(p \times \Delta)$	Reduction to Apparent $\Delta\alpha$	Reduction to Apparent $\Delta\delta$	Star.
1885.	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Dec. 29.	6 46 7.1	+0 56.64	—16 21.9	5	23 47 35.97	9.277	20 46 15.6	.500	—.25	+5.6	*a*
1886.											
Jan. 1..	6 34 58.6	—2 46.27	—15 23.4	5	23 44 6.15	9.295	20 51 13.9	.501	—.25	+5.2	*b*
Jan. 2..	6 41 30.8	—3 50.50	—13 10.5	5	23 43 1.91	9.341	20 53 26.7	.505	—.26	+5.1	*c*
Jan. 5..	6 30 25.6	—1 2.91	+1 42.1	5	23 40 3.15	9.354	21 1 15.5	.508	—.32	+5.0	*d*
Jan. 5..	6 53 12.2	—1 3.72	+1 43.8	5	23 40 2.34	9.354	21 1 17.2	.508	—.32	+5.0	*d*
Feb. 24.	7 8 38.3	—1 49.32	—2 19.3	5	23 21 4.77	9.707	28 21 41.5	.709	—.80	—0.8	*e*
Feb. 27.	7 17 43.0	+2 15.29	+4 49.1	5	23 20 41.91	9.707	29 7 37.7	.733	—.80	—1.2	*f*
Feb. 28.	7 24 4.9	—1 9.78	+7 46.6	5	23 20 36.41	9.706	29 23 41.4	.744	—.80	—1.3	*g*
Mar. 5.	7 32 6.3	—2 8.87	+3 14.9	5	23 19 57.27	9.706	30 45 40.4	.756	—.81	—2.1	*h*

COMET BARNARD.

Feb. 23.	8 35 17.5	+1 7.54	+16 5.0	5	1 58 58.36	9.658	19 36 49.5	.675	—.28	—4.4	*i*
Feb. 24.	8 1 46.3	—1 26.40	—10 46.8	5	1 58 30.43	9.638	19 52 1.8	.648	—.28	—4.4	*k*
Feb. 27.	7 59 2.3	—0 1.81	—4 2.9	5	1 57 33.31	9.648	20 39 29.8	.551	—.31	—4.4	*l*
Mar. 5.	7 56 11.6	+0 33.63	+0 46.1	5	1 55 10.75	9.668	22 19 14.9	.662	—.40	—4.4	*m*

MEAN PLACES OF COMPARISON STARS.

Star.	α 1886.			δ 1886.			Authority.		
	h	m	s	°	′	″			
a	23	46	36.50	21	2	12.0	W.	23.	954
b	23	46	52.67	21	6	32.1	W.	23.	960
c	23	46	52.67	21	6	32.1	W.	23.	960
d	23	41	6.38	20	59	28.4	W.	23.	850
e	23	22	54.89	28	24	1.6	W.	23.	454
f	23	18	27.42	29	2	49.8	W.	23.	344
g	23	21	46.99	29	15	56.1	W.	23.	421
h	23	22	6.96	30	42	27.6	W.	23.	432
i	1	57	57.10	19	20	48.9	W.	1.	1341
k	1	59	57.71	20	2	53.0	W.	1.	1397
l	1	57	35.43	20	43	37.1	W.	1.	1324
m	1	54	37.52	22	18	33.2	W.	1.	1260

BETHLEHEM, Pennsylvania, April 27, 1886. C. L. DOOLITTLE.

The Sidereal Messenger,

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

VOL. 5, NO. 9. NOVEMBER, 1886. WHOLE NO. 49.

OUR KNOWLEDGE OF COMETS.*

H. C. WILSON.

Few of the departments of astronomy have been more continuously and carefully studied in the centuries past than the one which pertains to comets, yet none is more interesting today, not only to the astronomer but also to those who occasionally turn their thoughts toward things unearthly. There is something about these wonderful bodies, their vast proportions, the suddenness of their apparition and mystery of their nature, well calculated to arrest attention. In the earlier centuries they seem to have been universally regarded with terror, as harbingers of some dire calamity to mankind;

> "Threatening the world with famine, plague and war;
> To princes, death; to kingdoms, many curses;
> To all estates, inevitable losses;
> To herdsmen, rot; to ploughmen, hapless seasons;
> To sailors, storms; to cities, civil treasons."

Even in the present age the sudden appearance of a brilliant comet, like those of 1881 and 1882, produces a profound impression and causes much speculation concerning its origin, nature and probable purpose.

On an average, about twenty-five of these "blazing stars" become visible to the eye in each century. Many times that number are seen with the aid of the telescope and doubtless many more are beyond the reach of the most powerful "optick

*Address delivered at the University of Cincinnati Commencement for the degree of Ph. D., June 17, 1886.

tubes." Probably the speculation of the illustrious Kepler is true: "That the celestial spaces are as full of comets as the sea of fish, only a small portion of them coming within range of our telescopes."

Let us, with the aid of a powerful telescope, follow one of these mysterious visitors on its journey to the sun and note the phenomena which it may exhibit. It is now about three times the distance of the earth from the sun and appears as a simple round patch of nebulous light nearly uniform in all its parts. It has been traveling for hundreds, perhaps thousands of years through the intensely cold space in the outer parts of the solar system. Gradually the meteoric particles of which the comet is composed begin to glow with increasing light and heat received from the sun, and in the central part, where the light and heat are concentrated by reflection from particle to particle, a condensation appears which gathers intensity from day to day. Finally, a point or disc of light appears in its center which shines with a light approximating that of planets. This is called the nucleus. Later on a faint streak of light or tail is seen extending in the direction opposite the sun. The great majority of comets never get beyond this stage of development, but the one which we now follow is destined to approach very near to the sun and to undergo a degree of heat as intense as that of the cold through which it has recently passed. Swifter and swifter it flies almost straight toward the great center of light, and hotter and hotter become the solar rays. Violent action appears to take place on the sunward side of the nucleus, and great volumes of vapor rise toward the sun with astonishing velocity. Jets are thrown up to the height of thousands of miles in an hour. Sometimes the whole hemisphere of the nucleus appears as one gigantic volcano belching forth an enormous fan-shaped jet of glowing vapor. But what do we see? These jets, after rising toward the sun, fall back, not upon the nucleus but past it on all sides, as if repelled by some force from the sun, and form a hollow cylinder which extends far out into the tail. This hollow cylinder is transparent in the middle portion, like a glass tube, so that it has the appearance of two bright streams of matter flowing away from the nucleus. The first direction of the cylinder is exactly opposite the sun, but it gradually curves backward, unable to keep up with the nucleus in its ever hastening flight.

Let us pass on and watch the behavior of the comet in the immediate vicinity of the sun. The temperature increases until it becomes 2,000 times hotter than a red hot iron. The nucleus becomes a seething, molten mass in which violent convulsions are taking place, and masses of vapor, and perhaps of molten matter, are ejected with terrific force. But, strange to say, these do not rise to such a height as before. The repulsive force from the sun seems to have proportionately increased and the streams flow away, immediately into the tail. This latter feature expands to an enormous extent and near the head becomes so brilliant as to be visible in midday and close to the sun.

The velocity is now so great that the comet seems about to pass the sun in a straight course and to fly off to the opposite part of the heavens, but here "Old Sol" exerts his powerful arm of attraction and whisks the little nucleus around him with incredible speed and hurls it back in nearly the same direction whence it came. The head of the comet has passed within 300,000 miles of the sun's surface, through, indeed, the very atmosphere of that luminary. Out of this fiery ordeal it comes shorn of everything but the nucleus. The magnificent tail which it possessed but a few hours before has been left behind, to be dissipated in the interplanetary spaces. The smaller particles composing the head, have been completely volatilized and driven away. Streams of matter, however, still issue from the nucleus, even more abundantly than before, and in a few days a new tail is formed more brilliant and of greater proportions than its predecessor. This tail is not behind the nucleus, but in advance and again in the direction opposite the sun. We can watch its growth from night to night, for it is not formed instantaneously, or even with the velocity of light, as many have supposed. It takes from twenty to forty days for the streams from the nucleus to reach the distance at which they vanish.

Sometimes there are condensations in the streams of vapor which may be recognized from night to night, until they reach a distance of a hundred millions of miles from the head of the comet. As they move outward they gradually fall back from the straight line, giving to the tail a gracefully curved form. Some of the particles seem to be driven off with greater velocity than others, producing tails of different lengths and different degrees of curvature. One long narrow branch seems to be propelled much more swiftly than the others and is therefore much straighter. Others are extremely faint, very short and greatly curved. The brightest tail extends to a distance of not less than 200,000,000 miles from the nucleus. The thickness of the tail is nowhere less than 100,000 miles, and its greatest width is about 10,000,000 miles. It seems almost incredible that such a vast appendage could be evolved from so small a body, and yet it is so attenuated that the faintest stars may be seen through the thickest portion.

Meanwhile the nucleus has been suffering the effects of the tidal action produced by its close approach to the sun. It must have the tenacity of steel in order to avoid being pulled apart by the tremendous tides, which continue for many days. Soon we find it becoming greatly elongated and in a a few days breaking up into two, three, and many smaller nuclei. As the comet recedes farther from the sun it gradually cools off, the evaporation becomes less abundant, the tail diminishes in size and splendor until all finally disappears, the last aspect being the same as the first: a faint, circular nebulous speck.

In this brief sketch, I have given only those phenomena which I have personally observed in the comets of the last six years. Most of them were exhibited by the one Great Comet of 1882, whose sudden appearance in September of that year, shining in midday close to the sun, startled astronomers themselves. This remarkable object came from the direction of the giant star *Sirius*, moving in an almost straight course towards the sun, swept around that great centre, at a distance of less than 300,000 miles from the sun's surface, with an incredible velocity of a million miles per hour, and is now receding in almost exactly the same direction whence it came. Its speed is constantly diminishing and at the extreme part of its orbit will be only five miles per hour. The one-half of its revolution around the sun was described in about four hours but the other half will take not less than 750 years.

The origin of comets is still a disputed question. They come from all directions in space and move in very eccentric paths across the sky. Some move around the sun in the same direction as the planets ; others take exactly the opposite course. Some come up from below the ecliptic ; others plunge down from the north polar regions and disappear in the opposite part of the heavens. Still others appear to move straight toward the sun, but suddenly sweep around that great centre, and fly off in the same direction whence they came. Their real paths through space are extremely elongated eclipses, so elongated, indeed, that in most cases they cannot be distinguished from the *parabola* or *infinite* eclipse.

The prevailing opinion is that comets originate outside of the solar system, either as fragments of the original chaotic nebula, out of which the starry worlds were formed, or as having been ejected from the stars and having come by chance within the influence of the sun's attraction ; that the greater number of them simply pass through the solar system and out again never to return ; but that a few happen to pass near some of the planets and are by their attraction drawn into closed orbits around the sun.

The millions of stars which surround us on every side are all remarkably like our own sun. Many of them are even larger and more powerful than he. Reasoning from analogy we may suppose that each of these suns is also attended by comets ; hence we are led to the conclusion that millions of comets, projected forth from millions of suns during countless ages past, are now flying through space in every direction,—restless messengers from star to star. By mere chance some of these must fall within the sun's far reaching power and be drawn into our planetary system.

On the other hand, there are serious objections to this theory;

and some eminent astronomers are arrayed against it. The problem is beset with difficulties and requires for its solution more accurate data than those which we now possess. Practically, for so long a time as history shall last, we may regard them as members of our system, for supposing the sun's power to extend only half way to the nearest star, it would take 10,000,000 years for a comet to pass beyond that limit.

The *physical nature* of these bodies is even more problematical than their origin. The vast proportions which some of them assume, compared with the small quantity of matter which even the largest actually contains, their perfect transparency and the mysterious force by which the tail is driven away from the sun while the nucleus is held firmly in its course, are almost incomprehensible. Recent researches by Professors Newton, Schiaparelli, Zollner, Bredichin and others have thrown much light upon these problems; but we must acknowledge that they are far from satisfactory solutions.

The most probable explanation is that comets consist of small detached particles, partly solid and partly gaseous, so widely separated as to allow the light of stars to pass between them unhindered, and so small that the individual particles cannot be distinguished, but all combined give a continuous light. The nucleus is a dense aggregation of the larger particles, which, perhaps, when near the sun, become fused together and form a planet-like body. The tail is composed of detached particles of vapor and gas, thrown off from the nucleus and the smaller meteoric bodies composing the head of the comet, by an electric force generated in the process of evaporation, and driven outward by an electric force from the sun.

Regarding the influence of comets upon the earth, I may say in conclusion, that they produce no physical effect whatever. There is about one chance in a million that a comet may strike the earth, and if we should happen upon that one chance, the only serious consequence would be a shower of meteors more or less brilliant.

One happy influence they do exert. They excite our curiosity and direct our thoughts to the contemplation of the grand problems of the universe which surround us.—*Carletonia.*

POPULAR FALLACIES ABOUT OBSERVATORIES.*

MISS MARY E. BYRD.†

During the years that my life has been well nigh lived in an observatory, I have felt that some things are viewed differently by those without and those within the walls. One does not willingly try to dispel pleasant illusions, and yet, since an observatory with all its domes and peers, appliances and instruments, is designed for the search of truth, standing so near its corner stone, I ask your leave to speak the truth frankly for a few minutes.

It has seemed to me, that in the popular imagination, an observatory exists for the purpose of being visited—like a parsonage; or that it is held to be some grand celestial amphitheatre where there are nightly shows of moon and stars and planets, with the astronomer for chief showman; that he delights to exhibit in the fields of his telescope comets' tails, Jupiter's satellites, Saturn's rings and pretty things, much as Barnum likes to show trained elephants and dancing ponies. Now, as a matter of fact, astronomical benevolence does not usually lie along these lines. The observer places a high value on his time, especially the time of clear evenings. Indeed, I fear he is sometimes tempted to say with the poet:

"Who steals my purse, steals trash; but he that filches from me my clear nights, robs me of that which not enriches him and makes me poor indeed." He feels as the Englishman does about his home; his observatory is his castle, and when some clear night he is fairly at work with transit instrument, meridian circle, equatorial or photometer, the casual, unannounced visitor is just about as welcome to him as brigands to the traveler in Spain, or Irish moonshiners to the English landlord, just about as welcome; and if the plain truth were known, not much more so. Now when I build my observatory—it is to be

* Delivered at the laying of the corner stone of the new Astronomical Observatory of Carleton College, Northfield, Minn.

† Assistant in Mathematics and Astronomy.

in California—I invite you all to the laying of the corner stone in 19—. I have fully decided that I shall have a moat and a draw bridge; about armed sentinels I have not quite made up my mind. On that point I am still willing to be labored with by my more generous-hearted friends. But then if any of you should come, (a friend from Northfield would be so welcome,) I don't doubt you could look through my telescope all night in spite of moat, draw bridge and sentinels.

Almost everyone else has some power in arranging and controlling the time for his work, but the astronomical observer has absolutely no control over the conditions that make his work possible. He cannot make the sky clear, the air steady, or star-disks sharp cut. As a noted astronomer has said: "The work he fails to do to-night, he may wait weeks, months, possibly years, for another opportunity to do;" so perhaps he is not very unreasonable when he asks only for a chance to do his work.

That word work hardly corresponds with popular ideas. It is commonly fancied that there is a great deal of poetry and romance within the walls of an observatory. All have read the ancient legend of Tycho Brahe, how he went to the observatory in velvet robes of state as if the presence of the stars was the presence of princes. And people fancy that here at midnight, in star-lit domes, you almost hear the music of the spheres. They picture to themselves the observer seated at his telescope, hour after hour, looking down, down into deep lunar craters, feasting on delicate nebulae and swift-flying comets, or reveling in gorgeous star-clusters. Here, they think, night after night before his rapt vision, there passes all the panorama of the heavens, multiplied and glorified a thousand fold by his powerful lenses. I have sometimes wished that it were so, but it is work that goes on in an observatory, work as stern and exciting as that of the factory.

I raise no objection to poetry or velvet gowns, but until some one invents a way of lighting telescopic fields so that the observer is not obliged constantly to handle greasy lamps, the question is not open for discussion; the bans between poetry and practical astronomy are positively forbidden. Why, I do not believe even Tycho Brahe himself could have kept grand and stately with grease trickling down his hand ! No, the modern observer is mindful of sulphuric acid and sperm oil and dons an old coat, or a shabby dress, as the case may be, and could you look within the walls of the observatory you would not find him idling or dreaming. He moves with a quick, brisk step, casts a hasty glance at the sidereal clock, notes that the batteries are in working order, the electric circuits without breaks, proper connections made, winds the chronograph, puts on the sheet, sets it in motion, and a little later perhaps you see him ready for work with the meridian circle ; but it is hardly likely that he is seated in one of those easy observing carriages that you have seen pictured in some advertising page, and set down in your mind as one of the manifold luxuries of an observatory; it is more probable that some home-made contrivance or a mere dry goods box answers his purpose. His hand is on the key, his eye is at the tube, he turns and looks up, but it is with no ecstatic gaze, he is noting the clearness of the sky and the danger from some fleecy clouds near the zenith ; again he looks through the glass ; there is a succession of short, sharp taps, that means the star is in the field of view : another tap, the star has crossed the first wire of the meridian circle. Then there is a series of taps, microscopes are read and recorded; another setting is made, and then operations may go on for several hours, varied by tying a knot in the chronograph chord, shaking up the stylographic pen, and doctoring the greasy lamp. " And is this all ?" you say. " He just puts his finger down there when a star crosses a wire, why a child could do that !" Yes, a child might do it after a fashion, and yet one of our excellent American astronomers, especially skilled in work with the meridian circle, has said it takes years to become proficient in that simple thing. He was too modest to add how much skill and talent were required, and it were better that I left to some one far wiser than I to tell how much of the eternal truth of the stars has been deciphered and brought within the grasp of the human mind mainly by the exact bisection of a star as it crosses the wires of the meridian circle. And so you might follow the observer from room to room in his work with different instruments, and you would find his duties made up of a large number of petty details, no one of which shows the skill required or the results involved.

Indeed, I think the observer himself is a different sort of personage from that he is commonly imagined to be. He does not dwell constantly in a state of ecstacy or enthusiasm ; he does not require a dictionary of superlatives to express his feelings about the stars; he does not stay up late nights to look at pretty things through his telescopes. He is, perhaps, rather indifferent to merely pretty things, and may shock some entranced visitor by his utter lack of proper emotion over some telescopic spectacle ; but he will spend his nights for weeks and months in painstaking observations, making hundreds of measures of angle and position ; he will give up his days to laborious computation, and all for what ? Why just to find out that two insignificant stars in the heavens, (one of which the unaided human eye will never see), to find out that they form a system, are bound together by the force of gravitation, the one moving in a path about the other in an orbit that he can map. It seems a prosaic result, and yet such truths as that are worth a world more to the earnest observer than years of pleasure hunting in fields sown thick with glittering stars. He is not looking for amusement or beauty, he is seeking the truth, if happily he may find it. He longs to find out, to understand, to know ; back of form and motion and color, he seeks the unchanging varities.

No, it is not to found a palace for dreams, a place where the the fancy may feast on swift-changing star pictures that the walls of an observatory go up. It is to establish a place where truth is sought. I know that there are those who think that an observatory is a monument to human pride and human intellect, and the truth found here appears cold and visionary, without power to warm the human heart or make the world better. To me it seems that God made human minds hungry for all truth and that he says to the observer here, as well as to the disciple of old—"Seek, and ye shall find."

THE SUPERSTRUCTURE.*

MISS MARY B. CUTLER, CLASS OF '87.

In the midst of the brick and the mortar,
  We pause, with plummet in hand,
To look backward and forward and upward,
  While 'neath heaven's dome we stand—
Back, to the small beginning,
  On, to the plan fulfilled,
Up, to the Masterbuilder,
  Without whom, in vain we build.
But besides this firm foundation,
  Which gives us pride to-day,
There has longer far been building
  A support that will longer stay
Of care and thought and devising,
  Both human and divine,
And labor self-sacrificing,
  These forces to combine.
Upon this rare foundation,
  With our mental vision's aid,
In bricks of imagination,
  With mortar of fancies laid,
There rises a fair superstructure
  All fitted and finished throughout
With the tried foundation substance.
  From its windows, the fields without
Reveal to companies eager,
  While upward their souls are led,
The handiwork of Elohim
  Upon the dark firmament spread.
Its rooms are all abounding
  In instruments of thought,
Their polished and balanced movements
  With skill and cunning wrought;
And yonder's a lofty tower,
  Where, in crystalline splendor, rests
A new thought of God adjusted
  To human use,—and the quests
Of years of patient study
  Have opened, at length, a way

*Delivered at the laying of the Corner Stone of the new Astronomical Observatory of Carleton College, Northfield, Minn.

To wider and deeper searchings
  Than any one knows to-day.
So may the future workers
  Disclose Orion's keys,
And learn the sweet influence
  Of gleaming Pleiades;
In the new revelation,
  Not seven stars only see;
The reward of their overcoming
  The Morning Star shall be.

HYMN.*

PROF. GEO. HUNTINGTON.

Creative Word! whose mandate broke
  The silence of primeval time,
Form, order, beauty to invoke,
  Reverent we wait thy voice sublime.
Formless and void our work must be,
Unless commanded first by Thee.

O Hand of Power! whose skill could frame
  From nought a world so vast, so fair,
Nor skill nor power our hands may claim.
  Make Thou our lowly task thy care.
Not small, not vain that work can be,
Whose least beginnings are from Thee.

O Mind divine! whose power hath wrought,
  In changeful form and changeless law,
The fashion of thy glorious thought,
  Thy shining paths we trace with awe
From height to starry height, and fain
Would think thy glorious thoughts again.

Light Thou our pathways from above;
  Our minds enkindle with thine own;
Till, like thy stars, our thoughts shall move
  In bright procession round thy throne;
Till all our joy and wisdom be
To think, to walk, to work with Thee.

*Sung at the laying of the Corner Stone of the Observatory of Carleton College, Northfield, Minn.

A BLAZING STAR.

About half past 9 o'clock last Friday night (August 20, 1886), the star Zeta in *Cassiopea* appeared to blaze up with unusual brilliancy. It was apparently more prominent than a star adjacent which is rated in the catalogues as being larger by about half a magnitude, and was nearly as bright as the most prominent stars in that well-known constellation. It so continued for almost half an hour, after which it receded to nearly its normal brightness as compared with other stars in the vicinity. At the time of its greatest brilliancy a ray of light, like the tail of a small comet, seemed to shoot out in the direction of Lambda in the same group, taking in the smaller stars numbered as 114 and 118 of *Cassiopea*.

It is high up in the northeast in the evenings of this month, and forms the "chair" or "W" which is described in many of the astronomical text-books as being on the other side of the pole from the big dipper. The star Zeta is the one nearest the upper right hand corner of the diagram, and is the one furthest from the north star.

The phenomenon here described was observed by an astronomer in this city, who noticed it first with the naked eye, only to doubt the evidence of his senses. He looked at it again and again, and finally examined it through a glass, carefully comparing its brightness with that of the other stars within a few degrees of its place in the heavens. It is not known that the appearance has been observed elsewhere, but it would seem strange if it escaped the attention of all other persons who are familiar with the face of the sky. The most singular thing about the phenomenon is the shortness of time that it lasted. The blazing out of a star to much greater prominence than it had hitherto assumed is not a very rare thing, and at least three of these apparitions are recorded as having occurred in this very constellation, around which have been woven the fanciful story of "The Star of Bethlehem." But in these and all other cases the extra brilliancy has continued for a much longer time than that above noted, the period occupying from a few weeks to several months. The extra prominence in this case may have lasted much longer than half an hour, as its beginning was not observed, but it could not be otherwise than describable by the use of the word ephemeral. It is very difficult to think of a satisfactory explanation of the phenomenon.—*Prof. E. Colbert in Chicago Tribune.*

THE TANGENT INDEX.

JOHN HAYWOOD.*

For the Messenger.

This summer it occurred to me to develop more fully than I had hitherto done, a method of making clearer to elementary students of astronomy the earth's motion in its orbit. I have been accustomed for many years to give my classes a precept of my own, at least one I have never seen anywhere, though its form was suggested by a rule given in Davis' Manual of Magnetism to enable one readily to determine the directive action of a current of electricity upon a magnetic needle. My precept is this: Conceive the body placed in the meridian and parallel to the earth's axis; with the head to the north; with the face to the sun. Extend the arms to right and left perpendicular to the body. They will represent roughly a tangent to the earth's orbit; and the earth is moving to the right, in its revolution around the sun.

This rule is inexact. Thus the tangent to the earth's orbit is perpendicular to the axis only at the solstices. At the time of the vernal equinox the tangent is depressed below a perpendicular to the axis 23½°. At the time of the autumnal equinox it is elevated above the perpendicular the same amount. That is, this angle, which I call the declination of the tangent, varies from —23½° to +23½°.

It is impracticable to place the body in the position contemplated in the rule above. To assist the class in understanding and applying it, I take two sticks, blackboard pointers, and

* Professor of Mathematics and Astronomy, Oberlin University, Westerville, O.

placing them in the form of a cross, readily bring the combination into the required position, so that one of the rods shall represent the earth's axis, and the other a tangent to the orbit.

Having some leisure this summer, I have constructed the tangent index to exhibit the subject more fully. The first step was to put a mortise through a convenient stick and insert in this another in the form of a cross; but moving on a pivot through a short arc in the plane of the first stick, which represents the axis. The next step was to attach a circle to the axis at the center of the cross with a suitably graduated arc, and an index on the cross piece so that it may be placed at the proper angle with the axis. The third step was to mount this cross on a frame by pivots in the line of the axis upon which it turns; and with the pivot at the north end of the axis resting in a small frame which slides along a graduated vertical arc, to adjust the axis for latitude. The last step was to attach a time circle graduated and numbered to 24 hours, with its index, to one end of the axis; the circle being adjustable for the hour angle of the tangent. By the hour angle I mean the diedral included between two hour circles, one passing through the sun, the other containing the tangent.

To use the instrument, place the axis in the meridian, elevate the north end for latitude, adjust the tangent arm for declination for the date. Adjust the hour angle for the date. Then turn the cross on its axis till the time index points to the local apparent solar time on the time circle. The tangent index is now parallel to a tangent to the earth's orbit, and points in the direction of the earth's orbital motion; that is, eastward along the orbit. It seems to me that this instrument, properly used, will help beginners in the study of astronomy to more definite and satisfactory knowledge of the earth's motions. I expect to test it in my class.

The declination of the tangent is obtained by computation according to these formulæ:

$$\text{Tan } P' = \tan e \cos l.$$

$$\text{Sin } \theta = \sin P' \cos \delta.$$

θ is the declination sought; e is the obliquity of the ecliptic; l is the earth's heliocentric longitude; δ is the earth's (or sun's) declination. P′ and θ have their values always between the limits $-e$ and $+e$. P′ and θ differ in value only 46′ at the greatest.

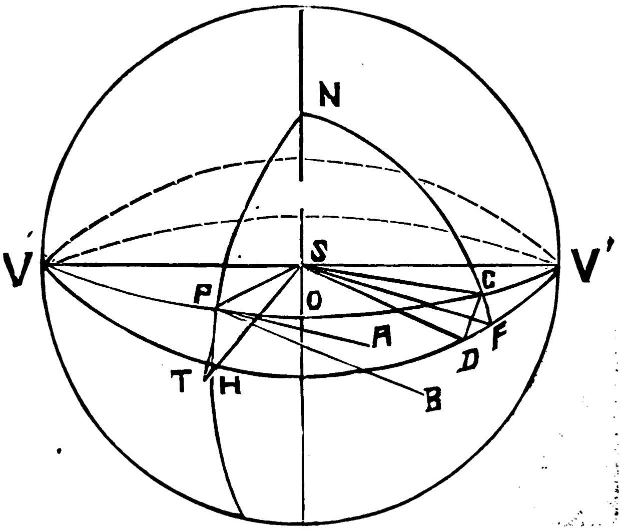
To demonstrate these formulæ, I refer to the accompanying diagram. This represents the celestial sphere. S the sun's center; VOV′ the earth's orbit; V the vernal equinox; VQV′ a great circle parallel to the earth's equator; we will call it the equator, and its secondaries, hour circles. Let P be the earth's position at some time; PA a tangent to the orbit at P, is the direction of the earth's motion at the time. It is assumed to be perpendicular to the radius vector SP. N is the North Pole of the heavens; NPH is an hour circle; PB a perpendicular to NPH at P, and therefore a tangent to a great circle passing through P perpendicular to NP. The angle APB is the complement to the spherical angle P of the triangle VPH. By Napier's rule we have cot P=tan PVH cos VP. Representing PVH by e, and VP, the earth's heliocentric longitude, by l, and the angle APB by P′, we have tan P′=tan e cos l.*

The plane of the angle APB is oblique to the equator. Draw PT tangent to the hour circle NH. The three tangents, PA, PB, PT, are in the same plane, since each is perpendicular to the radius vector SP; and the angle PTS, the complement of PSH, is the angle of the diedral. Draw SC parallel to PA; this line is in the plane of the earth's orbit. Draw SD parallel to PB; this is in the equator, since PB, being perpendicular to NP, is parallel to the equator. Connect C and D by the arc of a great circle, and draw the hour circle NCF; also draw SF. The angle CSF is the inclination or declination of the tangent PA. Represent this by θ. In the right spherical triangle CDF, the angle D is equal to PTS, which is the complement of PSH, the earth's declination. Call this declination δ. Then CDF=$90°-\delta$. CD measures the angle CSD, which

* This is as far as I had carried the analysis of the tangent declination at the time I exhibited and explained the instrument before Sec. A of the A. A. A. S. at Buffalo this summer.

equals the angle APB=P′. Then by Napier's rule, sin θ= sin P′ cos δ.

The hour angle of the tangent is found by the formula, cos (180°—H)=tan θ tan δ. To demonstrate this we can make use of the same diagram as in the former case; but it is necessary to change the meaning of some of the lines. Let S be the earth's center; VPV′ the ecliptic, the sun's apparent path; C the sun's place at some time; SC the radius vector; SP perpendicular to SC, be a tangent to the earth's orbit. The



orbit is not represented in the diagram. The apparent motion of the sun is supposed to be towards V′; therefore the earth's real motion is in the direction SP. In the spherical triangle PNC, PC, subtending the right angle PSC, is a quadrant. The arc of the hour circle NC=90°—δ; δ is the sun's declination. NP=90°—θ. The angle PNC is the required hour angle which is represented by H. Then taking the right triangle polar to the quadrantal triangle PNC, solving by Napier's rule, and returning to the triangle PNC, we have cos (180°—H)=tan θ tan δ. It is seen that when δ(CF)=0, the triangle has two sides quadrants, and is bi-rectangular; and H=90°. This occurs at the time of the equinoxes. Also when θ, or PH, =0, in like manner H=90°. This occurs at the time of the solstices. At intermediate times, the value of H varies from a minimum value of 85° 4′ about May 4th and November 6th, to a maximum value of 94° 56′ about February 4th and August 8th.

I add tables of the values of θ and H for certain dates through the year, at intervals of five days. The numbers in the tables are computed for Greenwich noon of the dates for the quarter March–June. For the remaining three quarters of the year the dates are selected so that the values are correct some hour of the day of date but not at Greenwich noon.

Table to accompany the Tangent Index. Theta is the Declination of the Tangent. Its sign is given at the head and foot of the column containing the date. H is the hour angle.

	H			θ			H		
—			+			—			+
March 20	90°	0′	Sept. 23	23°	27′	March 20	90°	0′	Sept. 23
" 25	89	11	" 27	23	22	" 15	90	49	" 18
" 30	88	21	Oct. 3	23	6	" 10	91	39	" 13
April 4	87	35	" 8	22	39	" 5	92	25	" 8
" 9	86	53	" 13	22	1	" 1	93	7	" 3
" 14	86	17	" 17	21	14	Feb. 24	93	43	Aug. 28
" 19	85	46	" 22	20	19	" 19	94	14	" 23
" 24	85	24	" 27	19	13	" 14	94	36	" 18
" 29	85	10	Nov. 1	18	0	" 9	94	50	" 13
May 4	85	4	" 6	16	40	" 4	94	56	" 8
" 9	85	6	" 11	15	13	Jan. 31	94	54	" 3
" 14	85	17	" 16	13	40	" 26	94	43	July 29
" 19	85	36	" 20	12	2	" 21	94	24	" 24
" 24	86	8	" 25	10	20	" 16	93	52	" 19
" 29	86	34	" 30	8	34	" 12	93	26	" 14
June 3	87	12	Dec. 4	6	46	" 7	92	48	" 9
" 8	87	55	" 9	4	55	" 2	92	5	" 4
" 13	88	42	" 14	3	2	Dec. 29	91	18	June 29
" 18	89	30	" 19	1	9	" 24	90	30	" 24
" 21	90	00	" 21	0	0	" 21	90	00	" 21
—			+			—			+

EDITORIAL NOTES.

The next number of the MESSENGER will close the current volume. Some changes are contemplated for 1887, which, it is hoped, will give our work a wider range of of usefulness.

THE NEW COMET.—Whilst sweeping the low eastern horizon, on the morning of October 5, with the 5 in. refractor, I found, in an open space between the observatory dome and a large mass of trees, a bright round nebulous object, at about 5*h* mean time. I had scarcely time to reach the observatory and turn the 6 in. upon it when it was lost in dawn ; however, two equatorial pointings were obtained, giving the place of the object:

$$RA = 10h\ 36m\ 8s.$$
$$Decl = +0°\ 58'.$$

at 17*h* 12*m*, October 4th, Nashville mean time.

Though positive that it was a comet, yet not having seen it long enough to detect motion, I feared to risk the announcement as a comet but at once gave the usual notification to Dr. Swift of a "suspected comet."

The following morning, Oct. 6, the object was again observed and found to be in motion towards the north-east, seven ring micrometer comparisons with an unknown 9th mag. star were obtained. Dr. Swift was then notified to announce it, which he did, having himself verified the discovery that morning.

The comet has been observed every morning since the discovery and ring micrometer positions obtained.

On the morning of the 6, a faint short tail was seen, pointing approximately away from the sun, and at each observation a small and rather difficult nucleus has been observed. The last two observations show the comet is getting fainter.

My eastern horizon is very bad, cut off to a considerable altitude by trees, and it was while sweeping in a narrow gap that the comet was found. Had it not been seen in this gap it would not have been found by me, for when its altitude is sufficiently great to bring it above the trees it cannot be seen, being blotted out by dawn.

E. E. BARNARD,
Vanderbilt University Observatory,
Nashville, Tenn.

October 9th, 1886.

COMET BARNARD (1886).—A telegram was received at Harvard College Observatory on October 5, from Mr. E. E. Barnard, of Nashville, Tenn., stating that an object, possibly a comet, had been seen by him, and requesting a verification, if possible, on the following morning. The morning of October 6 was hazy at Cambridge, but Prof. Lewis Swift succeeded in finding the object, and the announcement of discovery was accordingly made by telegrams, and by cable message to Europe. The discovery position was: October 4.96, Gr. M. T. R. A. 10*h* 36*m* +1° 58′. On the morning of October 6, a cable message from Dr. Krueger announced the independent discovery of the comet by Dr. Hartwig, with the position: October 5.668, Gr. M. T., R. A. 10*h* 37*m* 24*s*, Decl. +1° 3′. This information was made public through the medium of the Associated Press. On the morning of October 7 a good position was secured by Mr. H. V. Egbert, of Dudley Observatory, which was circulated in this country as the second position. On the morning of October 12 a telegram was received from Prof. Lewis Boss, of Dudley Observatory, giving the orbit as below, which was distributed in this country by telegraph and cabled to Europe.

Eight positions of the comet have been received, five from Albany, which are published by permission of the director of Dudley Observatory, two from Nashville, and one from Harvard College Observatory, published by permission of Prof. E. C. Pickering.

1886.	h. m. s.	M. T.	R. A. h. m. s.	Decl. ° ′ ″	Observer.
Oct. 5	22 34 14	Gr.	10 38 06.6	+1 05 19	Barnard.
6	16 57 23	Ca.	10 40 03.79	1 13 24 6	Wendell.
6	22 07 34	Gr.	10 40 06.84	1 13 43.3	Egbert.
6	22 40 11	Gr.	10 40 09.6	1 13 44	Barnard.
7	22 11 08	Gr.	10 42 10.42	1 22 14 4	Egbert.
8	21 28 36	Gr.	10 44 12.83	1 31 00.8	Egbert.
9	21 42 04	Gr.	10 46 22.16	1 39 43.9	Egbert.
10	21 59 17	Gr.	10 48 34.66	+1 49 14.1	Egbert.

From the mean of the Egbert and Barnard positions of October 6, and the Albany positions of October 8 and 10, Prof. Lewis Boss has computed the following elements and ephemeris, received to-day by telegraph:

ELEMENTS.

T=December 11.40, Greenwich M. T.

	°	′
$\pi - \Omega =$	89	26
$\Omega =$	135	39
$i =$	106	15

log. q=.5974

EPHEMERIS FOR GREENWICH 12*h*.

	R. A. *h.*	*m.*	*s.*	Decl. °	′	Light.
November 1	11	51	27	+6	40.5	
2	11	55	31	6	59.5	
3	11	59	44	7	19.2	
4	12	4	7	7	39.4	
5	12	8	41	8	0.5	5.56
21	13	25	12	23	20	14.2
December 7	17	0	32	33	39	22.1
23	19	29	2	10	40	10 2

Light at discovery=1.

COMET FINLAY.—This comet was discovered by Prof. Finlay, September 26, at the Cape of Good Hope. It was about one minute of arc in diameter, circular and faint, slight central condensation, no tail. The following elements were computed by Prof. Lewis Boss:

T=1886, November 20.989

	°	′	
ω	301	25	App. Eq.
π	352	51	App. Eq.
Ω	51	26	App. Eq.
i	3	20	App. Eq.
log. q	0.05866		

Middle Place (C—O).

$\Delta\lambda$ cos. $\beta = +0'.9$

$\Delta\beta = -9'.4$

From *Science Circular* No. 72, we also take the following:

In my communication of October 2, I intimated that I would prepare an ephemeris of the Finlay Comet based on the theory of its probable identity with Comet 1844 I., but an examination of the case shows that the elements of the Di Vico Comet have undergone considerable perturbations, and that an ephemeris based upon them and adjusted to fit the four observations now at hand (which are barely more than approximate) would be entitled to scarcely more confidence than that which is presented below in continuation of that published in the *Science Observer* circular of October 4.

EPHEMERIS.

Greenwich 12*h*	R. A. *h. m. s.*	Decl. ° ′	Light.
1886 October 25	18 30 04	—26 30	1.7
27	18 37 33	26 23	1.7
29	18 45 12	26 15	1.7
31	18 53 02	26 05	1.8
November 2	19 01 01	25 53	1.8
4	19 09 10	—25 38	1.9

Dudley Observatory, Albany, N. Y., Oct. 11, 1886.
—*Professor Lewis Boss in Science Observer (Circular No. 72).*

HITHERTO UNRECOGNIZED WAVE-LENGTHS.—In 1884 Professor Langley published a paper giving a description of a method of measuring wave-lengths in the solar spectrum as far as about 23,000 of Angstrom's scale. At this point the study greatly increased in difficulty, either by prism or grating, making it desirable, if not necessary, to devise new apparatus, that thereby any observer might determine the visible and invisible wave-lengths of any heat, whether from terrestrial or celestial sources, by the use of the prism and gain a knowledge of the intimate constitution of radiant bodies, which is now only known by a study of the vibratory periods of their molecules.

For description of the new apparatus and the detailed study of observations, reference must be had to Professor Langley's paper. In closing he says:

"Broadly speaking, we have learned through the present measures, with certainty, of wave-lengths greater than 0.005 of a milimeter and have grounds for estimating that we have recognized radiations whose wave-length exceeds 0.03 of a milimeter, so that we have directly measured to nearly eight times the wave-length known to Newton; we have probable indication of wave-lengths far greater, and the gulf between the shortest vibration of sound, and the longest known vibration of either is now in some sense bridged over."

STANDARD OF AMERICAN ASTRONOMY.—The standard of American astronomy is high. Noble work has been, and is being, done in every department of the science in this country. Alvan Clark & Sons of Cambridgeport, Mass., have made the world's largest refracting objective; the young firm of Warner & Swasey, Cleveland, Ohio, are mounting it. Mr. Burnham of Chicago is the referee of European double star observers in questions of dispute, and his catalogues of double stars are authority everywhere. Professor Young's "The Sun" epitomizes present knowledge of solar physics as the work of a leading discoverer and an astronomer of rare insight; Professor Hall's studies of stellar parallax and the difficult satellites of the planets are unrivaled; Professor Newcomb's astronomical papers, including that one on the velocity of light, are of great merit, however the world's physicists will not forget the skill of Michaelson in this American triumph. Professor Hill's researches in the Lunar Theory are widely known. "Acta Mathematica" of Stockholm quotes from his paper on the motion of the lunar perigee for its late prospectus and sample sheet for English readers. Professor Pickering leads in photometry, Chandler in the computation of comet orbits, Brooks and Barnard in comet discovery, while Dr. Gould's work in the southern heavens, Dr. Peters' star charts, and Dr. Elkin's measures of the *Pleiades* with the heliometer are not less important elements in the high standard of American astronomy. This standard is not without the idea of a Supreme Being in it who is fittingly and reverently recognized by many whose names appear above; but there are some who tarnish it by slur and ignorant innuendo in reference to sacred things that ill becomes the common sense of piety belonging to common people, to say nothing of that which is supposed to belong to true American scholarship.

ASTRONOMISCHEN GESELLSCHAFT.—In the third part of the *Astronomischen Gesellschaft* for 1886, just received, is contained brief biographical sketches of Andreas Hohwu, who died Sept. 28, 1885, at Amsterdam, at the age of 83; Julius Houel, professor of pure mathematics from the faculty of science at Bordeau, whose death occurred June 14, 1886; and Gustav Adolph Richard Maywald, who died July 19, 1886. Wilhelm Schur's article, containing the results of pendulum determinations at various points with reductions, is noteworthy.

E. Schoenfeld, one of the editors, reviews at length the papers entitled "The Zodiacal Light" and "The Apparent Position of Zodiacal Light," published by Arthur Searle of Harvard College Observatory within the last two years. Among other papers, Fr. Deichmuller notices D. P. Todd's preliminary account of a speculative, practical and telescopic search for a trans-neptunian planet which were published in Vols. 20 and 21 of the *American Journal of Science.*

EXTENSION OF ASTRONOMICAL RESEARCH.—Recently Professor Pickering has published a pamphlet suggesting a plan for the extension of astronomical research. The scheme makes Harvard College the centre of operations, and the depositary of all funds which may be contributed for this purpose, to be disbursed to competent observers and observatories with suitable instruments choosing to co-operate in one general system of astronomical investigation. This plan is thought to be wise because it will put at work idle observers and instruments in systematic way, which now contribute little or nothing to the progress of astronomy.

A plan, looking in the same direction, for equatorial work only, has been in the mind of Professor Holden since he began to direct the construction of the Lick Observatory in California, except that he asks or expects no contribution of money to carry it out. His words are "We mean to put the large telescope (36-inch clear aperture) at the disposition of the world, by inviting its most distinguished astronomers to visit us, one at a time, and by giving to them the use of the instruments at certain specific hours of the twenty-four. In this way we hope to make the gift of Mr. Lick one which is truly a gift to science, and not merely one to California and to its University."

Science commends Professor Pickering's plan generously and criticises Professor Holden as "hard-pressed to devise" his, implying that the Lick Observatory is short of funds to offer anything better.

Now, we beg *Science* not to plunge these two great observatories into war, for it does not need the skill of a prophet to foresee that such a calamity will certainly build up a great school of practical astronomy, midway between them, where one is already founded at the new observatory of Carleton College, which has the promise of instruments better than one of them, and expects an observing corps superior to the other, with ample funds to maintain both.

THE RED SPOT ON JUPITER.—I was much surprised on reading Prof. Hough's remarks in the SIDEREAL MESSENGER for June that the Chicago refractor shows a "narrow line of light" separating the red spot from the dark belts on its southern side. Large telescopes have hitherto been chiefly quoted in attempts to prove that small instruments exhibit too much detail, and it is quite a novelty to hear that the Chicago lens has at last revealed a feature which has eluded detection with less pretentious means.

It is, however, very unfortunate that this achievement is directly negatived by a large number of observations obtained in this country. And Prof. Hough entirely fails in his endeavor to explain the difficulty on the assumption that the telescopes and powers used by English observers are too small to exhibit the detail in question. He curiously avoids the fact that Mr. N. E. Green has been closely studying the disputed features with an 18-inch reflector and that the Rev. I. I. M. Perry has been similarly occupied with an 18½-inch reflector. In April, not a vestige of any bright line was traced separating the spot and S. belts. The outline of the spot remained definite, it is true, but the belts run right up to it and the obvious difference in tint enabled the margin of the spot to be readily distinguishable. Probably the latter object envelopes the belts in this region for the longitudinal extremities of one of the belts are distinctly visible, though the middle section appears interrupted by the projection of the spot upon it.

A large number of English observers, using telescopes ranging from 3¾ inches up to 18½ inches have, on my suggestion, critically examined Jupiter and the region of the red spot. High powers have occasionally been employed when the seeing was good. I have sometimes used 475 in my 10-inch reflector. In every instance the evidence has been the same, viz: that there was no bright division between the spot and belt.

Probably the two features are not physically associated, being situated at different heights in the Jovian atmosphere, but visually, the spot and belt were joined without the semblance of any bright line of demarkation.

I fear Prof. Hough will scarcely be able to substantiate his observation in the face of the mass of observations, published in the *Observatory* and *English Mechanic*, by which he is opposed.

W. F. DENNING.

Bristol, June, 1886.

SOLAR ECLIPSE OF 1886 —The total solar eclipse of this year (August 28-29) was observed at Grenada Carriacou, and other points with unexpected success. In the European expedition were some well-known astronomers, as Tacchini, Lockyer, Maunder, Schuster and Perry. As usual, four lines of work were attempted with encouragement in all, if preliminary reports are trustworthy. They were as follows: 1. New facts; 2. Testing of old views; 3. Use of new instrumental methods; and 4. Records of general phenomena.

Under the first head, it is reported that Professor Tacchini found that the solar prominences viewed during the eclipse and after it, under these different conditions and by means of different methods were not the same ; that the 'white' prominences, seen in 1883 at Caroline Island, were of the same character as those seen during the eclipse, and that these new phenomena are simply the descent of cooler material. If true, this is important as establishing the direction of solar currents.

The different appearances of the prominences during totality and after it arise from seeing only part of the phenomena in the latter case, that being the central portion of the prominence seen during totality.

The "flash" of bright lines, which has lately puzzled observers so much, is attributed to a "reduction in the intensity of the light reflected by the earth's atmosphere allowing the spectrum of the higher regions to be seen at the moment the lower stratum of the corona was covered by the moon."

The view that the corona may be photographed at any time was not supported, but that appearances on the plate thought to resemble the corona are due to glare only.

In the use of instruments the aim was to take a larger number of photographs than usual, increase the size of the image at the same time, by using larger lenses and secondary magnifiers. This change seemed to turn out well.

By the old methods of work about twenty photographs were taken, five being of the chromosphere and the lower regions of the corona. The official report of this work will be looked for with great interest.

ARMAGH CATALOGUE OF 3,300 STARS.—As early as 1828, observations to re-determine the places of Bradley's stars was undertaken at the Armagh Observatory, then under the direction of Dr. Robinson. Preceeding 1854, the places of 5,345 stars had been observed and were published in 1859 (Dublin), and have since been known as the Armagh Catalogue. The book before us is the *Second Armagh Catalogue* of 3,300 stars for the epoch of 1875, deduced from observations made at the above-named observatory during the years 1859 to 1883, under the direction of the late Dr. Robinson, and prepared for publication by his successor, Dr. J. L. E. Dreyer.

The catalogue is in the usual form. Column 1, giving the number of the star. 2. Leland's No. 3. Magnitude from Durchmusterung, Bessell and Argelander. 4. Mean R. A. for epoch. 5. Epoch. 6. Number of observations. 7. Annual precession. And then follows a similar arrangement for N. P. D., and a column of authorities finally. Proper motion is not taken into account. Under the head of "Accuracy of the Results," Dr. Dreyer has made a careful and instructive comparison of the Glasgow and the Armagh Catalogues. Also the Glasgow and this, and a reduction of this to Auwer's Fundamental System.

A NEW ASTRONOMICAL OBSERVATORY is being erected at Carleton College, Northfield, Minn. The building is eighty by one hundred feet in size, of St. Louis pressed brick trimmed with Bayfield brown stone. Portions of it are two stories high surmounted by two hemispherical domes of steel, made by Messrs. Warner & Swasey, of Cleveland, Ohio.

The corner stone was laid, with appropriate public exercises, Saturday, October 2, a most beautiful day, in the presence of a large assembly of people. The following was the order of exercises:

Music.	
Prayer - - - - - - - - - - -	Rev. E. M. Williams.
Music.	
Associations of Old Observatory and Students' hopes for the New -	Albert C. Finney.
Poem - - - - - - - - - - - -	Miss Mary B. Cutler.
Paper—Popular Fallacies About Observatories - - -	Miss Mary E. Byrd.
Statements—General and Financial - - - - - -	Pres. Jas. W. Strong.
Address and Laying of the Corner Stone - - - - -	Prof. Wm. W. Payne.
Singing of an Original Hymn - - - -	Written by Prof. Geo. Huntington.
Benediction.	

ASTRONOMY IN 1885.—The annual record of astronomy for 1885 was prepared for the Smithsonian report of that year by William C. Winlock, assistant astronomer at the Naval Observatory, Washington, D. C., and has been issued before-hand in pamphlet form. It is the best brief statement of the year's work in all departments of astronomy that we have seen from any source.

COMET ORBIT MODELS.—Prof. William Harkness, of U. S. Naval Observatory, not long ago kindly showed us some models of comet orbits made by himself, for the purpose of presenting to the eye, at a glance, the elements of an orbit, or its position in space. In some cases it is not an easy task for an experienced astronomer to imagine just how the path of a comet lies in space from the numerical values of the elements. The scheme above referred to is simple, neat and very useful. We are glad to add that Prof. Harkness has consented to write out and explain a set of rules for making these comet-orbit models, for the MESSENGER, so that any amateur may do the work for himself.

Measures of the double star preceding *Beta Capricorni.*

Date.	P.	S.	Mag.	T.	Power.
1886.701	108.7°	0.81″	6–9	19.8*h*	925.
1886.750	110.5	0.85	6–9	20.5	925.
		MEAN.			
1886.725	109.6°	0.83″.	6–9.		

The measures by Mr. S. W. Burnham, published in the SIDEREAL MESSENGER for September, 1884, are :

P.	S.
108.6°	0.86″

From which it would appear that there has been no appreciable change during the past two years.

Owing to the low altitude of the star, measures are difficult, unless the seeing is good. H.

SWIFT'S NEW NEBULÆ.—*Astronimische Nachrichtere* No. 2,746 contains Dr. Swift's third catalogue of one hundred new nebulae. Since, he has sent the fourth catalogue of one hundred, and is now at work on the fifth, having already found a number of new nebulae for it, besides a list of fifty yet unidentified. His 16-inch Clark equatorial is doing royal service for astronomy in this neglected field.

GENERAL CATALOGUE NO. 4,594.—This nebula is described as v F in the General Catalogue. I marked it on my chart, some four years ago, as v v F with the 5-inch telescope, under fairly good conditions of seeing and altitude. I find it now almost bright, certainly not faint. It is moderate in size, round v g b M with some small stars grouped about it. Its brightness is a little less than that of the cluster G. S. 4590 in same field with it. Observed May 28 and June 4.

E. E. BARNARD.

REMARKABLE COMET DISCOVERIES.—The discovery of three telescopic comets by Professor Brooks, within one month in 1886, is certainly the most remarkable comet-observing in the history of astronomy. It is also true that two of these were found within a period of four days, giving to this diligent student of the skies four comets in succession and five since August 31, 1885; three of which were visible at the same time.

Professor Brooks has now discovered nine comets in all.

CHABOT OBSERVATORY.—This new observatory is located in Lafayette Square, Oakland, California. Its geographical position is

Latitude, 37° 48′ 5″
Longtitude, $3h$ $0m$ $54.3s$ west

from Washington.

The observatory building with its fine equipment of instruments, consisting of an 8-inch equatorial telescope with circles, driving clock, spectroscope, micrometer, a transit instrument with aperture 4⅛ inches, a sidereal and a mean time clock, chronometer, chronograph, and meteorological instruments, all of the most modern and approved construction, was the gift of Anthony Chabot to the Board of Education in trust for the City of Oakland.

Charles B. Hill and Charles Burckhalter will be connected with the observatory, and F. H. McConnell is in charge of the clocks. The director is F. M. Campbell.

MARSHALL D. EWELL, of Chicago, has purchased a 6¼ equatorial by A. Clark & Sons, and is fitting up a small observatory for astronomical work. Astronomy ought to rejoice when a man of ability enters its fields of labor.

GREEN AND BLUE STARS.—For some time past Mr. Charles L. Woodside has been at work on a catalogue of blue stars, and also one of green stars. These may be ready for publication soon.

BROCKWELL OBSERVATORY.—Recent intelligence from Lewisburg, Pa., informs us of further generous gifts of Mr. Brockwell to the university at that place, which bears his name. This time it is $10,000, to build an astronomical observatory. It is expected that the observatory will be ready for use in June, 1887.

J. C. HOWVER, of Auburn, California, has a 7-inch aperture telescope, and he is beginning astronomical work in a limited way. The mounting was done by himself.

J. E. KEELER, who has charge of the time service at the Lick Observatory, uses a 4-inch Fauth transit instrument for observation. Messrs. Warner & Swasey, of Cleveland, have furnished the observatory a fine electrical control chronograph and a mounting for a 6½-inch objective.

JULY AURORA.—A brilliant aurora was visible here last night, a rather unusual occurence at this season. First appearance about 10*h*. A low arch, rising and brightening to an altitude of 25 degrees and extending 90 degrees or more in azimuth. Brilliant streamers shooting up to a height of 45 degrees, some above Polaris, continued from 10*h* 25*m* till nearly 11*h*.

The greatest activity occured at about 10*h* 35*m*, diminishing from then to end of display at 11*h* 30*m* or thereabouts. A light green tint was perceptible in the brighter portions.

Hartford, Ct., July 28, 1886. W. C. P.

WINNECKE'S PERIODIC COMET.—This comet is being observed here every night, for position with the ring micrometer on the 6 in. Cook equatorial.

The comet was first seen here on Oct. 16, the sky having been cloudy previous to that date. On the above date the comet was swept up low in the southwest with the 5 in. and was supposed at first to be a new comet, as Winnecke's had for the time been forgotten.

The comet is about 1′ in diam., round and gradually brighter in the middle to an ill-defined nucleus. It is between the 9th and 10th magnitude. Very little time is given to observe it as it sets soon after the sky gets dark enough to see it.

E. E. BARNARD.

BOOK NOTICE.

A Manual of Land Surveying, comprising an elementary course of practice with instruments and a treatise upon the survey of public and private lands, prepared for the use of schools and surveyors, by C. F. K. Bellows, M. A., C. E., professor of mathematics in the Michigan State Normal School, and F. Hodgman, M. S., C. E., practical surveyor and engineer. Pp., 364; tables, 100. Neat, flexible cover.

The motto of this hand book is, "Let things that have to be done be learned by doing them;" a good precept certainly, to guide in giving instruction in this branch of study. Every teacher of surveying, who expects his pupils to have any practical knowledge of the branch, knows full well that such knowledge is gained only by actual use of the instruments in the field.

The first section gives a review of the trigonometry necessary to the branch, then follows a description of all the varied instruments in common use, with illustrations and problems for each in accordance with useful practice. The sections on Leveling, Drainage, Surveying, Original Surveys, Re-surveys, Lost corners, and miscellaneous matter are especially helpful. Tables of logarithms, natural sines, tangents and secants and logarithmic sines and tangents, traverse tables, etc., conclude the volume. The book contains what the practical surveyor needs to know and omits much useless matter often found in such hand-books.

The Sidereal Messenger,

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

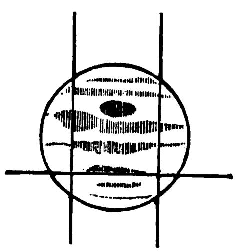
VOL. 5, NO. 10. DECEMBER, 1886. WHOLE NO. 50.

ROTATION TIME OF THE RED-SPOT ON JUPITER.

PROF. C. A. YOUNG.

For the Messenger.

I send herewith a determination of the rotation period of the "red-spot" deduced from the observations obtained at this place during the past opposition. All the observations were made by myself except the first, which was by Prof. McNeill. Numbers 6 and 8 were made with the 9½ inch equatorial; the rest with the 23 inch. The power used ranged from 360 to 500 according to the state of the air. Observation No. 8 was made some minutes before sunset, and naturally the spot was rather difficult to see ; still so far as can be judged from the residuals, it appears to have been fairly comparable with the rest in accuracy, and I have let it stand as of equal weight. The observations were made by setting the micrometer wires about 30″ apart, placing them perpendicular to the planet's equator and so as to cut off equal segments of the disc, and then noting when the spot was midway between them, as in the diagram. The times given are eastern standard mean time, *five hours slow* of Greenwich mean time. In most cases the observations were made in local sidereal time, which was subsequently reduced to standard time. In correcting the observations for the planet's motion in longitude, they were reduced to a geocentric longitude of 180°, the slight



inclination of the planet's orbit and equator to the ecliptic being neglected, as its effect would be quite insensible. This longitude correction (in minutes of time) $=0.993m$ $[180°-L]$, taking the rotation period as $9h$ $55.7m$. The observations were also reduced for the light equation to a distance equal to the planet's mean distance from the sun, 5.203. This correction (also in minutes of time), $=8.33m$ $[5.203-\Delta]$, assuming $500s$ for the time required by light to traverse the distance unity—from sun to earth.

In the table the first column contains a reference number, the second gives the standard mean time of transit as observed; the columns headed L and Δ give the planet's geocentric longitude and distance from the earth taken from the *Connaisance des Temps*; the column C gives the sum of the corrections to be applied; while T gives the corrected minutes and decimals used in forming the equations of condition. Column N gives the number of rotations elapsed since the transit of March 17th. Finally the last column gives the residual error of each observation, deduced from the least square solution of the equations.

TRANSITS OF JUPITER'S 'RED-SPOT,' 1886, OBSERVED AT PRINCETON.

	Observed Standard Mean Time.			L	Δ	C	T	N	E
		h	m	° ′		m	m		m
1	March 17	11	25.00	181 39	4.458	+3.47	28.47	0	+1.05
2	April 15	10	16.06	178 07	4.542	+8.60	24.66	70	−0.24
3	May 12	7	33.05	176 13	4.817	+9.47	42.52	135	−1.47
4	May 26	9	08.05	176 04	5.010	+8.12	16.17	169	−0.88
5	May 28	10	48 36	176 05	5.039	+7.85	56.21	174	+0.76
6	June 5	7	26.00	176 19	5.160	+6.45	32.45	193	−0.88
7	June 19	9	03.64	177 08	5.376	+3.32	6.96	227	+0.56
8	June 29	7	23.25	178 02	5.532	+0.52	23.77	251	+1.09

EQUATIONS OF CONDITION.

	m	c		m	c
1	$a+0\rho=0.00$	[−1.05]	5	$a+174\rho=-4.06$	[−4.82]
2	$a+70\rho=-2.81$	[−2.57]	6	$a+193\rho=-6.12$	[−5.24]
3	$a+135\rho=-5.45$	[−3.98]	7	$a+227\rho=-5.41$	[−5.97]
4	$a+169\rho=-5.60$	[−4.72]	8	$a+251\rho=-5.40$	[−6.49]

Each observation furnishes one equation of condition of the form

$$a+N(595.7m+\rho)=T-T_0$$

in which a is the error of the observation of March 17th; N, the number of rotations since that date; ρ, the small correction to $595.7m$, the assumed period; T, the *corrected* time of transit, and T_0 the corrected transit of March 17th. These equations of condition are given at the foot of the table, and need no explanation, except that the numbers in brackets are the result of substituting the values of a and ρ found from the solution of the equations: which solution gives

$$a = -1.055m \pm 0.566\ ;\ \rho = -0.02166m \pm 0.00330.$$

From this we find that the *observed* time (uncorrected) of the transit of March 17th, should have been $16h\ 23m\ 57s \pm 34s$, *Greenwich* M. T., while the rotation period is $9h\ 55m\ 40.7s \pm 0.2s$.

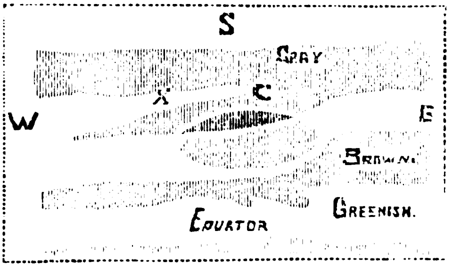
The probable error of a single observation comes out $\pm 0.73m$, or $44s$: but the number of observations is not sufficient to determine the probable errors with much certainty.

The remarkable retardation of the period of rotation still persists.

In 1879 Mr. Pratt made the period	9	55	34.9
" 1880–81 Mr. Hough	9	55	37.2
" 1882 3 " "	9	55	38.4
" 1883–4 " "	9	55	38.5
" 1884–5 " "	9	55	40.1

Mr. Denning's values for 1882–3–4 are about $1s$ larger than Mr. Hough's, but agree in showing that the period was but slightly retarded during that interval, while the renewed activity of the spot, indicated by its revived color and easier visibility, has been accompanied by a new increase of period.

The spot was faint during the last season, but far more conspicuous than in 1885. At one time (April 15) a prong or wisp from the northern edge of the southern belt seemed to overlie the red spot, encroaching upon it about one fourth of the width of the spot. I say *seemed* to overlie; but it was impossible to say certainly which was uppermost, for the outlines *both of spot and belt*, were visible as if the belt were a semi-transparent cloud through which the form of the spot could be seen; or equally as if the spot were the semi-transparent overlying object. Still my own impression was strong that the spot was underneath. The figure gives an idea of the appearance. When I next observed it, on May



Red-spot and Surroundings, April 15, 1886. Power, 790.

12th, the belt had drifted to the west, so that the point of bifurcation (*C* in the figure) had moved about to *X*, and the filament seemed to have narrowed so that the encroachment upon the spot, if it still existed, was very slight—too slight to be sure of in the unsteady air of that evening.

On the 26th and 28th there was certainly a clear, bright streak—very narrow, to be sure, surrounding the oval spot completely. The central white shade on the red spot was smaller and less noticeable than in '85. At times it became a mere streak.

Princeton, N. J., Oct. 15, 1886.

P. S.—In the Monthly Notices of the R. A. Soc. for June, 1882, Prof. C. Pritchett publishes an extensive series of observations of the red-spot made during the preceding opposition. He compares them with Marth's ephemeris, but does not appear to have worked out the rotation period corresponding. I have selected 14 of the observations which seem to be the best and the best spaced for the purpose, and have reduced them in the manner indicated above. They give for the rotation period 9*h* 55*m* 38.15*s*. The residuals are generally satisfactory, but three of them are between 2 and 3 minutes, showing either some want of extreme accuracy of observation or else *some irregular motion of the spot.*

I have also made a similar reduction of Mr. Pratt's observations in 1879, already referred to, (M. N. R. A. S. Jan. 1880). They give 9*h* 55*m* 34.05*s*, and only one of the 12 residuals exceeds two minutes. This result differs slightly from that deduced by Mr. Pratt himself by a less thorough treatment—33.91*s*.

I may add that the rotation period of a small round white spot which I observed three times in March and April, 1885, over a range of 58 revolutions, comes out 9*h* 55*m* 11.14*s*. The observations are almost absolutely accordant; and it is noteworthy that although this spot was in a higher latitude (about 50° south) than the red-spot, it yet rotates more rapidly.

ASTRONOMY AND THE ICE AGE.

For many years past, search has been diligent, for an explanation of the glacial epochs which are so well marked in the earth's crust that science declares them settled facts in geological history. In the solution of this fundamental problem, the astronomer has been able, so far, to give very little assistance, and that chiefly of a negative kind. Laplace has shown that the secular change in the obliquity of the ecliptic is confined within so narrow limits that no astronomer has regarded this as a cause seriously affecting climate. In itself considered, the precession of the equinoxes can have no influence on the climate. The secular change in the eccentricity of the earth's orbit is the only remaining cause which has generally occupied the attention of astronomers. Lagrange, Leverrier and Stockwell agree fairly well in results obtained for the greatest value of this change, which, in decimal form, does not probably exceed 0.077747, and whose least value is not less than 0.0022, making a possible variation between the upper and lower limits of the eccentricity of the earth's orbit, by these data not so much as one-twelfth of the whole. Now, since the major axis of a planetary orbit is invariable, and consequently the absolute length of the year, it follows, as Herschel said more than fifty years ago, that "The quantity of heat received by the earth from the sun in one revolution is inversely proportional to the minor axis of the orbit." As the eccentricity of the earth's orbit has been diminishing for the last 800,000 years, its minor axis has been increasing (although very irregularly) and consequently solar radiation diminishing proportionately. Now, if the fluctuation of eccentricity should amount to as much as one-twelfth of the semi-major axis, the variation of the sun's heating power as a whole would not be increased as much as one-half of one per cent. And if it should even amount to one-fourth, as Herschel supposed in 1830, the increase in solar radiation would be only three per cent of the whole. Our smaller fraction of change is nearly the maximum as derived from Leverrier's formulæ for computing the eccentricity of the earth's orbit and published in 1843. As tabulated by Croll, it covers a period of 4,000,000 years.

The very small change in the numerical value of the sun's heating power for the entire surface of the earth, at the known limit of the eccentricity of its orbit, has led astronomers to claim that this cause, though tending in the right direction, was not sufficient to account for the glacial periods of geology.

So far as the writer knows, this view has been held by astronomers generally, and scientists have not questioned it until, in 1875, there appeared a work entitled *Climate and Time*, by James Croll, the purpose of which was to show that the glacial epochs were due indirectly to the secular variation of the eccentricity of the earth's orbit. The tabular data, before referred to, which this book gives, cannot, of course, be accepted as rigorously true in regard to dates of epochs, because the formulæ of Leverrier depend on the solar parallax which was then certainly two per cent. in error. With a solar parallax now possibly one-half of one per cent. wrong, we will find the dates of those ice-age epochs still very uncertain. For example, if a maximum of eccentricity should be declared to have occurred 2,000,000 years ago, by this method of calculation, and the perihelion of the earth's orbit be so placed that the sun would be nearest the earth in northern winter, a condition which Mr. Croll argues might produce a glacial epoch in the southern hemisphere, the probable error of result from uncertain data would make the computed date uncertain by half a million of years, and therefore the physicist would not certainly know whether to name it an ice or a tropical epoch.

In connection with this interesting theme, attention is called to a note recently published in *Nature*, October 21, 1886, by Dr. R. S. Ball, of Ireland. It is appended in full.

Note on the Astronomical Theory of the Great Ice Age.

The following calculation has convinced me that Mr. Croll's theory affords an adequate explanation of the Ice Age. I compute the total quantity of heat received by each hemisphere of the earth during summer and winter respectively as follows:

Let $\frac{2H}{a^2}$ be the quantity of sun-heat falling perpendicularly on an area equal to the section of the earth at the mean distance a from the sun in the unit of time.

Let δ be the sun's north declination. Then the share received by the northern hemisphere will be

$$\frac{H}{a^2}(1+\sin\delta),$$

and by the southern

$$\frac{H}{a^2}(1-\sin\delta).$$

At the distance r, and in the time dt, the heat received in the northern hemisphere will be

$$\frac{H}{r^2}(1+\sin\delta)\,.\,dt\,;$$

but we have

$$r^2 d\theta = h dt,$$

whence the expression becomes

$$\frac{H}{h}(1+\sin\delta)\,.\,d\theta\,;$$

but we have

$$\sin\delta = \sin\theta\,.\,\sin\varepsilon,$$

where ε is the obliquity.

The total heat received by the northern hemisphere from the vernal to the autumnal equinox is the integral between π and o of,

$$\frac{H}{h}(1+\sin\varepsilon\sin\theta)\,.\,d\theta = \frac{H}{h}(\pi+2\sin\varepsilon).$$

We have thus the following theorem :

Let $2E$ be the total sun-heat received in a year over the whole earth; then this is divided into shares as follows:

$$\text{Northern hemisphere, summer, } E\frac{\pi+2\sin\varepsilon}{2\pi},$$

$$\text{" \quad " \quad winter, } E\frac{\pi-2\sin\varepsilon}{2\pi};$$

with identical expressions for the summer and winter in the southern hemisphere.

If we make $\varepsilon = 23°27'$ we find that the heat received during the summer (equinox to equinox) of each hemisphere is $\cdot 627E$, while the heat during the winter of each hemisphere is $\cdot 373E$. More briefly still. If each hemisphere receives in the year a quantity of sun-heat represented by 365 units, then 229 of these are during summer, and 136 during winter. These figures are independent of the eccentricity of the earth's orbit.

The length of the summer is defined to be the interval when the sun's centre is above the equator. The length will of course vary with the eccentricity and with the position of the equinoxes on the orbit. We need only take the extreme case where the line of equinoxes is perpendicular to the major axis of the orbit. The maximum difference between the length of summer and winter is thus

$$365 \text{ days} \times \text{eccentricity}.$$

I take the maximum eccentricity of the earth's orbit to be

$$0{\cdot}0745,$$

this being the mean of the values by Leverrier, Lagrange and Stockwell (See Croll, "Climate and Time.," p. 531), and therefore, the greatest difference between summer and winter will be about 33 days, *i. e.* one season in 199 days, and the other in 166 days.

The total quantity of heat received during the year on each hemisphere is practically independent of the eccentricity ; but the mode in which that heat is received at the different seasons will vary, and thus give rise to the following extreme cases :

GLACIAL.

(Summer)	229 heat units spread over	166 days.		
(Winter)	136	"	"	199 "

INTERGLACIAL.

(Summer)	229 heat units spread over	199 days.		
(Winter)	136	"	"	166 "

We hence deduce the following, where unity represents the mean daily heat for the whole year on one hemisphere :

GLACIAL.

Mean daily sun-heat in summer (short) ...	1·38
" " winter (long) ...	·68

INTERGLACIAL.

Mean daily sun-heat in summer (long) ...	1·16
" " winter (short) ...	·81

PRESENT (NORTHERN HEMISPHERE).

Mean daily sun-heat in summer (186 days)	1·24
" " winter (179 days)...	0·75

These figures exhibit a thermal force of great intensity. The unit represents all the mean daily heat received from the sun by which the earth is warmed up from the temperature of space. The heat unit in fact maintains a temperature perhaps 300°, or even more, above what the earth would have without that heat. Each tenth of a unit may thus roughly be said to correspond to a rise or fall of mean temperature of 30° or more. The long winter of 199 days, when the average heat is only two-thirds of a unit, leads to the accumulation of ice and snow, which form the glacial epoch. The short winter of 166 days, where the temperature is ·06 of a unit above that of our present winter, presents the condition necessary for the mild interglacial epoch.

THE SIX INNER SATELLITES OF SATURN.

Astronomy is indebted to Professor Hall, of the Naval Observatory, for recent important work on the six inner satellites of the planet *Saturn*. Excepting *Titan*, most of these satellites are faint objects, and the ring increases the difficulty of making accurate observations, and so, for many years after the discovery of these satellites, their orbits were only rough approximations. Bessel published in the *Astronomische Nachrichten*, vols. 9 and 11, an orbit of *Titan* from which the mass of *Saturn* was determined, and this value has been commonly used in computing perturbations produced by this planet.

Before his death in 1846, the distinguished Bessel began (but did not complete) a memoir on the *Theorie des Saturns Systems*, which Professor Hall pronounces "the most complete investigation we have of the differential equations of this system, and of the various forms of the perturbative function arising from the figure of the planet, the Ring, the action of the satellites on each other, and the action on the sun." It was published in vol. 28 of *Astronomische Nachrichten*, and in convenient form in Englemann's *Abhandlungen von F. W. Bessel*, vol. 1, p. 160. In Bessel's work, to determine the mass of the Ring from the motion of the line of apsides of the orbit of *Titan*, the figure of the planet was neglected, supposing its influence to be small. In order to separate the forces due to the Ring and the figure of the planet, M. Tisserand pointed out the necessity of determining the orbits of the other inner satellites, in vol. 1 of the *Annals l'Observatoire de Toulouse*, from which it appears that if these orbits are decidedly eccentric, so that the motion of their apsides may be accurately observed, the mass of the Ring and the figure of the planet may be found by comparison with theoretical expressions.

The first step in Professor Hall's work was to determine these orbits with as much accuracy as possible. *Titan* was observed at the oppositions of 1875-6-7 and also in 1883, and the other satellites chiefly within the same period by himself and Professor Newcomb.

In the paper before us, Professor Hall's summary of results is as follows: "From the observations thus far made at Washington, we have the remarkable result that the five inner satellites of *Saturn* move in orbits that are sensibly circular. This result, of course, sets aside all considerations of the motion of their lines of apsides. It is probable also that these five inner satellites move in the plane of the Ring; at least so nearly that we may take this plane for the plane of their orbits in all calculations of their motions. The error of this assumption will certainly be very small. The mass of *Saturn* is found most accurately from *Japetus* and *Titan*, since very small errors of observation entering into the determinations of the mean distances of the inner satellites have a great influence on the value of the mass. The motion of *Titan* is so connected with that of *Hyperion* that a little doubt may arise from this source, but probably the mass of *Hyperion* is very small and the observations of *Titan* are well satisfied by pure elliptic motion. The mass of the planet has been computed from the elements that have been found for *Titan*, *Rhea*, *Dione* and *Tethys*. * * *

The mean result from the four satellites is therefore—

$$\text{Mass of } Saturn = \frac{1}{3478.7 \pm 1.10}$$

This is an increase of the mass of the planet amounting to nearly one sixteenth of itself over the value given by Newcomb and Holden.

Since the five inner satellites move nearly in the plane of the Ring, and also in circular orbits, it is easy to furnish tables of their motions, which, with the elements of the Ring, complete the paper.

SOME ACCOUNT OF A NEW CATALOGUE OF THE MAGNITUDE OF SOUTHERN STARS.

EDWIN F. SAWYER, CAMBRIDGE, MASS.

The present short paper is merely intended to announce the completion, in the immediate future, of a work undertaken in 1882, namely, the determination of the relative magnitude of the stars included between the equator and 30° S. Dec., and not fainter than the 7th magnitude. In fact the work is a revision of so much of Dr. Gould's valuable catalogue the Uranometria Argentina, as is included in the above limits, and his catalogue has been used as the basis of the undertaking. The observations have been made by Argelander's well known method of step estimations; the stars being gathered into convenient sequences, and these sequences formed from the stars as closely adjacent as possible; thus reducing to a minimum errors arising from atmospheric causes and the unfavorable situation of the stars, except in a few sequences formed from bright stars necessarily more widely scattered. In making the observations, an opera-glass magnifying two and one-half diameters has been employed and the glass placed slightly out of focus, expanding the stars into disks of light; this method after repeated trials appearing to give the most reliable results, especially where the stars are colored. The observations have generally been made during evenings free from the moonlight and clouds and haze. As at first planned, each star was to have been observed but once (owing to the press of other astronomical work on our leisure time), but after the observations had been practically completed in 1885 (comprising some 3500 stars) and while their reduction was under way, it was decided to re-observe each star once in ordinary cases, repeatedly where large discordances appeared. This duplication of the observations, while it increased the amount of time and labor which I had originally intended to devote to the undertaking, would, I felt, be justified by the enhanced value of the results; observations were therefore resumed in 1886, and it is hoped that another year will find the work completed and ready for publication.

The number of stars comprised will approximate 3500, and the average number of observations for each star will be about three and one-half. During the progress of the work one variable star has been discovered, and large discordances in the observations of several stars may possibly lead to the detection of others.

As a test of the character of the work, the following results have been deduced from a partial discussion of the observations of about 900 stars observed from two to five times each.

To determine the accidental errors of observation, I have found from 593 stars, observed twice, that the average difference between two independent determinations of a magnitude of a star is .112 of a magnitude, which corresponds to a probable error of a single observation of ±.065 of a magnitude. There appears to be no sensible difference in the values of this element dependent on the zenith distance.

The process of reduction adopted presumably excludes a liability to any systematic deviation from the system of magnitude of the Uranometria Argentina, which, as is known, is based on that of the Uranometria Nova. But a direct test has been made to verify this point, by employing stars observed three or more times. Taking the difference between my mean magnitude and that of Dr. Gould's, and classifying according to magnitude we have the following table :

Mag.	No. of Stars.	G.—S. Systematic Difference.	Probable Error of a Difference. G.—S.
1—4	49	—.033	±.106
4—5	46	—.004	±.109
5—6	59	+.017	±.093
6—7	98	+.002	±.073
	252		±.091

The values in the third column are merely nominal and afford satisfactory evidence of the coincidence between my magnitude scale and that of Dr. Gould's. From the fourth column, it appears as would naturally be expected that the estimates for the fainter magnitudes are ratably the more accurate. The probable error of a difference G.—S. is on the average .091 of a magnitude. Assuming for want of a criterion that both catalogues have equal weight, this corresponds to a probable error in each of .064 of a magnitude.

I have not limited the observations to the stars only contained in Dr. Gould's Catalogue, but have inserted all objects which have appeared to be in the neighborhood of his fainter class.

The number of such objects is surprisingly small, probably not over seventy-five; and this, in connection with the observed small probable error appears to be a most satisfactory evidence of the high degree of precision of the magnitudes of the Uranometria Argentina.—*Salem Press.*

PROVISIONAL VALUE OF THE LATITUDE OF THE LICK OBSERVATORY.

PROFESSOR GEORGE C. COMSTOCK.

The following provisional value of the latitude of the Lick Observatory depends upon observations made upon four nights in August, 1886, with the Repsold meridian circle by Professor George C. Comstock, assisted by President E. S. Holden, who kindly read the microscopes. All of the stars observed were selected from the star list of the *Berliner Astronomisches Jahrbuch*, and the latitude depends upon the apparent declinations of the stars as given in that ephemeris. Both the fixed and the movable circle of the instrument were read for each star, and were separately reduced. The discordances found between the results from the two circles are not greater than may fairly be attributed to division errors; the results from the fixed circle are, however, rather more accordant with each other than are those from the movable circle, indicating either inferior graduation or unstable clamping of the latter.

Each observed star furnishes a value of the reading of the circles when the telescope is pointed to the celestial equator (technically called an equator point), and the mean of all the equator points obtained during a night is taken as the equator point for that night. The circle reading corresponding to the nadir was obtained at the beginning and end of each night's observations, and the mean of these nadir points is assumed as the nadir point for the night. The agreement of the individual nadir points is fairly satisfactory, the difference between separate determinations upon the same night in no case amounting to as much as 1″. The difference between the mean equator point and the mean nadir point is the supplement of the latitude.

The following table furnishes a brief summary of the results derived from the observations of each night :

Date.	Position of Instrument.	No. of Stars.	Latitude from Fixed Circle.	Latitude from Movable Circle.
1886—August 5..........	Clamp W.	7	37° 20′ 24.7″	37° 20′ 24.5″
August 8..........	" W.	12	24.2	25.1
August 13..........	" E.	8	25.3	24.8
August 14..........	" E.	11	25.3	25.4

The mean of the results Clamp W. is 37°20′24″.6 ; the mean for Clamp E. is 37°20′25″.2, showing a slight discordance between the results derived from different positions of the instrument. Such a discordance was *a priori* probable, having been found in the case of other meridian circles.

The most probable value of the latitude that can be derived from these observations, is the mean of the results Clamp W. and Clamp E.:

$$37^\circ\ 20'\ 24''.9,$$

which may be adopted as a provisional value for the latitude of the centre of the mercury basin of the meridian circle. The probable accidental error of this result, estimated from the discordances of the individual results, is not far from ±0.″10, but the above value of the latitude provisionally assumed, may be affected by systematic errors arising from defective graduation of the circles, flexure, irregular refraction, etc., amounting in the aggregate to a considerably greater quantity.

The north dome of the Lick Observatory is twenty-seven feet north of the meridian circle, whence its latitude results from these determinations, 37°20′25″.2.

Mr. C. A. Schott, Chief of the Computing Division of the U. S. Coast and Geodetic Survey, has kindly communicated results for the position of this station, which have been derived from the triangulation measures of Professor Davidson.

These are (for the dome of the 12-inch equatorial):

Latitude = + 37° 20′ 24″.752.
Longitude = + 121° 38′ 35″.284 (Greenwich).
Longitude = 8*h* 6*m* 34.352 (Greenwich).
Longitude = 2*h* 58*m* 22.26 (Washington).

It will be observed that our determination of the latitude gives a result, 0″.4 greater than that of the U. S. Coast Survey. This corresponds to about forty feet, six inches. The agreement between the two results is perfectly satisfactory, when we consider the small number of stars observed by us, and also that the position derived by the U. S. Coast and Geodetic Survey is not strictly definitive, as two stations (viz., Macho and Sta. Ana) require to be occupied to complete the primary triangulation in this vicinity.

ASTRONOMICAL THEMES IN LATE PERIODICALS.

Monthly Notices, No. 9, Vol. XLVI. Observations of the variable star R *Carinæ* from September, 1883, to April, 1886, by John Tebbut.

Observations of Calliope, by R. Luther.

Observations of Comets, 1877, I, II, III, VI; 1880, III; 1882, III; 1884, III, at Dun Echt Observatory, made with 15-inch refractor, with remarks and illustrations.

Observations of Comet of Fabry, 1885, Barnard, 1885 (*e*), c, 1886, and Brooks I, 1886, at Sydney Observatory with 11½-inch refractor.

Ephemerides of the Satellites of Saturn and the Satellite of Neptune for 1886 and 1887, by A. Marth. From observations at Malta in 1852 and 1864, Mr. Marth computed the orbit of the satellite of Neptune. In 1874, Professor Newcomb, and in 1883, Professor Hall, each published elements of the same orbit with the following results in regard to *inclination* and *Longitude of node on Neptune's orbit*:

		Long. of Node.	Incl. of two orbits.		
Malta,	1852	176.20°	148.33° or	31.67	if the satellite's
	1864	180.41	146.19	33.81	motion is reck-
Washington,	1874	182.59	144.04	33.96	oned as retro-
- -	1883	184.31	142.38	37.62	grade.

The question is how are these figures to be explained ? Are these changes in the position of the plane of the satellite's orbit by some disturbing force, or are these systematic errors of observation ?

Mr. Marth properly suggests that large telescopes, with good micrometers may be profitably employed at the present opposition of Neptune in obtaining measures of position angle and distance.

In *l'Astronomie* (French), for November, the leading article is by the editor, Camille Flammarion, on *The Secular Movement of the Pole and the Solar System.* The motion of the pole of the earth about the pole of the ecliptic is described, in popular language, giving dates and principal stars which it passes in its revolution, its path being neatly shown by a large plate. The path of the pole is not a smooth curve as determined by the places of the stars, for they have proper motion, and the whole solar system is in motion also. This is also shown in the figure by a dotted curve line, indicating drift towards *Hercules.* When the celestial pole shall pass near *Vega,* 11,700 years hence, the real distance will be less than now supposed on account of the two reasons just given. The proper motion of *Vega* is A. R. + 0.0173*s*., P. D. —0″.295 ; resultant 0″.359, amounting in 12,000 years to 1° 12′.

The path of precession has yet another cause of variation, due to the change in the obliquity of the ecliptic, its extreme range of oscillation being 2° 37′, which, however, is so slow as not to modify the curve sensibly, only very slightly diminishing it toward the centre.

The condition of the world at different epochs in the past is then noticed, followed by an imaginary prophecy for epochs in the future.

The second article is by Gustave Hermite on *The Determination of the Number of Stars of our Universe.* The stars are not innumerable. The unaided eye sees in the northern hemisphere, 2,478 ; in southern, 3,307. Opera-glass shows 20,000 ; small telescope, 150,000 ; large telescopes reveal 100,000,000. Apparent brightness or magnitude depends on (1) real size,

(2) intrinsic brightness, (3) distance. After speaking of variable stars, a half-page table is given, showing (1) different magnitudes from 1 to 20; (2) luminous intensity of each magnitude compared with the first; formula, $x=2.56$ with exponent $n-1$, n being corresponding order. For example, 6th magnitude would be 110 times less luminous than 1st; (3) gives number of stars belonging to each magnitude forming nearly a geometric series, with $r=3$; (4) contains numbers for each magnitude corresponding more nearly with results of observation obtained by another formula; (5) gives ratio for luminous intensity of each magnitude and (6) furnishes computed results. Then follows the statement of two laws:

1. The number of stars passing from one magnitude to the next follows an increasing geometrical progression whose first term is 19 and whose ratio is 3.

2. The total luminous intensity of the different magnitudes follows also in increasing geometrical progression whose first term is 19 and whose ratio is $\frac{3}{2.56}$.

These facts are well established; and yet the writer properly adds, that the terms of this increasing geometrical progression increase to infinity; but if the number of stars increase to infinity by the first law, the luminosity ought to increase in the same way according to the second law. It is claimed that the second law is arrested in its operation by a cause intimately connected with the constitution of our Universe.

Other articles of this issue of *l'Astronomie* are elsewhere noticed.

Astronomische Nachrichten, Nos. 2751, 2752. (German.) The leading article in No. 2751 is concerning the method of computing the curves of objectives according to Scheibner's new principles. The theoretical way of doing this work is given in detail, as well as some account of how the new method came to be published. The optician who has some knowledge of the mathematics will be interested in this paper, which he should read entire for a proper understanding of the method. Following this is a report from several prominent observers claiming that the great nebula of *Andromeda* was active again during

October 2-6, and that a star certainly as bright as a 10th or 10.5th magnitude was then observed in, or near, the place of the wonderful *nova* of last year. Herr N. von Konkoly, of Ogyalla, said that he saw the star without question on the 3d day of October. On the same day, the nebula was photographed by Herr Eugene von Gothard, of Hereny, and he found, on comparing it with a photograph of the *nova*, taken September 7, 1885, that the correspondence with the surrounding stars, and the new star with the *nova* of 1885, was perfect.

Other prominent observers, however, on examining the nebula later with more powerful telescopes saw nothing new or unusual; and some think that the observers first named must have mistaken a certain 11th magnitude star for the supposed new one. Drs. Englemann, Lamp, Krueger Schœnfeld, and Baron von Englehardt are satisfied that for several days near the middle of October, and so late as October 20, there was nothing unusual in the appearance of the nebula. These opinions are given in No. 2752 A. N., which also contains Dr. Lewis Swift's 4th Catalogue of new nebula discovered at Warner Observatory, Rochester, N. Y.

Gould's Astronomical Journal, No. 145. This publication is resumed again; first number of Vol. VII appeared November 2. It contains an article by S. C. Chandler *On the Light Variations of Sawyer's Variable in Vulpecula; A New Variable of Short Period*, by E. F. Sawyer, and part I of *Inequalities of the Moon's Motion produced by the Oblateness of the Earth*, by John N. Stockwell. Part I presents general considerations and history of the problem. Four points are made in the outset, the first three of which deal with the known principles of gravitation, and the last gives a brief history of the problem beginning at the middle of last century, with Meyer's co-efficient of inequality in longitude amounting to 4″, which Mason declared later should be 7.7″. In 1773, LaGrange first announced that the non-spheroidal form of the earth would affect the moon's motion, the amount of which Laplace found to be 6.8″ in longitude, if the oblateness of the earth be $1 \div 304.6$. Laplace's theory also revealed a more surprising inequality of 8″ in latitude which had been unnoticed before. In 1879 and later, Mr. Stockwell gave attention to the lunar theory, using a method of computation depending on the variation of the co-ordinates of the disturbed body, the results of which he attempted to verify by another common method, viz.: varying the elements of elliptical motion, but without success. The difficulty he could not explain. Later he found serious errors in his own work, and, as he supposed, in the solutions of other investigators also, notably that of Mr. Hill, of Washington. Attention was called to these errors in *The American Journal of Science*, February, 1885, in which Mr. Stockwell says (pp. 160, 161) that there are 374 inequalities of motion, and that not more than *two* of them, if indeed *any*, are acurate in Mr. Hill's *Supplement to Delauny*, chiefly because he has neglected three important terms in the development of his equations representing the disturbing forces. In the March *Observatory* (1886), Professor J. C. Adams claims that Mr. Stockwell's criticisms are not good, because the perturbations due to the earth's figure are very small compared with those due to the action of the sun, and therefore Mr. Hill's formulæ are sufficiently accurate. Mr. Stockwell is not satisfied to leave the discussion in this way and will continue it further.

Nature (October 14, 1886) has, for its frontispiece, a beautiful steel engraving of Professor J. C. Adams, Cambridge, England. Under the title "Scientific Worthies," will be found a sketch of the life of that distinguished scholar.

In *Nature* (October 28) Miss A. M. Clerke presents an extended review of Schulz's Solar Physics. Articles entitled "The New Optical Glass," and "The German Naval Observatory" also appear.

EDITORIAL NOTES.

This number completes Volume V of the MESSENGER, and with it expires a large number of subscriptions. Persons desiring its continuance will please say so by card or letter and thereby assist us in preventing irregularities by mailing.

FINLAY'S COMET (*e*, 1886). Professor Boss has computed a second orbit for Finlay's Comet, from four observations, giving decidedly elliptical elements. The period found is only 4.32 years. The inclination of the orbit being very small (3° nearly), the position of the node is uncertain. The comet is approaching the earth, and on December 1 it will be (theoretically) nearly twice as bright as it was November 1. At the present writing (November 20) its coma is about 4′ in diameter, with strong central condensation and no train. It is among the small stars of *Capricornus*, about 2° south by the ecliptic. December 3 the comet will pass very near δ *Capricorni*, its general path being nearly northeast.

RECENT SHOWERS OF METEORS.—I send the following in continuation of the results already published in the SIDEREAL MESSENGER, December, 1885, p. 300 and February, 1886, p. 61.

Between the end of April, 1886, and the beginning of November, I recorded 958 shooting stars during watches covering a total of 119 hours. I have made the following selections from the radiant points derived from these observations. The *Perseids* have been omitted as already sufficiently investigated:

Epoch of Shower.	Night of Max.	Radiant Point. R. A.	Dec.	No. of Meteors.	Appearance.
1886.		°	°		
April 27—May 5	May 5	234	+ 10	8	Swift.
April 30—May 6	May 6	337	— 2½	11	Rather swift. Streaks. Long.
April 30—May 7	May 5	254	— 21	5	Slow, long paths.
May 1—4	May 1	239	+ 46	8	Rather swift, short and faint.
May 29—June 4	May 29	333	+ 27	4	Swift. Streaks.
June 26—July 6	July 1	294	+ 39	9	Slow, short.
July 27—Aug. 11	Aug. 2	291	+ 51	14	Rather slow, short.
July 30—Aug. 11	Aug. 4	350	+ 51	11	Swift, short.
July 31—Aug. 4	July 31	20	+ 57	7	Swift, streaks.
August 2—10	Aug. 4	48	+ 43	10	Swift, streaks.
August 4—10	Aug. 4	26	+ 42	6	Swift, streaks.
August 22—28	Aug. 22	331	+ 71	8	Swift, short.
August 22—29	Aug. 29	292	+ 70	11	Swift, bright.
August 29	Aug. 29	106	+ 52	6	Rather swift.
September 21—22	Sept. 21	63	+ 23	7	Swift, streaks (1879-86).
September 22—27	Sept. 27	115	+ 52	7	Swift, streaks.
September 22—30	Sept. 27	14	+ 12	8	Slowish bright.
September 22—30	Sept. 22	292	+ 71	10	Swift.
September 27	Sept. 27	75	+ 15	8	Very swift. Streaks.
September 30—Oct. 2	Oct. 2	73	+ 41	7	Swift, streaks.
October 22	Oct. 22	43	+ 5	5	Slow, faint.
November 2—3	Nov. 2	55	+ 9	17	Slowish, trained, bright.

Bristol, England, Nov. 5, 1886. W. F. DENNING.

ANNALS, VOL. XVI, H. C. O.—Volume XVI of the Annals of the astronomical observatory of Harvard College has been distributed It contains observations of fundamental stars made with the meridian circle during the years 1870 to 1886, and prepared for publication under the direction of Joseph Winlock and Edward C. Pickering, by William A. Rogers.

The introduction to this volume should have special mention because of the full explanations given under the heads of reductions in right ascension and declination and illustrative examples of the methods ; tabular values of the coefficient of collimation constant; investigation of the homogenious character of the value of a certain constant called *n*; flexure constant, its variability, and, as a function of the sine of the zenith distance; reduction of the equator point; reduction of the mean of two to the mean of four microscopes, and many more points of as much value to those especially interested in meridian circle places as those already named. It is work of the highest order.

COMET OF BARNARD.—The comet discovered here on the morning of October 5, has been regularly observed when the weather permitted. On the morning of October 30, it had so increased in brightness as to become visible to the naked eye, as a hazy spot, as bright as a sixth magnitude star. The same morning I suspected that the broad brush-like tail was bifurcated and on the morning of November 1, I readily detected two tails, the longest being at a position-angle of (by estimation) 287°, and was about 2½° long, while the second tail at a position-angle of 134° was somewhat less than ½° long. Evidence of the formation of a third tail was visible at a position-angle of 150°.

They were both distinct but somewhat faint, and the sky between them was free of nebulous matter, showing that their tails were entirely distinct from each other. Both tails, at subsequent observations, were found to be brighter and increasing in length. At the last observation, before the present moon interfered, the comet was quite noticeable to the naked

eye, fully as bright as a fifth magnitude star, and traces of the tail were beginning to be apparent without the telescope. November 15 in nearly full moonlight, the comet could be seen without the telescope, a short distance above *Epsilon Virginis*.
Vanderbilt University Obs'y, Nov. 18, '86. E. E. BARNARD.

BARNARD'S COMET (*f* 1886).—From three observations of Barnard's Comet (*f* 1886) I have derived the following system of elements:

T = Dec. 18.0335 *G. M. T.*

$$\left.\begin{aligned} \omega &= 85^\circ\ 00'\ 40'' \\ \Omega &= 137\ \ 58\ \ 04 \\ \pi &= 52\ \ 57\ \ 24 \\ i &= 80\ \ 01\ \ 29 \end{aligned}\right\}\text{Mean Eq. 1886.0}$$

$\text{Log}\ q = 9.839356.$

Motion retrograde.

$$x = 9.876084\, r\, (3^\circ\ 53'\ 10'' + v)$$
$$y = 9.827726\, r\, (199^\circ\ 02'\ 45'' + v)$$
$$z = 9.996166\, r\, (100^\circ\ 36'\ 20'' + v)$$

The geocentric path of this comet will be above the western horizon in December and January, and there is a probability that the body itself will become visible to the naked eye about the middle of next month; but if it does not, there is almost a certainty that it may be seen easily by those who possess even very ordinary telescopic aids.

Washington, D. C., November 17, 1886. S. J. CORRIGAN.

PARALLAX OF *a* LYRÆ AND 61 CYGNI.—In 1882 Professor Hall, Naval Observatory, Washington, D. C., published his observations made with the filar micrometer of the 26-inch equatorial for determining the annual parallax of the stars *a Lyræ* and 61 *Cygni*. The results then obtained were:

$\pi = 0.1797'' \pm 0.005612$, for *a Lyræ*.

$\pi = 0.4783'' \pm 0.01381$, for 61 *Cygni*.

making the distances of the two stars, respectively 18.11 and 6.803 Julian years, as measured by the velocity of light. The observtaions from which these results came were the differences of declination of the principal stars, with respect to small ones near them, supposed to have no physical connection. Professor Hall suspected something wrong in the process of reduction at the time and Dr. Peters later observed that the correction for temperature had been applied with the wrong sign. From 1883 to 1886 further observations of these stars and 40 *Eridani* and 6 B *Cygni* were made with a 26-inch equatorial, but preceding their reduction, a full discussion of the value of the arc of one revolution of the micrometer screw is given in Professor Hall's paper on the fuller study of the parallax of these stars recently pub.ished. The following table gives the summary of results as found in that paper:

Date.	Star.	Parallax.	No. of Obs.
Feb. 23, 1883, to March 4, 1884	40 Eridani	+0.223″ ± 0.0202″	30
July 31, 1883, to April 15, 1886	6 B Cygni	—0.021 ± 9.0077	54
May 24, 1880 to July 2, 1881	a Lyræ	+0.134 ± 0.0055	128
Oct. 24, 1880, to Jan. 26, 1886	61 Cygni	+0.270 ± 0.0101	101

The change in parallax of the last two stars is very considerable, and, of course, makes a corresponding change in distance from our sun. While we have recently thought of light reaching us from 61 *Cygni* in 6.8 Julian years, we must now wait for it 11.8 years. The light-distance of *a Lyræ* is also increased from 18.1 to 24.3 Julian years.

Professor Hall's paper is good reading for variety of method in finding the value of one revolution of the micrometer screw.

THE SIDEREAL DAY.—In the October number of *l'Astronomie* (French), H. Rapin discusses the sidereal day and the rotation of the earth on its axis. After speaking of the diurnal, annual and precessional motions of the earth, he claims that the first is not accurately defined in text-books and works on astronomy because the effect of precession is not considered; that when a meridian of the earth, in its daily rotation, comes a second time to the equinox, it has then described 360°; that the earth's arc of rotation, as limited by the successive culminations of a star absolutely fixed in space, is more than 360° by the small amount of .008 of a second of time and that the ordinary definitions of the sidereal day do not distinguish between these two periods.

He criticizes the common definition of the sidereal day in the following language :

"We find fault with these definitions

1. Because they present as absolute and general and without qualifying words an identity which does not exist, and can be assumed as true only for short periods of time.

2. Because they call that sidereal which is so only by practical necessity, and which is really equinoctial or tropical.

3. We wish that the books for instruction, including the practical, contained a short article to make this point clear and prevent false ideas."

CATALOGUE OF 1213 STARS.—The catalogue of 1213 stars by Professor W. A. Rodgers, of Harvard College Observatory, has recently been published. It contains the annual results for the fundamental stars during the years 1870-1879; results for the separate observations of the same stars during the years 1883-1886, in the form of corrections to the places obtained by previous observations and results for the separate observations of various other classes of stars particularly described in the introduction.

This catalogue of 1213 stars was fully explained in a publication under the above title which was issued in 1884.

AUGUST ECLIPSE PHOTOGRAPHED.—Mr. R. D. Schimpff of Scranton, Pa., photographed the partial eclipse of August 29, 1886, at *6h 18m* A. M., with a 3-inch refracting telescope. The copy sent the MESSENGER is beautifully clear and definite. Mr. Schimpff says : "The fogs at that early hour obscured all the detail upon the solor disc ; also, prevented delicate spectrocopic examination which I intended to make."

EDINBURGH OBSERVATIONS, VOL. XV.—This star-place catalogue and ephemeris for 1830 to 1890 contains astronomical observations for 1878 to 1886, made at the Royal Observatory at Edinburgh, under the direction of Professor C. Piazzi Smyth, Astronomer Royal for Scotland. Volume XIV, which was published in 1877, is part of this catalogue and has star numbers to 641 in the consecutive count with this volume designated XV. The preceding volume covers only the first four hours of right ascension, while this embraces the remaining eighteen hours, making a large book of 1675 large pages with 3890 consecutive star numbers.

In this catalogue each page is ruled into seventeen vertical columns. The first gives its own consecutive star number; the second, name and number in the British Association catalogue, history, and, if a double star, the brighter component observed when definitely possible; third, observed or tabular magnitude; fourth, date of right ascension observations; fifth, year reduced to, by observer and editor of catalogue; sixth, mean right ascension on January 1 of the year referred to, observed, (tabular); seventh, number, and name of observer, and correction to tabular place at date; eight, nine, precession in right ascension; ten, annual proper motion; eleven, date of north polar distance; twelve, reduction; thirteen, fourteen, fifteen, sixteen and seventeen, treat north polar distance similar to right ascension.

Three or four stars only occupy one page, in consequence of the varied and comprehensive data presented. (Professor Smyth calls our attention to one correction that should be made on page 642, column 17, and line 4. For R. Asc. read N. P. D.)

The preparations of this catalogue has required an immense amount of labor, which, doubtless, has been carried forward with the skill and care for which the Astronomer Royal of Scotland is well known during forty years of useful and distinguished astronomical work.

This catalogue will be heartily welcomed by star observers on this side of the water.

PHOTOGRAPHY OF THE HEAVENS.—The marked success of the observers, Paul and Prosper Henry, at the Paris Observatory, in celestial photography recently, is worthy of the general and favorable notice it is receiving. The instrument used consists of two telescopes, side by side; one objective being 9.4 inches aperture, and 11 ft. 10 in. focal length, used as a pointer, the other 13.4 inches aperture, and 11 ft. 3 in. focal length, and corrected for photographic rays. The latter objective consisting of a single lens has a field of 3° in diameter. In the first trials of the new instrument, on a surface of five degrees square, the sensitive plate showed 2,790 stars, between the fifth and fourteenth magnitudes with unmistakeable clearness.

Stars of the fourteenth magnitude appear on the plate as $\frac{1}{1000}$ of an inch in diameter and require an exposure of the plate for one hour. The clock-work that will keep an instrument so steadily in motion for so long a time as is necessary to photograph stars of the fourteenth magnitude must have a control of marvelous precision.

The photographic plate is manifestly more sensitive than the retina of the eye, and hence it can be used in discovering and mapping the asteroids, in the examination of double and multiple stars, and in the study of the colors of the stars.

LEANDER MCCORMICK OBSERVATORY.—The report of the Director, Professor Ormond Stone, to the Board of Visitors, shows that the great 26-inch equatorial has been chiefly employed in studying the southern nebulæ. The nebula of *Orion*, the Trifid and Omega nebulæ have received special attention. Two hundred and thirty-three new nebulæ have been found, three hundred and fifty-one observations of miscellaneous ones have been made resulting in two hundred and twenty-six drawings. Some work has been done on difficult double stars and Barnard's comets, (1885 II and 1886) and Tuttle's periodic comet were observed. Part 3 of volume I of the publications of the Observatory has also appeared. Its subject matter is the nebula of *Orion*, 1885, and is a detailed statement of the notes and observations of Professor Stone and Mr. Leavenworth, his assistant, from January 12 to March 18. The notes are accompanied by drawings and finely executed plates of the nebula as a whole.

BRIGHT METEOR.—While returning to town with Rev. J. E. Garrett, on Sunday evening, October 24, at about 11 o'clock, Washington, D. C., time, I saw an unusually large and bright meteor. When first seen, it was in the neighborhood of the *Pleiades*, and it disappeared in the neighborhood of μ *Cassiopea*. I think it must have been visible much further to the southeast than the *Pleiades*, as it was light enough to see the telegraph wires distinctly as I looked up, although there was no moon and the stars were faint. It was quite a brilliant object, almost terrifying in its vividness. I cannot give the exact time, as I had no means of making a light to consult my watch, but the time given is not many minutes wrong.

Washington, Ohio, Oct. 25, 1886. W. R. SCOTT.

A NEW OBSERVATORY IN LA PLATA.—We are glad to learn that the government of La Plata are fitting out an observatory in the Province of Buenos Ares. If supplied as liberally with good workers as with instruments we may expect soon to have some good work done here. Among the numerous instruments are a telescope (reflector) 31·5 inches in diameter, an equatorial coude 17 inches aperture, an 8-inch transit, an altazimuth, an apparatus for celestial photography, a large Thollon spectroscope, 9·8-inch objective, numerous geodetic instruments, including three portable transits, a set of magnetic instruments, and finally fourteen collections of meteorological instruments, to be distributed over the district. The optical portion of these instruments is to be constructed by MM. Henry of Paris. A time service is to be instituted. The observatory is to be under the direction of M. Beuf, late an officer in the French navy. It would seem that a large amount of geodetic work is to be done, inclnding the measurement of an arc of a meridian, for which the immense plains of Chaco and Patagonia are extremely favourable.—*Observatory.*

OBSERVATIONS OF METEORS.—On the evening of the 4th inst., while endeavoring to observe the variables, R. and S. *Tauri*, a few degrees south of the *Hyades*, at about 9*h* 47*m* standard time, with a 6-inch telescope, power 45, the field of view was suddenly filled with a blaze of bluish light. Quickly withdrawing my eye from the glass, I saw a very brilliant meteor just before its disappearance, and which had passed within two or three degrees of the neighborhood I had been examining. It left a bright trail which remained visible to the naked eye for three or four minutes, and through the telescope for as much longer. With the glass it appeared as a long sinuous mass of luminous vapor, being almost curled up in itself in one place. The whole having a very perceptible drift towards the southeast. The length of the trail was about 8 degrees, extending from neighborhood Σ 495, past 57 *Tauri* and ending about midway between 88 and 95 *Tauri*, as traced on Proctor's atlas. It could probably have been traced much further had it not been for the presence of the moon then at first quarter.

It was the brightest meteor I have seen in a long time. It was sufficiently luminous to cast a shadow almost at right angles to the rays of the moon. On the same evening, some other meteors, but much fainter, were noticed dropping down in the east and northeast, in paths nearly parallel to above. Also on the 1st inst., several were seen in the same portions of the heavens, between eight and nine o'clock, falling in same general direction, some of these being as bright as first magnitude stars. Again on the evening of the 5th inst. a member of my family noticed quite a brilliant one, which he described as shooting downwards and not very far from the position of the one of the previous evening.

These apparently came from direction of *Aries* or *Andromeda* but I cannot speak positively of this.

Bayonne, N. Y., Nov. 7, 1886. JOHN H. EADIE.

COMET *b*. (BROOKS) 1886.—The elements of Comet *b*, by Professor Frisby, given in June MESSENGER, made $i = 100°57.4'$; i should have been $100°21.0'$.

THE NEW STAR IN ORION.—My photometric measures of Gore's new star in the club of *Orion*, made it last December, 6.2mag.; and it gradually diminished to 10.0 mag. by April, when it was lost from the sun's proximity. In October it was somewhat brighter, 9.2 ; and now it is nearly as bright as at first, 6.8. I am not aware that a new star has ever before been observed to return to its original brightness. It has either disappeared utterly and finally, or gone to its lowest point and there remained without material change. It it hardly possible that this star can have been a variable, rising to nearly the 6 magnitude at its maximum, long before Gore's discovery ; and it remains to be seen whether it will now assume that character.

New York, November 22, 1886. HENRY M. PARKHURST.

THE LICK PHOTOGRAPHIC LENS.—Some time ago, it was decided by the Lick Observatory management to procure an additional lens for the great equatorial for the purpose of photography. The glass disc was obtained from Paris and given to Clark & Sons to work. While being ground it burst in pieces. Because of strong polarization at the edges indicating powerful strain, the Clarks knew, from the outset, that the disc was seriously imperfect, and would not assume the responsibility of working it ; so the loss falls on Feil & Son of Paris. Another will doubtless soon be furnished.

NEW MINOR PLANET was discovered by Dr. Palisa, October 3. 4836. Gr. M. T. in R. A. 23*h* 3*m* 17.4*s*, Declination 6°42′46″ and of fourteenth magnitude, its *number* being (260).

New Minor Planet (261) was discovered by Dr. Peters, October 31.79 Gr. M. T., R. A.=25°0′0″; P. D.=85°30′49″.

New minor Planets (262) and (263) were discovered by Palisa November 3, and are each of the twelfth magnitude. Their places respectively were :

R. A.=12*h* 39.7*m* ; P. D.=75°57′43″.
R. A.=12*h* 56.0*m* : P. D.=76°13′25″.

The title to plate No. 3 in Essay on Red Light October issue should have been "Prismatic Halo, Nov. 20, 1885, photographed by H. C. Maine."

LIVERPOOL ASTR. SOCIETY.—Gore's *Nova* (1885) *Orionis* was observed here last night (Sept. 14th) and found to have a magnitude of 9.2. The star is very red. The small comes F was estimated as of 9.7 magnitude. T. E. ESPIN.

BOOK NOTICES.

Examples of Differential Equations, with Rules for their solution. By George A. Osborn, S. B., Professor of Mathematics in the Massachusetts Institue of Technology, Boston. Ginn & Company, Publishers, 1886, pp. 50.

This book was prepared to meet a want felt by the author in a practical course of Physics for advanced students, and is to be used in connection with a course of lectures on the theory of differential equations and methods for their solution. The topics treated are: Derivation of the differential equation from the complete primitive; differential equations of the first order and degree between two variables; exact differential equations—integrating factors; differential equations of the first order and higher degrees; singular solutions, linear differential equations; special forms of differential equations of higher degrees; simultaneous differential equations and geometrical applications.

The author has done real service for those teachers who wish to apply the Calculus to ordinary practical uses in the scientific school, and who have time to instruct students only so far in the uses of the differential equation. His 50 pages of matter gives the pith of Boole's larger work on the same subject containing nearly 500 pages.

SEDGWICK AND WILSON'S GENERAL BIOLOGY.—The American science series, published by Messrs. Henry Holt & Co., is constantly receiving important additions. This most recent contribution furnishes what was much needed, an introduction to the general facts concerning "matter in the living state."

The number of labratory manuals is already considerable and they all have commendable features. This book is more than a manual. It presents and discusses fully and admirably the facts and deductions which the study of the organisms illustrates. It is doubtless true that a stronger grasp upon a subject is gained when it is possible to bring the student to just conclusions from his own observations. This is impracticable and wasteful in many cases and resort must be had to direct presention enforced by carefully choosen illustrative examples.

This book will be welcomed by many who have been trying under unfavorable circumstances, to carry on instruction in this line. It furnishes much in excellent shape, which, heretofore, it has been necessary to give by lecture. This will leave more time for that thorough study of the illustrations which is needful to satisfactory results. Even those, who may dissent from the form in which some doctrines are presented, will find the volume helpful. L. W. C. JR.

Carleton College.

ARTHUR, BARNES AND COULTER'S PLANT DISSECTION.—Although published first, this work forms a supplement to the General Biology along the plant branch of the subject.

The illustrative plants are well chosen, being all easily accessible, and with, perhaps, a single exception, perfectly typical.

A term's use of the manual in the labratory shows that it has one essential feature of such a work, perfect clearness of statement. The ordinarily intelligent student can, with scarcely any assistance, follow the directions with success and profit. The directions for manipulations have proved of decided value, rendering unnecessary much personal attention and instruction.

The annotations, which conclude each topic, are well suited to impress the important points and stimulate to further investigation.

Good results , both in the way of general facts and familiarity with special structures, must follow the careful use of this manual. L. W. C. JR.

Carleton College.

GENERAL INDEX.

Note.—The numbers following the titles of articles are the pages of Volume V. Those in parenthesis are the numbers of the minor planets.

ILLUSTRATIONS.